Russian River/Bodega Watershed Management Area

316 - California Land Stewardship Institute, Fish Friendly Farming and Fish Friendly Ranching Environmental Certification in the Russian, Navarro, and Gualala River Watersheds

California Land Stewardship Institute Technical and Scientific Documentation Table		
Technical and Scientific Document Name	**Document Description**	**Relevant page #**
California Stewardship Institute, Fish Friendly Ranching: BMP Workbook, March 2013	Workbook of BMPs for livestock management, grazing areas, water sources, roads, creek network and photo-monitoring	all
Laurel Marcus. Fish Friendly Farming: BMP Workbook. 1999, last updated 2012.	Workbook of BMPs for vineyards, orchards, roads, creek networks, water sources, chemical use and photo-monitoring.	all
Supporting Documents provided digitally via the BMS upload and by CD		
California Stewardship Institute, Fish Friendly Ranching: Ranch Plan Template, March 2013	Template for completion of comprehensive plan for grazing areas, water sources, roads and creeks and photo-monitoring.	all
Laurel Marcus. Fish Friendly Farming: Farm Plan Template. 1999, last updated 2012.	Template for completion of comprehensive plan for vineyards/orchards, roads, creek networks, water and soil conservation, water sources and photo-monitoring.	all
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.	All
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-	109-115, 202-207

	2004-0087).	
California Department of Fish and Game (CDFG). Recovery Strategy for California Coho Salmon. Report to the California Fish and Game Commission. Species Recovery Strategy 20041. 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
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
DFG. California Salmonid Stream Habitat Restoration Manual – 4th Edition - Part X and XI. 2010.	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

Russian River/Bodega Watershed Management Area

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FISH FRIENDLY FARMING™
ENVIRONMENTAL CERTIFICATION PROGRAM
SONOMA AND MENDOCINO COUNTIES
FARM CONSERVATION PLAN WORKBOOK AND BENEFICIAL MANAGEMENT PRACTICES

CALIFORNIA LAND STEWARDSHIP INSTITUTE

Fish Friendly Farming® Environmental Certification Program

Fish Friendly Farming® Environmental Certification Program is a project of the California Land Stewardship Institute (CLSI) a not for profit organization.
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FARM CONSERVATION PLAN WORKBOOK
INTRODUCTION

The Fish Friendly Farming® Certification Program was designed to improve water quality and to restore and sustain habitat for the federally-listed threatened Coho salmon, Chinook salmon, and steelhead trout in the Russian, Navarro, Gualala and Napa Rivers and Sonoma, Suisun, Salmon and Greenwood Creek watersheds.

The Fish Friendly Farming® (FFF) program is a voluntary certification program for farmers who implement land management practices that restore and sustain fish habitat on their property and improve water quality. The Farm Conservation Plan includes a format to allow for the farmer to use one notebook to include all of the information and maps. The FFF Program recognizes that improved land stewardship is best accomplished through a cooperative and positive working relationship with landowners and farmers. Landowners make numerous decisions regarding land management and will use improved methods, if encouraged, and if technical and financial assistance is available for projects.

The following concepts guide the Fish Friendly Farming® Environmental Certification Program:

- ❑ Cooperative efforts between landowners and interest groups in the watershed will increase the level and success of restoration and recovery efforts for salmon and steelhead.
- ❑ An incentive program that rewards farmers for practicing beneficial management practices (BMPs) will protect fish habitat over the long term.
- ❑ Restoration and recovery of threatened fish populations is an immediate concern. The certification program, by providing incentives, will encourage rapid improvements. Some phasing of improvements is built into the program to recognize the economic needs of the landowner.
- ❑ Beneficial management practices are based on a credible scientific approach to watershed restoration and focus on the needs of the fish and water quality.
- ❑ Recovery of the salmon and steelhead is a long-term endeavor. Changes to support and sustain these fish populations must be integrated into all land uses in each watershed. There are many land uses and facilities not associated with agriculture that have had significant effects on the fish. This program focuses on one land use, farming, and recognizes that changes must be made in other activities and land uses as well if the fish are to recover.
- ❑ This program is entirely voluntary. Landowners chose to participate.

The potential benefits of the Fish Friendly Farming™ program for the farmer include:

- ❑ Improved soil and water conservation

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- ❑ Better roads
- ❑ Lower maintenance creek corridors
- ❑ Advice and assurances from three regulatory agencies regarding the consistency of the actions in the farm conservation plan with regulations
- ❑ Implementation funds and technical assistance for riparian corridor restoration including invasive plant removal and erosion control projects
- ❑ Road and erosion site repair
- ❑ Public recognition as an environmentally conscious farmer
- ❑ Personal satisfaction for assisting in the recovery of the steelhead trout for your children and grandchildren

In Sonoma and Mendocino Counties the Sotoyome Resource Conservation District (RCD) sponsored the program from 1999-2005. Other agencies involved include the North Coast Regional Water Quality Control Board, the California Department of Fish and Game, the National Marine Fisheries Service and the Natural Resources Conservation Service. In 2005 the California Land Stewardship Institute, a non-profit organization was formed to operate the FFF program in four counties.

This version of the Fish Friendly Farming™ Program was partially funded by the State Water Resources Control Board and the State Coastal Conservancy. A Technical Advisory Committee (TAC) reviewed the program and provided input.

This program uses a workbook for the landowner/manager to evaluate the property, the current practices, and create a farm conservation plan for the property focusing on resource concerns including fish habitat. The participants attend a series of four workshops. The FFF program staff complete a site visit and provide technical assistance to the farmer as needed to complete all aspects of the farm plan. Other technical experts may also be involved in implementation of creek restoration, road repair and other projects. The farmer will keep the workbook and the farm conservation plan and use it and revise it as necessary. The Farm Conservation Plan includes a format to allow for the farmer to use one notebook to include all of the information and maps for the property.

Once the assessment and farm conservation plan are completed the landowner can have the farm plan certified. A certification team made up of three resource agencies, Regional Water Quality Control Board, National Marine Fisheries Service and the County Agricultural Commissioner will evaluate the farm plan and perform a site visit. The FFF program staff assists the grower in presenting the Farm Conservation Plan. The certification is based on the completeness and accuracy of the site inventory in documenting the natural resources of the site, current practices and all needed BMPs and there is a reasonable timeline for implementation of additional BMPs and projects as needed. The certification process is meant to provide assistance to the farmer and result in a collaborative effort to improve land stewardship.

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Following this review each regulatory agency issues a letter to the owner stating the Farm Conservation Plan is certified. If the Farm Conservation Plan is not certified, then the agencies provide detailed comments on the steps necessary to become certified. Continued monitoring will allow for the landowner to document their practices and land stewardship and demonstrate implementation of the plan. Re-certification will occur on a 5-7 year cycle for most sites.

The following policy outlines measures required for re-certification and maintaining a valid certification:

The Fish Friendly Farming Certification is initially awarded based on the accuracy and completeness of the Farm Conservation Plan for a given site and for the list of needed actions in the Implementation Timeline to bring the site into compliance with the FFF program BMPs. We have been asked to develop a policy for revocation of the certification and define the circumstances that will result in a site losing its certification. The Board of Directors of the California Land Stewardship Institute approved this policy at its December 2008 meeting after the certifying agencies had reviewed and provided their input.

Here are the conditions under which CLSI will revoke a certification:

1. At the first re-certification no progress, or a clearly insufficient amount of progress, has been made on items in the Implementation Timeline. Extenuating circumstances, such as problems receiving permits, will be evaluated on a case-by-case basis and an additional re-certification progress check may be scheduled.

2. At re-certification a significant reduction in BMP application has occurred changing the basic condition of the site and requiring significant improvement to be recertified.

3. There is an act by the certified owner/manager that causes a violation of a particular regulation and for this the owner is cited[1]. Examples include clearing the riparian corridor along a creek, dumping spoils or debris in the creek, spilling pesticides into the creek, or grading in the winter. The issuance of a citation or other similar documented action (e.g. notice of violation, cease and desist order) is required. Having a complaint filed or an interaction with a regulator does not affect the certification. Only citations involving the laws and regulations which the FFF program covers (Clean Water Act, Porter-Cologne Act, Federal Endangered Species Act, Ca Water Code, State pesticide regulations) will affect the certification. So for example labor, health and safety laws will not be included. Not having a 1600 permit for existing permitted or licensed water facilities will not be counted as a violation due to the unclear legal status of application of the Ca. Fish and Game code to water rights facilities.

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[1] *1. Citations affecting certification status include:*
Administrative Civil Liabilities (Clean up and Abatement order from RWQCB); Notice of Violation/Federal lawsuit from NMFS; Violation List – County Agricultural Commissioner; Warden's ticket or County District Attorney/State Attorney General lawsuit – Ca. Dept. of Fish and Game. Only lawsuits settled against the certified owner/manager will apply.

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4. All use of the FFF logo and name for marketing will be done after a license agreement has been issued and such marketing will be consistent with the license agreement and this policy. Misrepresentation of program coverage such as claiming all wines come from FFF certified vineyards when, in fact, some vineyard designated wines are sourced from vineyards not certified in the program. Wines must have a minimum of 75% certified grapes to be considered FFF certified wine. This restriction will also apply to the Napa Green program where a trade organization provides a different trademark which is entirely based on the FFF certification.

5. For each instance where a certification may be revoked due to a violation the issues will be reviewed by CLSI and the owner and a set of steps to repair or mitigate the problem will be established along with the necessary actions to re-instate the certification. These will be reviewed by the certifying agencies for approval. Whatever actions are required by the agency issuing the violation could become the steps in CLSI plan with the owner. These actions would be substantive work such as revegatation, erosion control and would not involve fines such as the agency issuing the citation may impose.

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FARM CONSERVATION PLAN WORKBOOK INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES (BMPs)

This Farm Conservation Plan workbook is designed for use by the landowner/manager to evaluate, inventory and assess site conditions, evaluate current management practices, and create a conservation plan for the farm. The assessment and conservation plan that the farmer develops is the foundation tool for a continuous and thorough assessment of the resource base and operation of the farm. The workbook directs the completion of a conservation plan that provides the basis for certification as a fish friendly farm. Once completed, the workbook also provides a centralized database for the property.

The farm plan includes the following elements:

- ❑ **Element I - General Site Features**
- ❑ **Element II - New Vineyard/Orchards**
- ❑ **Element III - Managing Agricultural Lands***
- ❑ **Element IV - Major Replants**
- ❑ **Element V - Roads**
- ❑ **Element VI - Creek/River Corridors**
- ❑ **Element VII - Photo-monitoring**

Certification of the Farm Conservation Plan requires completion of all of the elements that apply to the site. For example, if you are developing a new vineyard, the plan needs to include Elements I, II, III, and VIII and if appropriate Elements V and VI. In contrast, if you have an existing vineyard and no plans to expand or replant, the plan will need to include all the Elements III and VII and if appropriate Elements V, VI. Elements V and VI are typically completed by FFF staff in collaboration with the landowner/manager and are not done for all sites.

The Farm Conservation Plan does not have to be done in one day or even one month. Take your time. Be thorough and provide as much detail as possible. The more you give to the planning process, the more you will benefit. The more you quantify your descriptions, the easier it will be to measure improvement over time. The Farm Conservation Plan will prepare you to improve your long-term efficiency and improve the bottom line. At the same time, you will be helping to bring back salmon and steelhead trout and improve water quality.

The program is designed to provide technical assistance to the farmer. The Farm Conservation Plan workshop instructor and other technical experts will assist with all the elements, but especially the Roads and Creek/River Corridors elements.

* We can provide this element for Vineyards and Orchards

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ELEMENT I - GENERAL SITE FEATURES: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

These instructions should be used with Element I of the Farm Conservation Plan template.

1. LOCATION AND BACKGROUND INFORMATION

This section should summarize the address and contact information for the property.

2. WATERSHED LOCATION

- ❑ Where is your property in the watershed? Define the tributary watershed in which the property is located.

- ❑ You will receive aerial photographs and topographic maps of your property as part of enrolling in the FFF program. If you are completing a new vineyard or major replant, you will need to have detailed topographic maps created for the proposed development area. Complete the preliminary evaluation in Element II or IV before having these detailed maps completed.

3. GENERAL SITE DESCRIPTION

- ❑ Approximate the acreage in various land uses on the property including existing vineyard, proposed new vineyard, other agricultural lands, residential or winery areas, and open spaces or wildland areas. For wildland areas, fill in the vegetation type and general slopes, if known.

4. ELEMENTS

- ❑ Check the elements included in your plan. All the plans for certification must include: Element III-Managing the Vineyard, as well as Elements 5-Roads, Element VI-Creek/River Corridors, and Element VII-Photo-monitoring. Include the New Vineyard or Major Replant Elements, if appropriate for your site.

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5. ADDITIONAL INFORMATION

- ❑ This is an area to explain any other site feature that needs more elaboration or to describe more detail about the elements you feel are needed. For example, you might explain about the replanting schedule for the site and why this element is or is not needed. You might also explain if other crops and agricultural uses occur on the property or the site history prior to a new vineyard development to document causes of exiting erosion. This is also the place to state any goals that you are using as part of the farm plan.

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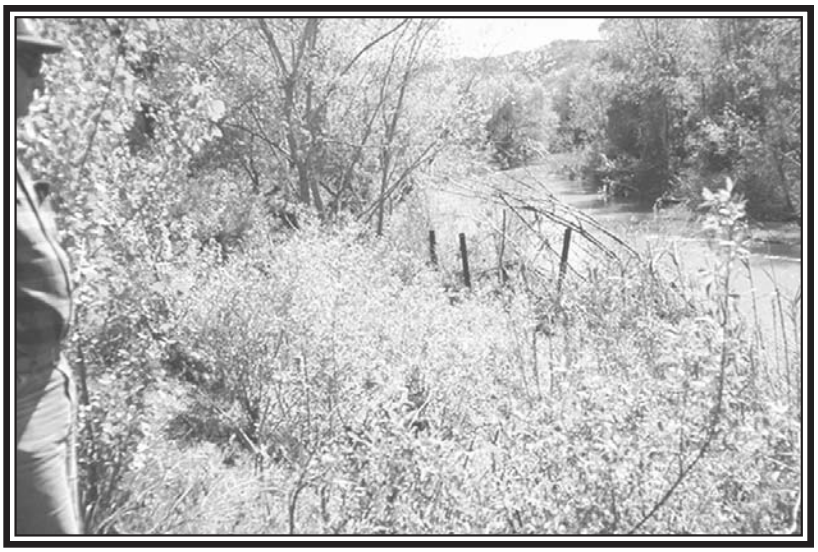

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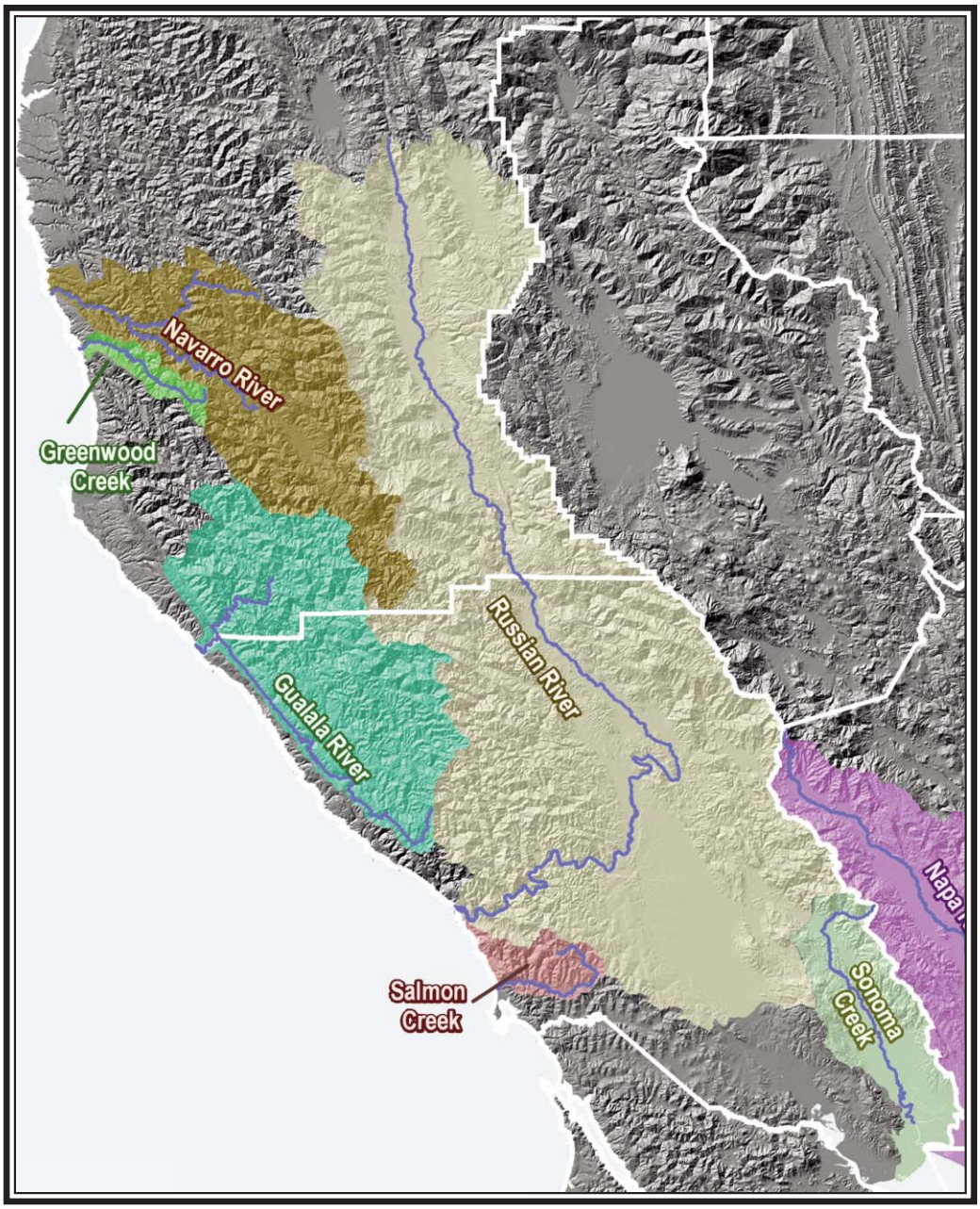

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ELEMENT II - NEW VINEYARD*: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for new proposed vineyards* and expansion of an existing vineyard and includes:

- ❑ Inventory/Assessment of the features of the property where development is being considered to integrate compliance with laws and regulations, including the California Environmental Quality Act (CEQA).
- ❑ Evaluation and application of Beneficial Management Practices (BMPs) into the site design.
- ❑ Evaluation and Beneficial Management Practices for the installation of the vineyard.

EVALUATING A SITE FOR A NEW VINEYARD*

Use Element II of the Farm Conservation Plan, your maps and aerials and take site photos as instructed in the directions. There is some overlap with other elements and you will need to refer to a few other sections of the workbook.

1. COMPLETING A PRELIMINARY SITE EVALUATION

Background: Preliminary Site Evaluation

This evaluation creates an inventory of site features including natural features, potential constraints, potential vineyard areas and potential resource protection areas. Under Sonoma County regulations an Erosion Control Plan is needed to develop a new vineyard in most locations. The Erosion Control Plan must review site slopes, soils, topography and layout in great detail. To address habitat and biological issues as well as hydrologic processes, which can affect downstream areas, a more thorough evaluation and site design process is needed. Additionally, a thorough site evaluation process can assist the property owner in avoiding significant project impacts under the California Environmental Quality Act, or CEQA. For more information on CEQA visit http://ceres.ca.gov.

This preliminary site evaluation of the property assesses the features required under local regulations and of importance to water quality protection – soils and slopes as well as vegetation, special status species, and the drainage network. The result is a set of overlays of the site used to define constraints and opportunities for location and development of new vineyards.

The preliminary evaluation will determine potential vineyard areas with the least environmental impacts. The FFF program staff can provide assistance in completing this evaluation.

**** Throughout this document we will be using the term vineyard but the information is also intended to include orchards.***

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2. RESOURCES FOR THE INVENTORY

- ❑ A relatively detailed color aerial of the entire property will be needed (scale of at least 1'' = 500'). As part of the farm plan workshops, digital color photos will be ordered at the appropriate resolution for planning on each enrolled site. Make a number of color copies of the aerial or make a digital scan. Use these copies for the next sections of the farm plan.

- ❑ A detailed topographic map will be needed for the Erosion Control Plan. However, for the first level of evaluation of the property a USGS topographic quad sheet can be used and the detailed map prepared later.

- ❑ Separate the property into areas. These can be areas where you plan to develop vineyards and areas which will not be developed, the north/south or east/west areas of the site, or you may want to separate the areas by sub-watershed for use later in evaluating site hydrology. Name or number each and delineate each area on a copy of the aerial.

3. SLOPES

Background: Slopes

Slope has an enormous effect on soil erosion, drainage and land use. Slope magnifies the effects of rainwater runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage and mass movement. Steep slopes (greater than 30%) have high to extreme erosion hazards for most soil types.

U.S. Geologic Survey (USGS) topographic maps can be used to determine the general percentage slope on a site for preliminary review purposes. The contours on a topo map indicate elevations and by adding up the number of contours one can generally determine the change in elevation on a hillside. The percent slope of a hillside is measured as rise over run multiplied by 100. The first step is to measure the elevational increase along a hillside (shown by the contours on the map) and divide by the linear distance or length over the same area measured to the scale of the map (1"=2000'). This number is then multiplied by 100 to get the percent slope. For example, a hillside which measured a 200 ft. elevation increase in a 2000 ft linear distance would have a 10% slope (200/2000 x 100). Another hillside with a 200 ft elevation gain in a 1000 ft linear distance would have a 20% slope (200/1000 x 100). A short steep slope such as a 200 ft elevation rise in a 500 ft linear distance would have a 40% slope (200/500 x 100).

For each area defined on the site, make numerous slope measurements. There are several inexpensive computer software programs such as Maptech Terrain Navigator and TOPO, as well as sophisticated Geographic Information Systems (GIS) which can be

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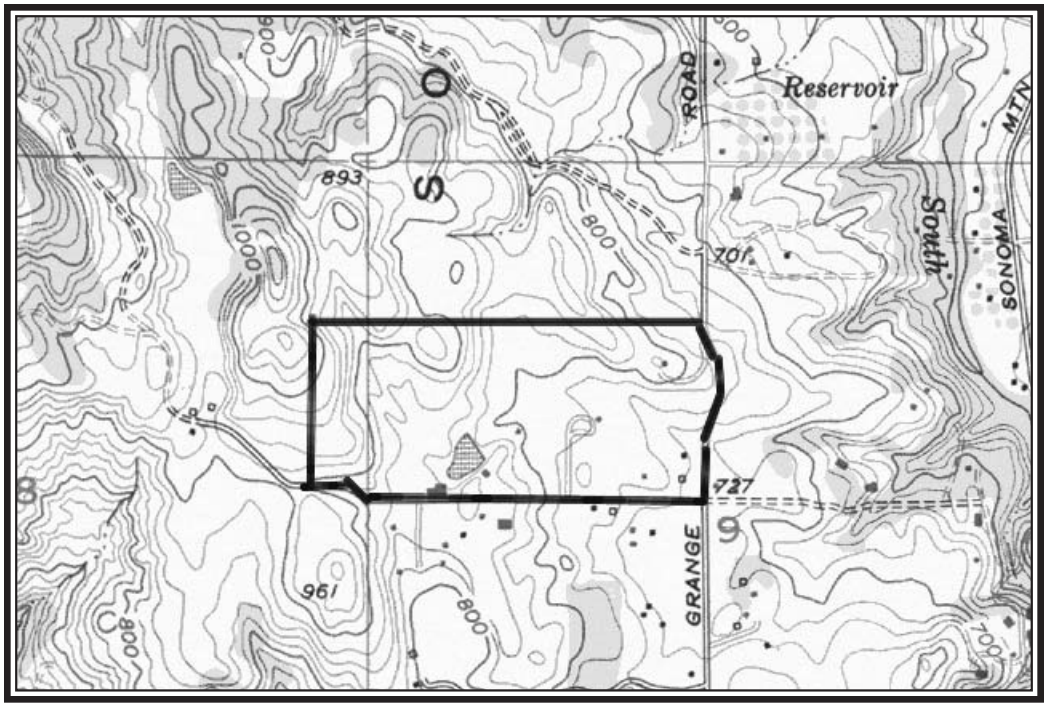
AERIAL AND MAP PROPERTY BOUNDARY



Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: PROPERTY BOUNDARY

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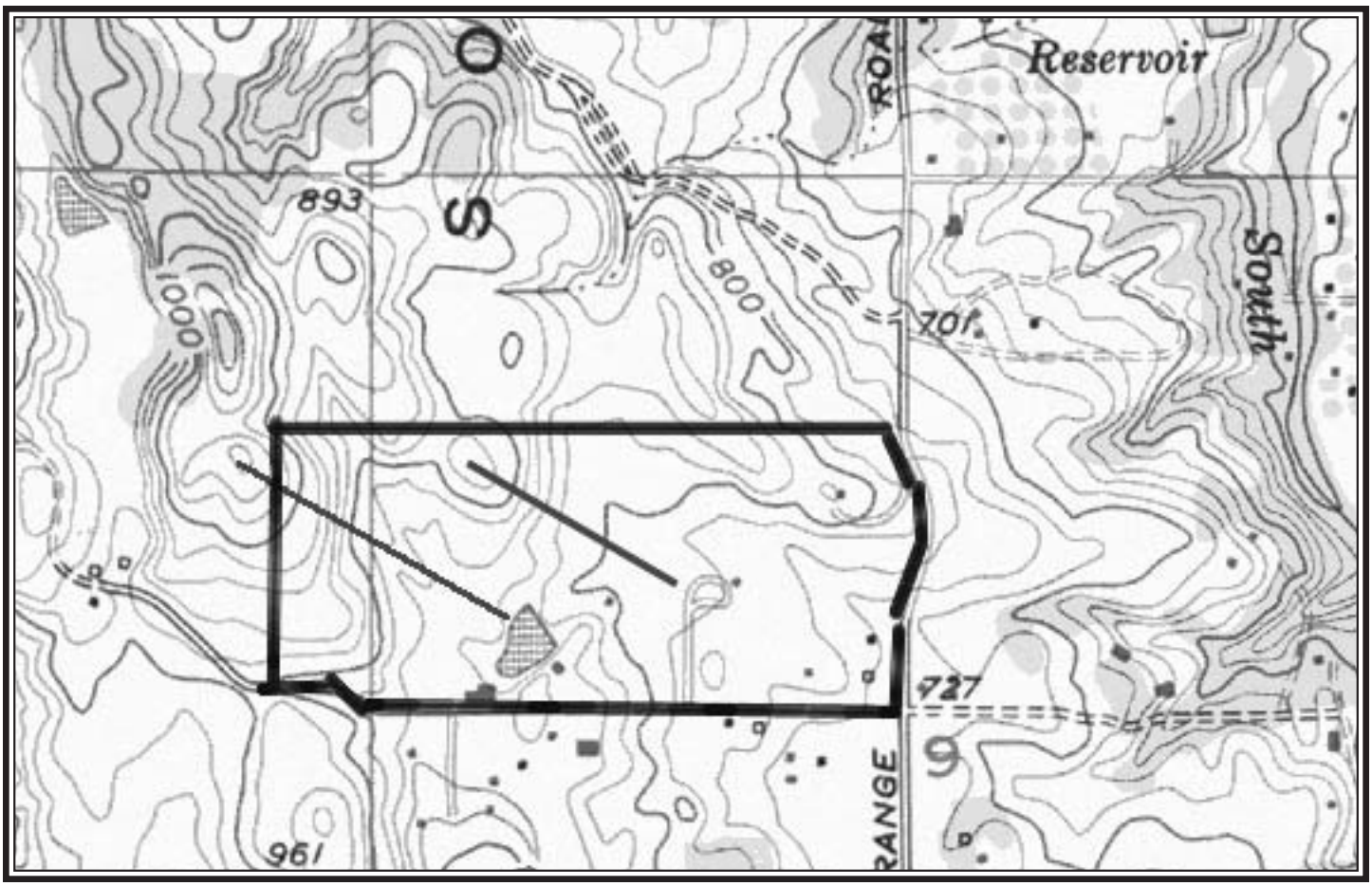

LINES SHOW EXAMPLE OF SLOPE AND SLOPE LENGTHS

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: SLOPE AND SLOPE LENGTH

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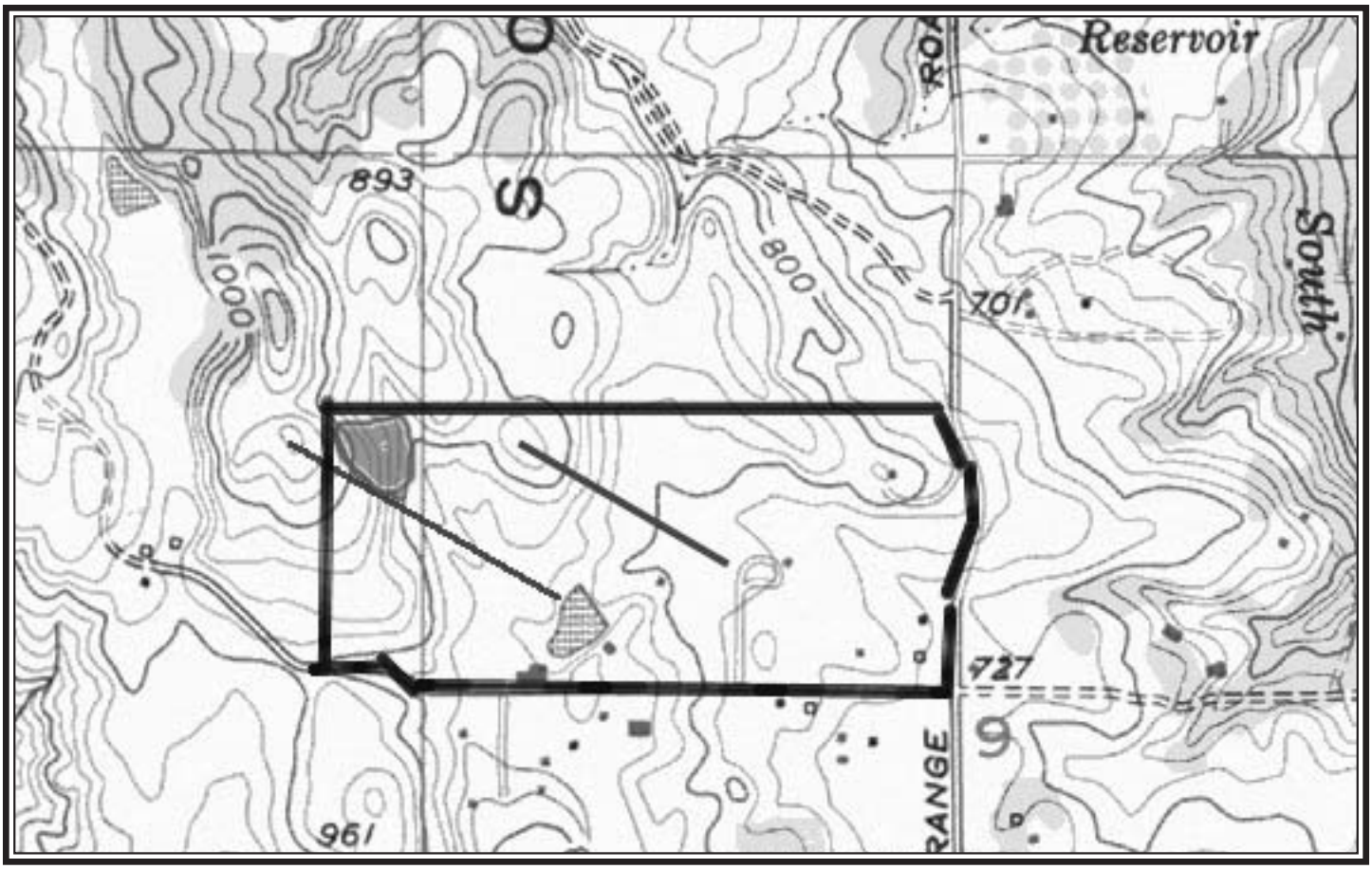

SMALL AREA OF STEEPER LAND IS OUTLINED WITHIN A GENERALLY LOW SLOPE SITE

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: DELINEATING AREAS OF STEEPER SLOPE

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used to generate a slope map of the property based on USGS topographical maps. However a much more detailed survey with two foot contours at a 1'' = 200' scale should be completed for the Sonoma County permit. Preparation of the detailed topographic map will require a site-specific survey.

SITE INVENTORY: SLOPES

- ❑ Make several measurements of slopes in each area from a topographic map or have a detailed site survey completed. In the 5-30% slope areas also measure knolls, hills and small steep areas and delineate all of these small areas over 30% slope. Keep your map and record your measurements in the Farm Conservation Plan.

- ❑ Measure and record the length of the slopes in the area of 5-30% slope class.

- ❑ With assistance from the farm plan workshops, field check the 5-30% slope areas, maps and aerials and record the measurements in the Farm Conservation Plan.

- ❑ Create an overlay either in a digital format or on paper of slope classifications of <5%, 5-15%, 15-30%, 30-50%, and >50% for the areas of the property.

4. SOIL TYPES AND HYDROLOGIC RATINGS

Background: Soil Types

Soil is the fundamental resource for all types of agriculture and will determine both the suitability of a site for various crops as well as the potential for erosion. The easiest place to find out the soil type for a site is to look in the Sonoma or Mendocino County Soil Survey available from the Natural Resource Conservation Service (NRCS). Participants in the FFF workshops receive a soil map and description for their property.

Soils are grouped into series according to their thickness and physical makeup. Within each series of soils are various soil types, which are given numbers and mapped onto aerials. For example, the Forward series has several soil types: Forward gravelly loam, 2 to 9 percent slopes (138), Forward gravelly loam, 9 to 30 percent slopes (139), Forward gravelly loam, 30 to 75 percent slopes (140), and Forward-Kidd complex, 50 to 75 percent slopes (141). These soil types are also called mapping units. Each soil series and type is described in the Soil Survey. For example:

"Forward series (Map units: 138, 139, 140, 141)

The Forward series consists of well-drained soils on uplands. Slope is 2 to 75 percent. Elevation is 400 to 3,500 feet. These soils formed in material weathered from rhyolite. The plant cover is Douglas fir, madrone, scrub oak, pepper, and bay trees. The mean annual precipitation is 30 to 50 inches, and the mean annual temperature is 54° to 56° F. Summers are warm and dry, and winters are cool and moist. The frost-free season is 200 to 230 days.

In a representative profile the surface layer is light gray, slightly acid gravelly loam 4 inches thick. The subsoil is light gray, medium acid and strongly acid loam 22 inches thick. The

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substratum is light gray, strongly acid gravelly loam that overlies weathered rhyolitic tuff at a depth of 35 inches.

Permeability is moderately rapid. The effective rooting depth is 20 to 40 inches. Available water capacity is 2 to 4.5 inches.

Forward soils are used for watershed, wildlife habitat, and limited timber production."

The description of each soil type within the soil series includes descriptions of erosion and runoff characteristics:

138- Forward gravelly loam, 2 to 9 percent slopes. *This gently sloping to moderately sloping soil is on side slopes on uplands.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and that are less than 20 inches deep to bedrock.

Runoff is medium. The hazard of erosion is slight.

This soil is used for limited timber production, vineyards and orchards, wildlife habitat, and watershed.

139- Forward gravelly loam, 9 to 30 percent slopes. *This strongly sloping to moderately steep soil is on side slopes on uplands.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and that are less than 20 inches deep to bedrock.

Runoff is medium. The hazard of erosion is slight to moderate.

This soil is used for limited timber production, wildlife habitat, and watershed.

140- Forward gravelly loam, 30 to 75 percent slopes. *This steep and very steep soil is on uplands. It has the profile described as representative of the series.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and areas of clayey, less sloping soils.

Runoff is very rapid. The hazard of erosion is high to very high.

This soil is used for timber, recreation, wildlife habitat, and watershed.

141- Forward-Kidd complex, 50 to 75 percent slopes. *This complex consists of very steep soils on uplands. These soils are so intermingled that it was not practical to separate them at the scale used in mapping. Commonly, the Forward soils are on toe slopes and the Kidd soils on side slopes.*

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This complex is about 60 percent Forward soils, about 20 percent Kidd soils, and about 20 percent Aiken, Boomer, and Sobrante soils and areas of rock outcrop.

Runoff is rapid and the hazard of erosion is high in the less sloping areas. Runoff is very rapid and the hazard of erosion is very high in the more sloping areas. The soils in this complex are used for limited timber production, wildlife habitat, and watershed."

The change in slope for a similar soil type changes the erosion rating. Soil types are defined based on slope classification. The slope classes typically used in soil surveys are:

0 - 5 % or 0 - 9%
2 – 9%
5 - 15 % or 9 - 15%
15 - 30 %
30 - 50 %
50 - 75%

Another feature of soils that the NRCS has identified is the hydrologic soil group. Soils are grouped as A, B, C or D according to the minimum rate of infiltration occurring in bare soil after prolonged wetting. Infiltration is the movement of rainfall into and through the soil and is largely affected by the surface condition of the soil and the composition and depth of the soil profile. One property may have several soil types and slope classes. The erosion hazard of each soil type/slope class is different and should be evaluated separately. Table IIA lists the hydrologic soil group for each Sonoma County soil type and is available at the soil survey website. Table IIB lists the Mendocino County soil types.

SITE INVENTORY: SOIL TYPES

- ❑ Look up your site in the Sonoma or Mendocino County Soil Survey. Use the map and soil descriptions provided in the FFF workshops

- ❑ Print out copies of the Soil Survey map and descriptions of the soil types for your site for inclusion in your Farm Conservation Plan. Use the soil survey, Appendix 1 and Table IIA to fill in the table in the Farm Conservation Plan for soil type, slope classification, erosion rating, K and T values, and hydrologic soil group for the entire property. If more detailed site information is available also include it.

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TABLE IIA
Sonoma County Soil Survey
Soil and Water Features

Soil Name and Map Symbol	**Hydrologic Group**
Arbuckle: AgB, AgD, AgE, AkB, AkC	B
Atwell: AtF, AtG	C
Baywood: BaC, BaE	A
Blucher: BcA, BhA, BhB, BlA, BlB	C
Boomer: BoE, BoF, BoG	B
Caspar: CaE, CaF	B
Cibo: CbF	D
Clear Lake: CcA, CcB, CeA, CeB, Cfa	D
Clough: CgC, CgD, CgE	D
Cohasset: CmE, CmF, CmG	B
Cole: can, CnB, CoA, CoB	C
Comptche: CpG	B
Cortina: CrA, CsA	A
Cotati: CtC, CtD, CtE	C
Diablo: DbC, DbD, DbE, DbE2, DbF, DbF2	D
Dibble: DcC, DcD, DcE, DcE2, DcF, DcF2	C
Empire: EmE, EmF, EpF	B
Felta: FaD, FaE, FaF	B
Forward: FoE, FoG, FrG	C
Goldridge: GdC, GdD, GdD2, GdE, GdE2, GdF, GdF2	B
Goulding: GgD, GgE, GgF, GgF2, GgG, GlD, GlE, GlF, GlF2, GlG, GoF	D
Guenoc: GrE, GrG	C
Haire: HaB, HbC, HbD, HbD2, HbE, HbC, HcC, HcD, HcD2, HcE, HcE2	C
Hely: HeF, HeG	C
Henneke: Hge, HgG2	D
Hugo: HhG, HkF, HkG, HkG2, HlF, HlG, HmF, HmG, HnE, HnG, HnG2, HoG, HrG, HsF, HsG	B
Huichica: HtA, HtC, HtD, HvC, HuB, HwB	D
Huse: HyG	C
Josephine: JoE, JoF, JoF2, JoG, JsG	B
Kidd: KdF, KeE, KkG	D
Kinman: KlD, KlE, KlF, KmF	C
Kneeland: KnC, KnD, KnE, KnF, KoG	C
Kneeland, sandy variant: KsD, KsE, KvE	C
Laniger: LaC, LaD, LaE, LAE2, LaF	C
Laughlin: LgE, LgF, LgG, LgG2, LhG	C
Los Gatos: LkG, LmG, LnG	C
Los Osos: LoD, LoE, LoF, LoF2, LsD, LsE, LsE2, LsF2	C
Los Robles: LuA, LvB	B

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TABLE IIA (cont.) Sonoma County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	**Hydrologic Group**
Manzanita: MbC	B
Maymen: McF, MlG	D
Mendocino: MmE, MmF, MnF	B
Montara: MoE, MoG	D
Noyo: NoD	C
Pajaro: PeA, PaB, PbB, PcA, PcB	C
Pleasanton: PeA, PeC, PgB, PhB, PkC, PlC, PlD	B
Positas: PsC, PsD	D
Raynor: RaC, RaD, RaE, RcD, ReE	D
Red Hill: RhD, RhE, RhF, RlG	B
Rayes: RmA	D
Rohnerville: RrC, RrD	B
Sebastopol: SbC, SbD, SbD2, SbE	B
Sheridan: SeE	B
Sites: SfE, SfF	B
Sobrante: ShE, ShF, ShG	C
Spreckels: SkC, SkD, SkE, SkE2, SkF	C
Steinbeck: SnC, SnD, SnD2, SnE, SnE2, SnF, SnF2	B
Stonyford: SoF, SoG, SrG	D
Supan: SsG	D
Suther: StE, StE2, StF, SuF, SuG	C
Toomes: ToE, ToG	D
Tuscan: TuC, TuE	D
Wright: WgC, WhA, WmB, WoA	C
Yolo: YlA, YmB, YnA, YoB, YrB, YsA, YtA	B
Yorkville: YuE, YuF, YvF, YwF, YwG	D
Zamora: ZaA, ZaB	B

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TABLE IIB Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	**Hydrologic Group**
101: Asabean Sanhedrin	B B
102: Asabean Sanhedrin Speaker	B B C
103: Asabean Speaker Neuns	B C C
104: Bearwallow Hellman	C C
105: Bearwallow Hellman Witherell	C C D
106, 107, 108: Bluenose Neuns Gudgrey	 B D B
109, 110: Casabonne Wohly	 B B
111: Casabonne Wohly Pardaloe	B B B
112: Clear Lake	D
113, 114: Cole	C
115: Cole	C
116: Cummiskey	B
117: Dingman Beaughton	 D
118, 119, 120: Dunsmuir Maymen Varient	 C D
121: Etsel Neuns	D C
122: Etsel Woodin	D C
123, 124, 125, 126: Feliz	B

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
127: Fluvaquents	
128: Gielow	C
129: Gshwend Frenchman	B B
130, 131, 132: Grudgey Bluenose Neuns	 B B C
133: Haplaquepts	
134, 135: Haploxeralfs Argixerolls	
136, 137: Henneke Montara	 D D
138, 139: Holohan Hollowtree Casabonne	 B C B
140: Holohan Hollowtree	B C
141, 142: Hopland	 B
143, 144: Hopland Maymen Etsel	 B D D
145, 146, 147: Hopland Sanhedrin Kekawaka	 B B B
148, 149: Hopland Witherell Squawrock	 B D C
150, 151: Hopland Wohly	 B B

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
152, 153:	
Hopland	B
Woodin	D
154, 155:	
Kekawaka	B
Casabonne	B
Wohly	B
156: Maxwell	D
157: Mayacama	C
Hopland	B
Etsel	D
158: Maymen	D
Etsel	D
Hopland	B
159: Maymen	D
Etsel	D
Mayacama	C
160: Maymen	D
Etsel	D
Snook	D
161, 162:	
Maymen	D
Woodin	C
Etsel	D
163, 164:	
Nashmead	B
Updegraff	B
Woodin	C
165, 166:	
Nashmead	B
Woodin	C
167, 168:	
Neuns	C
Bluenose	B
Tyson	B
169, 170, 171:	
Ornbaun	B
Zeni	C

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
172: Pardaloe Kekawaka Casabonne	B B B
173: Pardaloe Woodin Casabonne	B C B
174: Pardaloe Woodin	B C
175, 176: Pinnobie	 B
177, 178, 179, 180, 181, 182: Pinole	 B
183: Pits and Dumps	
184, 185, 186: Redvine	C
187: Rock Outcrop	
188: Russian	B
189: Russian	B
190: Russian	B
191, 192: Sanhedrin Asabean Speaker	 B B C
193, 194, 195: Sanhedrin Kekawaka Speaker	 B B C
196: Shortoyork Tyson Witherell	C B D
197: Shortyork Witherell Updegraff	C D B
198, 199, 200: Shortyork Yorkville Witherell	 C D D

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
201, 202: Squawrock Witherell	 C D
203, 204: Talmage	 B
205, 206: Tyson Updegraff	 B B
207: Updegraff Sanhedrin	B B
208, 209: Updegraff Speaker Neuns	 B C C
210: Urban land	
211: Witherell Hopland Squawrock	D B C
212: Wohly Casabonne	B B
213: Wohly Casabonne Pardaloe	B B B
214: Xerochrepts	
215, 216: Xerochrepts Haploxeralfs Argixerolls	
217: Xerochrepts	
218: Xerochrepts Riverwash	
219: Yellowhound Kibesillah Ornbaun	B C B
220: Yellowhound Kibesillah	B C
221, 222, 223: Yokayo	 D

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
224: Yokayo Pinole Pinnobie	D B B
225, 226: Yorktree Hopland Woodin	 C B C
227, 228: Yorktree Yorkville	 C D
229, 230: Yorkville	 D
231: Yorkville Hopland	 D B
232, 233: Yorkville Squawrock Witherell	 D C D
234, 235: Yorktree Yorkville Squawrock	 C D C

TABLE IIC Sonoma County Soils Defined as Highly Erodible by the Natural Resource Conservation Service	
Soil Name	**Slope Class**
Diablo	>5%
Los Osos	>5%
Goldridge	>5%
Dibble	>5%
Suther	>5%
Steinbeck	>5%
Laughlin	>5%

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THE SOIL SURVEY INCLUDES INFORMATION ON EROSION HAZARD RATINGS AND OTHER FEATURES OF EACH SOIL TYPE

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: SOIL TYPES

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5. SLOPE STABILITY, EXISTING EROSION SITES AND SEDIMENT SOURCES

Background: Slope Stability, Existing Erosion Sites and Sediment Sources

Some landscapes have a high level of natural instability due to their geologic make-up. Depending upon the vegetative cover, unstable hillside areas can sometimes be outlined from aerial photographs. Landslides and lumpy looking hillsides pose a problem for any type of development and should receive special attention.

Erosion sites include gullies that are relatively large and often located in ephemeral creeks. Gullies are often the result of prior land uses, roads, vegetation clearing and changes in drainage by various developments. Stabilization and repair of existing erosion sites improves the condition of the property by reducing siltation and improving water quality.

Dirt roads and old skid trails may represent a major source of sediment into waterways. Roads are specifically assessed in Element V but are also included in the preliminary site evaluation as a sediment source.

SITE INVENTORY: SLOPE STABILITY / EXISTING EROSION SITES / SEDIMENT SOURCES

- ❑ Look over the site aerial for indications of old landslides and slope movements. Are there hillside slips or lumpy looking, unstable ground? Older aerial photos are often available through the NRCS, or the county, and can show the site at different time periods. Vegetation can mask the scars of old slides and slips. Long time residents may also have information. Landslide hazard maps are available from the California Department of Mines and Geology and the California Department of Forestry. Sonoma and Mendocino Counties also have landslide maps. These will indicate large landslide and landslide prone sites. Smaller slips and gullies may sometimes be repaired and integrated into a vineyard or road. However major unstable slopes should not be developed without a structural repair. If your site has unstable areas you will need to consult with an engineering geologist or civil engineer. The FFF program staff will assist with identifying these problems.

- ❑ Create an overlay on the site map and aerial photo and outline unstable slopes and any landslides for each area.

- ❑ On the copies of the aerial photo, delineate all gullies or small slips. On the farm plan, list observed and potential causes of the erosion such as road drainage, past overgrazing and soil compaction, past agricultural lands, prior timber harvesting, past grading activities, vegetation removal, or other causes.

- ❑ Delineate on the copies of the aerial photo, roads, skid roads, trails or other dirt or paved roads. Give each a name or number.

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6. NATURAL DRAINAGE FEATURES

Background: Natural Drainage Features

The entire network of creeks on the property from upstream to downstream are included in the farm plan. Perennial and seasonal creeks are evaluated in great detail in Element VI and a restoration/management program is developed for each. Ephemeral creeks are addressed in Elements II and III as well as in Element V under road crossings. The overall drainage network is delineated here for defining constraints on the property.

Blue and dashed lines on the topo map indicate perennial and seasonal creeks. Ephemeral streams occur in swales, on hillsides and only carry runoff in large storms. These are typically the first stream “channels” that can be defined below the ridgetop. Ephemeral streams are an essential part of the drainage network and, if disturbed, can quickly become gullies or landslides. The primary goals for ephemeral creeks are to repair existing erosion, revegetate to reduce the potential for erosion on the site, and retain a set of natural drainage channels that can serve as wildlife habitat corridors.

Identifying ephemeral waterways is crucial in evaluating natural drainage patterns. There are often many areas that only carry water during large storms and they may carry a great deal of water during that storm. Ephemeral streams are not indicated on topographic maps with blue lines. The topo map can be used to identify many ephemeral channels - a series of V or U shaped contour lines pointing upslope show a fold in the hillside that funnels water. On the aerial photograph identify all ephemeral creeks and outline each from the channel to the edge of vegetation or the topographic edge of the swale.

A site inspection during or just after a winter storm can be used to further delineate the ephemeral waterways on your site map. If the site is near to the headwaters of a creek, there may be numerous ephemeral streams. Carefully mark where the surface water flows on its way to the more obvious creek channel. Both the topography and surface signs of water movement, such as piles of leaves, sand deposits or scour left by surface flows, can give clues. Observations on the relative amount of flow in each creek and its condition can enhance the baseline information for the preliminary evaluation.

A review of neighboring lands can determine if there are sources of concentrated drainage that may enter your site in storms. For example, are there roads and culverts that feed into a channel? Are there plans for development such as housing or reservoirs? Are there conditions downstream that might create a backwater condition and affect the flows moving off of your site? Your site may, or may not, have any of these conditions, but a review is warranted.

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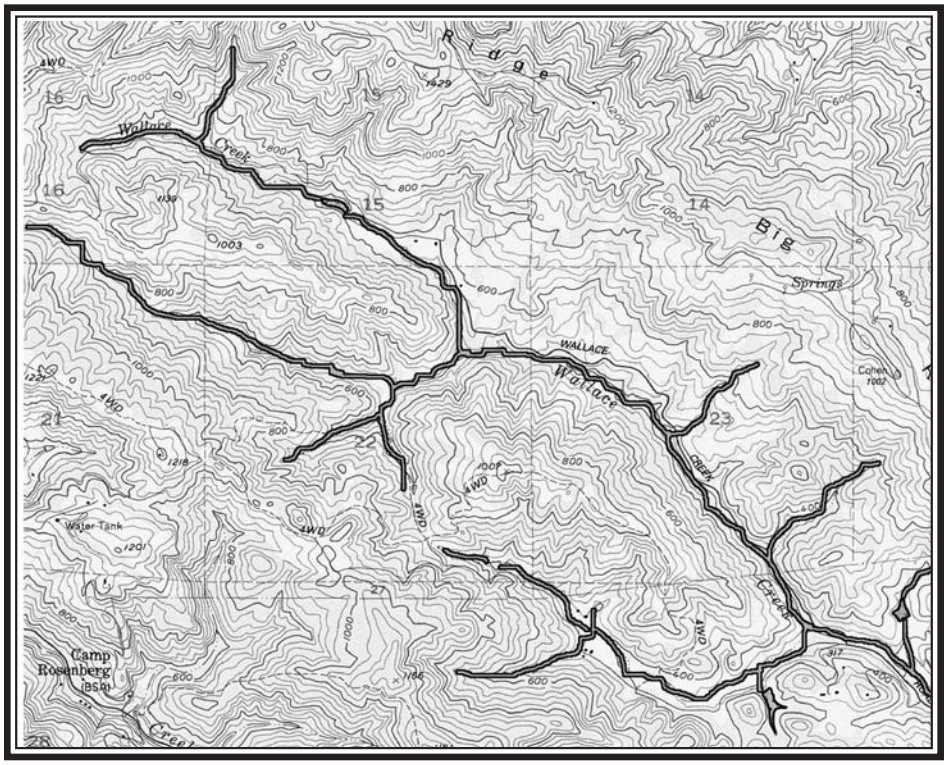
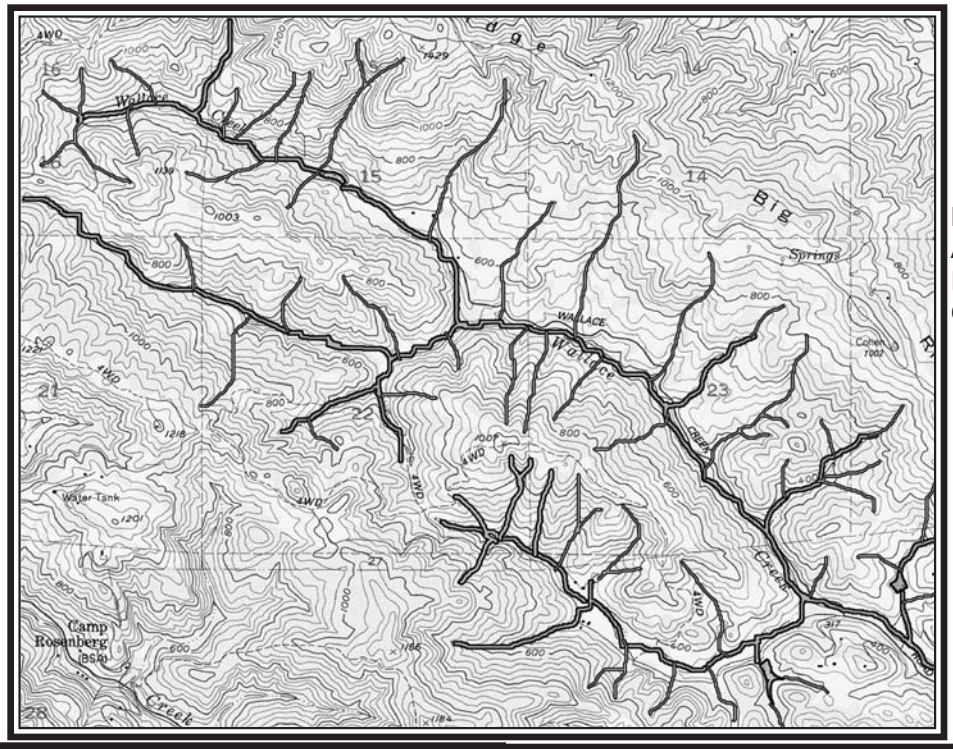


YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED



EPHEMERAL CREEKS AS WELL AS YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED

Fish Friendly Farming Environmental Certification Program	EXAMPLE OF TOPOGRAPHIC MAP WITH CREEKS OUTLINED

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Document the condition of the ephemeral creeks on the site. The condition of all the perennial and seasonal creeks is covered in Element VI. Is the ephemeral creek channel eroding? Erosion can come from the effects of upstream reservoirs, vegetative clearing, impervious surfaces or road runoff. Additionally, erosion can occur from downstream processes. For example, the main creek channel may have incised - its bed has dropped in elevation - this drop will move up into the ephemeral tributaries over time. This process will cause erosion and damage in the small channels and ephemeral streams. Look at the main channel nearest to the site. If it is alluvial (made up of sand, cobble and gravel) does it have steep high banks? Is it significantly deeper (10-15 ft) than the lands next to it? Perennial creeks also incise below on-channel reservoirs, or as a result of channel straightening or narrowing, and vegetation removal. The FFF program staff will assist with this evaluation.

The density and extent of vegetative cover in each channel should be recorded in the Farm Conservation Plan as well as erosion and other conditions.

Springs may not be obvious from an aerial photo, or map. They are often identified by the presence of water loving plants, such as willows or sedges in isolated clumps or hollows on the hillside amongst otherwise dry vegetation. In a dry year, the vegetation may be the only indication of the spring. Springs saturate soils, and if disturbed, can cause slips and slope failures.

SITE INVENTORY: NATURAL DRAINAGE FEATURES

- ❑ Indicate the blue line and dashed blue line streams on the topo map and the aerial. Give each creek a number, or a name. Take photographs of each seasonal and perennial creek.

- ❑ Indicate the ephemeral streams on the site map. Give each a number or name on the map. Take photos of each stream.

- ❑ Indicate any springs on the map/aerial photo.

- ❑ Fill out the Farm Conservation Plan on the condition of each perennial, seasonal, and ephemeral creek on the site. Indicate vegetation type and density, level of bank stabilization (riprap), level of erosion, and other features.

- ❑ List observations about site drainage from upstream conditions, downstream conditions, and other features.

7. VEGETATION / HABITAT / SPECIAL STATUS SPECIES

<u>Background: Vegetation / Habitat / Special Status Species</u>

The type, density and condition of the vegetation on the property, in combination with management practices, determine the wildlife species that may use the site and the overall habitat value of the property. The presence of a certain vegetation type does not necessarily indicate its value as wildlife habitat. The level of site disturbance, size of vegetation areas, surrounding land uses, the connection, or lack of connection, between patches of vegetation, the availability of certain food plants, nesting, roosting and burrowing areas as well as other features determine the number and diversity of wildlife in an area.

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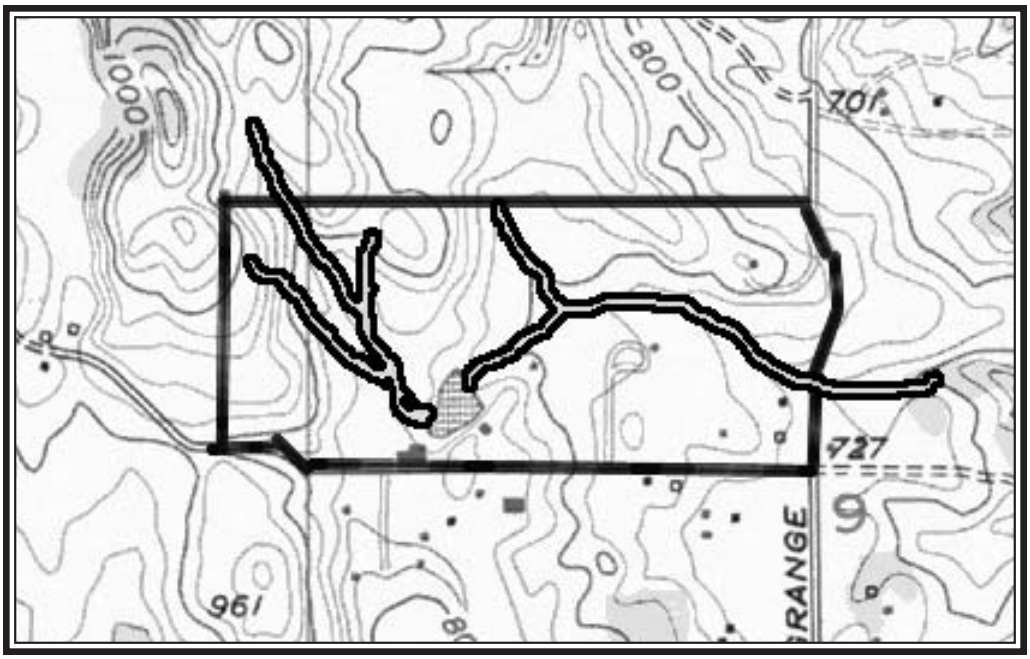
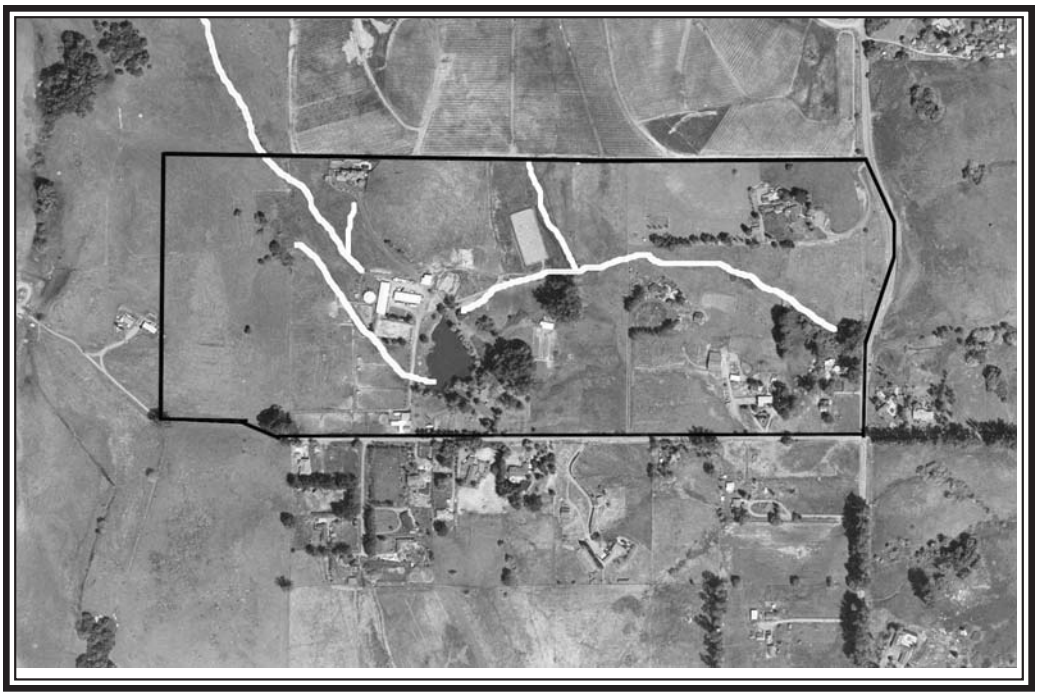


EXAMPLE OF TOPOGRAPHIC MAP AND
AERIAL PHOTO WITH STREAMS DELINEATED



Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: STREAM DELINEATION

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This preliminary evaluation allows for delineation of various vegetation types. Some vegetation types such as vernal pools, wetlands, and heritage oak trees are considered rare and more sensitive to change. Additionally, vegetation of certain types such as coniferous forest that is relatively undisturbed may be considered sensitive habitat. Finally, vegetation types, in addition to other site factors, give an indication of the potential for listed, threatened, or endangered, plant or animal species.

There will be areas of the site where vegetation should not be removed and others where revegetation or other actions can compensate for vegetation changes. For removal of some plants – vernal pools, wetlands, riparian corridors, oaks and large areas of coniferous forest, special permits and mitigations are required. This preliminary delineation will assist in determining site design.

SITE INVENTORY: VEGETATION / HABITAT / SPECIAL STATUS SPECIES

- ❑ Outline the different vegetation areas on the site aerial. The CalVeg GIS layer may be useful to review but will likely not be detailed enough for site evaluations. Vegetation types are broad groupings of plants such as:
  - Coniferous forest – Douglas fir, redwoods, pine
  - Woodland forest/mixed shrub – oak, madrone, bay laurel intermixed with chaparral and other shrub species
  - Chaparral – manzanita, chemise, buckbrush and other species
  - Grassland including grazed pasture
  - Oak/grassland – grassland with scattered oaks
  - Wetlands including springs, natural seasonal pools, marshes
  - Riparian or streamside corridors – willows, cottonwoods and other deciduous species
  - Ephemeral creeks/swale corridors – riparian trees, oak woodland or chaparral lining swales and ephemeral creek corridors
  - ▪ For oaks and coniferous forest measure the trees using a dbh tape which converts circumference to diameter. The FFF program staff will assist with this task. Record these measurements in your Farm Conservation Plan.
  - ▪ Check the California Natural Diversity Database at www.dfg.ca.gov/whdab/html/cnddb.html for a map of the area with recorded occurrences of listed species, candidate species, certain plant communities, and species of concern on the property or in the vicinity. This information is recorded on a 1:24,000 mapping base, the same as a topo map. Tables II D and E list the special status species in Sonoma and Mendocino Counties. A survey for rare species may be needed, depending on the site.

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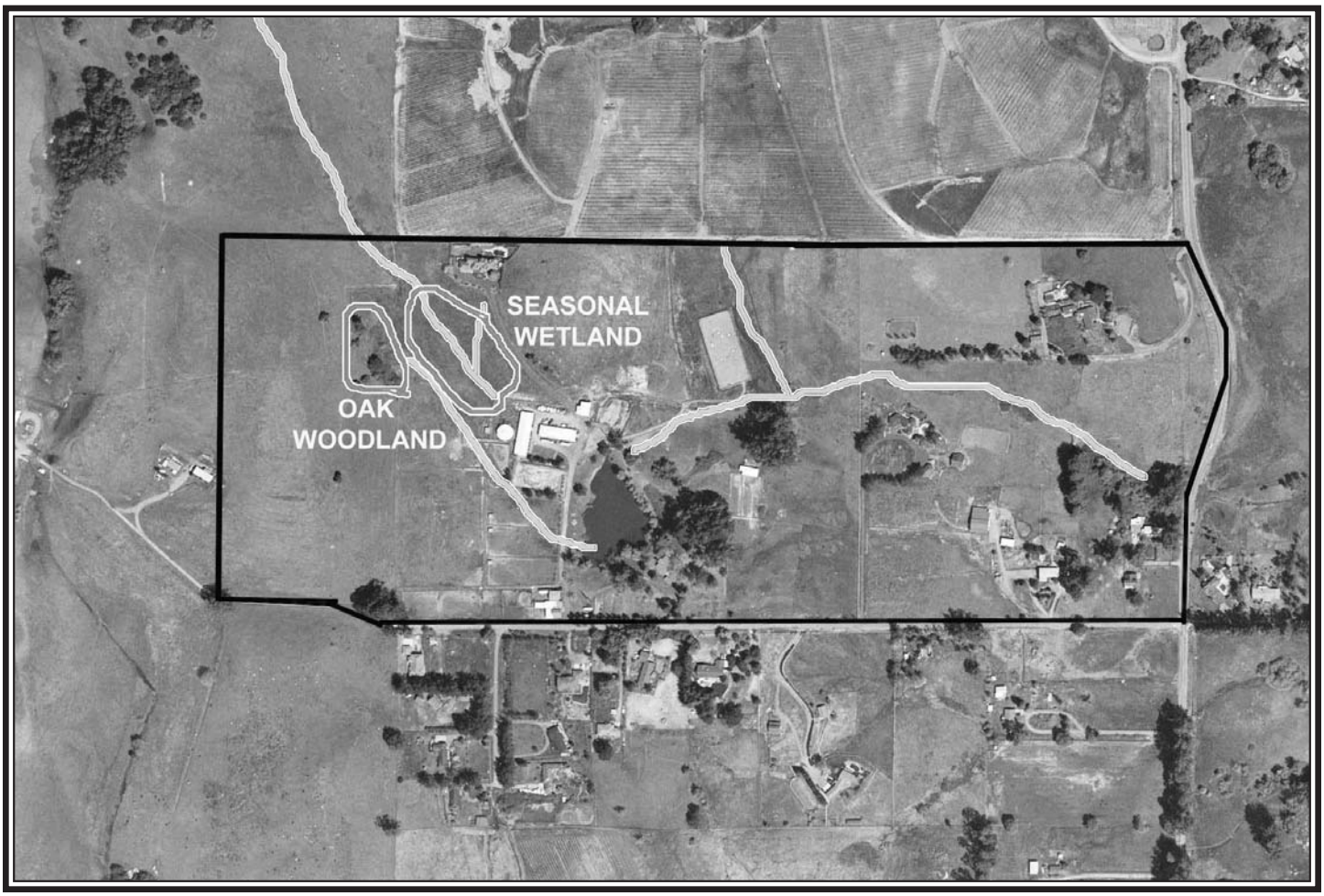

EXAMPLE OF AERIAL MAP WITH VEGETATION DELINEATED

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: VEGETATION DELINEATED

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TABLE IID California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Sonoma County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Agrostis blasdalei	Blasdale's bent grass	Species of Concern	None	--	1B
Allium peninsulare var franciscanum	Franciscan onion	Species of Concern	None	--	1B
Allopecurus aequalis var sonomensis	Sonoma alopecurus	Endangered	None	--	1B
Amorpha californica var napensis	Napa false indigo	Species of Concern	None	--	1B
Arbronia umbellate ssp breviflora	Pink sand-verbena	Species of Concern	None	--	1B
Arctostaphylos bakeri ssp bakeri	Baker's manzanita	Species of Concern	Rare	--	1B
Arctostaphylos manzanita ssp elegans	Konocti manzanita	None	None	--	1B
Arctostaphylos bakeri ssp sublaevis	The cedars manzanita	Species of Concern	Rare	--	1B
Arctostaphylos canescens ssp sonomensis	Sonoma manzanita	Species of Concern	None	--	1B
Arctostaphylos densiflora	Vine hill manzanita	Species of Concern	None	--	1B
Arctostaphylos stanfordiana ssp decumbens	Rincon manzanita	Species of Concern	None	--	1B
Astragalus clarianus	Clara hunt's milk-vetch	Endangered	Threatened	--	1B
Astragalus tener var tener	Alkali milk-vetch	None	None	--	1B

* Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

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TABLE IID (cont.)
California Department of Fish and Game
Natural Diversity Database
Special Status Plants, Animals and Natural Communities of Sonoma County

Scientific Name	Common Name	STATUS			
		Federal	California	CDFG	CNPS
Mammals					
Sorex ornatus sinuosus	Suisun shrew	Species of Concern	None	Species of Concern	--
Natural Communities					
Coastal and valley freshwater marsh	N/A	None	None	--	--
Coastal brackish marsh	N/A	None	None	--	--
Northern coastal salt marsh	N/A	None	None	--	--
Northern hardpan vernal pool	N/A	None	None	--	--
Northern vernal pool	N/A	None	None	--	--

* Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

TABLE IIE
California Department of Fish and Game
Natural Diversity Database
Special Status Plants, Animals and Natural Communities of Mendocino County

Scientific Name	Common Name	STATUS*			
		Federal	California	CDFG	CNPS
Plants					
Abronia umbellate ssp breviflora	Pink sand verbena	Species of Concern	None	--	1B
Agrostis blasdalei	Blasdale's bent grass	Species of Concern	None	--	1B
Alisma gramineum	Narrow-leaved water-plantain	None	None	--	2
Arabis macdonaldiana	McDonald's rock cress	Endangered	Endangered	--	1B
Arctostaphylos canescens ssp sonomensis	Sonoma manzanita	Species of Concern	None	--	1B
Arctostaphylos mendocinoensis	Pygmy manzanita	None	None	--	1B

*Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Arctostaphylos stanfordiana ssp raichei	Raiche's manzanita	Species of Concern	None	--	1B
Astragalus agnicidus	Humbolt milk-vetch	Species of Concern	Endangered	--	1B
Blennosperma nanum var robustum	Point reyes blennosperma	Endangered	Endangered	--	1B
Boschniakia hookeri	Small groundcone	None	None	--	2
Calamagrostis crassiglumis	Thurber's reed grass	Species of Concern	None	--	2
Calystegia atriplicifolia ssp buttensis	Butte county morning-glory	Species of Concern	None	--	1B
Campanula californica	Swamp marebell	Species of Concern	None	--	1B
Carex californica	California sedge	None	None	--	2
Carex livida	Livid sedge	Species of Concern	None	--	1A
Carex lyngbyei	Lyngbye's sedge	None	None	--	2
Carex saliniformis	Deceiving sedge	Species of Concern	None	--	1B
Carex viridula var viridula	Green sedge	None	None	--	2
Castilleja affinis ssp litoralis	Oregon coast Indian paintbrush	None	None	--	2
Castilleja mendocinensis	Mendocino coast indian paintbrush	Species of Concern	None	--	1B
Ceanothus confusus	Rincon ridge ceanothus	Species of Concern	None	--	1B
Chorizanthe howellii	Howell's spineflower	Endangered	Threatened	--	1B
Collinsia corymbosa	Round-headed Chinese houses	Species of Concern	None	--	1B
Cryptantha clevelandii var dissita	Serpentine cryptantha	None	None	--	1B
Cupressus goveniana ssp pigmaea	Pygmy cypress	Species of Concern	None	--	1B
Epilobium nivium	Snow mountain willowherb	Species of Concern	None	--	1B

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Epilobium oreganum	Oregon fireweed	Species of Concern	None	--	1B
Erigeron supplex	Supple daisy	Species of Concern	None	--	1B
Eriogonum kelloggii	Kellogg's buckwheat	Candidate	Endangered	--	1B
Eryngium constancei	Loch lomond button-celery	Endangered	Endangered	--	1B
Erysimum menziesii ssp mensiesii	Menzie's wallflower	Endangered	Endangered	--	1B
Erythronium revolutum	Coast fawn lily	None	None	--	2
Gentiana setigera	Mendocino gentian	Species of Concern	Threatened	--	1B
Glyceria grandis	American manna grass	None	None	--	2
Hesperolinon adenophyllum	Glandular western flax	Species of Concern	None	--	1B
Horkelia bolanderi	Bolander's horkelia	Species of Concern	None	--	1B
Horkelia marinensis	Point reyes horkelia	Species of Concern	None	--	1B
Horkelia tenuiloba	Thin-lobed horkelia	Species of Concern	None	--	1B
Howellia aquatilis	Water howellia	Threatened	None	--	2
Lasthenia burkei	Burke's goldfields	Endangered	Endangered	--	1B
Lasthenia conjugens	Contra Costa goldfields	Endangered	None	--	1B
Lewisia stebbinsii	Stebbins's lewisia	Species of Concern	None	--	1B
Lilium martimum	Coast lily	Species of Concern	None	--	1B
Limnanthes bakeri	Baker's meadowfoam	Endangered	Endangered	--	1B
Lupinus antoninus	Anthony peak lupine	Species of Concern	None	--	1B

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Lupinus milo-bakeri	Milo baker's lupine	Species of Concern	Threatened	--	1B
Malacothamnus mendocinensis	Mendocino bush mallow	Species of Concern	None	--	1A
Microseris borealis	Northern microseris	None	None	--	2
Mitella caulescens	Leafy-stemmed mitrewort	None	None	--	2
Monardella villosa ssp globosa	Robust monardella	Species of Concern	None	--	1B
Navarretia leucocephala ssp bakeri	Baker's navarretia	None	None	--	1B
Ophioglossum pusillum	Northern adder's-tongue	Species of Concern	None	--	2
Phacelia insularis var continentis	North coast phacelia	Species of Concern	None	--	1B
Pinus contorta sspbolanderi	Bolander's beach pine	Species of Concern	None	--	1B
Plagiobothrys lithocaryus	Mayacamas popcorn-flower	Species of Concern	None	--	1A
Pleuropogon hooverianus	North coast semaphore grass	Species of Concern	Threatened	--	1B
Puccinellia pumila	Dwarf alkali grass	None	None	--	2
Sanguisorba officinalis	Great burnet	None	None	--	2
Sedum eastwoodiae	Read mountain stonecrop	Candidate	None	--	1B
Sidalcea calycosa ssp rhizomata	Point reyes checkerbloom	Species of Concern	None	--	1B
Sidalcea malachroides	Maple-leaved checkerbloom	Species of Concern	None	--	1B
Sidalcea oregana ssp hydrophila	Marsh checkerbloom	None	None	--	1B
Tracyina rostrata	Beaked tracyina	Species of Concern	None	--	1B
Viola palustris	Marsh violet	None	None	--	2

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Butterflies					
Lycaeides argyrognomon lotis	Lotis blue butterfly	Endangered	None	--	--
Speyeria zerene behrensii	Behren's silverspot butterfly	Endangered	None	--	--
Amphibians					
Ascaphus truei	Tailed frog	Species of Concern	None	Species of Concern	--
Plethodon elongates	Del Norte salamander	Species of Concern	None	Species of Concern	--
Rana aurora draytonii	California red-legged frog	Threatened	None	Species of Concern	--
Rana boylii	Foothill yellow-legged frog	Species of Concern	None	Species of Concern	--
Rhyacotriton variegates	Southern torrent salamander	Species of Concern	None	Species of Concern	--
Fish					
Eucyclogobius newberryi	Tidewater goby	Endangered	None	Species of Concern	--
Hysterocarpus traski pomo	Russian River tule perch	Species of Concern	None	Species of Concern	--
Lavinia symmetricus navarroensis	Navarro roach	None	None	Species of Concern	--
Lavinia symmetricus parvipinnis	Gualala roach	Species of Concern	None	Species of Concern	--
Oncorhyncus kisutch	Coho salmon	Threatened	Endangered	--	--
Oncorhyncus mykiss	Steelhead trout	Threatened	Threatened	--	--
Oncorhyncus tshawytscha	Chinook salmon	--	--	--	--

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Reptiles					
Clemmys marmorata marmorata	Northwestern pond turtle	Species of Concern	None	Species of Concern	--
Birds					
Accipiter gentiles	Northern goshawk	Species of Concern	None	Species of Concern	--
Agelaius tricolor	Tricolored blackbird	Species of Concern	None	Species of Concern	--
Amphispiza belli belli	Bell's sage sparrow	Species of Concern	None	Species of Concern	--
Charadrius alexandrinus nivosus	Western snowy plover	Threatened	None	Species of Concern	--
Dendroica petechia brewsteri	Yellow warbler	None	None	Species of Concern	--
Fratercula cirrhata	Tufted puffin	None	None	Species of Concern	--
Haliaeetus leucocephalus (nesting & wintering)	Bald eagle	Threatened	Endangered	--	--
Icteria virens	Yellow-breasted sparrow	Species of Concern	None	Species of Concern	--
Pandion haliaetus	Osprey	None	None	Species of Concern	--
Phalacrocorax auritus	Double-crested cormorant	None	None	Species of Concern	--
Progne subis (nesting)	Purple martin	None	None	Species of Concern	--
Strix occidentalis caurina	Northern spotted owl	Threatened	None	Species of Concern	--
Mammals					
Aplodontia rufa nigra	Point Arena mountain beaver	Endangered	None	Species of Concern	--
Arborimus pomo	Red tree vole	Species of Concern	None	Species of Concern	--

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Mammals					
Corynorhinus townsendii pallescens	Pale big-eared bat	Species of Concern	None	Species of Concern	--
Corynorhinus townsendii townsendii	Townsend's western big-eared bat	Species of Concern	None	Species of Concern	--
Martes pennanti pacifica	Pacific fisher	Species of Concern	None	Species of Concern	--
Gulo gulo luteus	California wolverine	Species of Concern	Threatened	--	--
Natural Communities					
Coastal and valley freshwater marsh	N/A	None	None	--	--
Coastal brackish marsh	N/A	None	None	--	--
Coastal terrace prairie	N/A	None	None	--	--
Fen	N/A	None	None	--	--
Grand fir forest	N/A	None	None	--	--
Northern coastal bluff scrub	N/A	None	None	--	--
Northern coastal salt marsh	N/A	None	None	--	--
Sphagnum bog	N/A	None	None	--	--
Upland Douglas fir forest	N/A	None	None	--	--
Valley oak woodland	N/A	None	None	--	--

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- ❑ Indicate in the Farm Conservation Plan the past use of the property including grazing history, logging, mining, residential and agricultural uses. Estimate when these uses occurred, for how long and at what intensity. For example, if the site has been clear-cut and then heavily grazed up to three years ago, include this information. Prior and recent land uses contribute to the current distribution of vegetation. Changing land uses can result in regeneration of native plants and identification of site areas for revegetation.

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8. CULTURAL AND HISTORICAL SITES

Background: Cultural and Historic Sites

There are a number of steps to document cultural and historical sites including a literature review for previously recorded sites, a field inventory and, if archaeological resources or historic sites are found, an impact mitigation plan must be prepared. Additional information on cultural and historical sites and procedures is available at: www.ohp.parks.ca.gov and http://ceres.ca.gov.

SITE INVENTORY: CULTURAL AND HISTORIC SITES

- ❑ A licensed archaeologist must complete the survey. The survey should focus on those areas of the site where disturbance is likely.

9. OTHER SITE FEATURES

There may be other features of the site that need to be evaluated both for site development. These might include:

- ❑ Locations of buildings, on-site landfills and any areas of the site where hazardous material could occur, such as pesticides or leaking diesel or gasoline tanks.
- ❑ Existing reservoirs and wells, groundwater and surface water resources
- ❑ Utility corridors
- ❑ Access routes to public roads
- ❑ Mines and quarries
- ❑ Recreational sites

10. USING THE PRELIMINARY EVALUATION: DETERMINING THE PROPOSED NEW VINEYARD AREAS

Slopes

- ❑ Using the slope measurements, delineate the areas of the site of less than 30% slope. Within these general areas there may be areas of less than one acre with higher slopes.

Creek Channels

- ❑ Once the slope areas available for vineyard development are delineated the natural drainage features need to be factored in. Changes to the drainage network as part of the vineyard development should be minimized.

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Element VI contains the detailed evaluation procedure and science-based protocols for restoration plans on perennial and seasonal creeks. This element includes the Russian, Gualala and Navarro River watersheds and ecological "sizing" requirements for stream corridors as well as vegetative restoration methods. New vineyards adjacent to perennial and seasonal creeks should complete this element and there may be a reduction in the potential vineyard footprint based on this analysis.

For ephemeral creeks the setback should extend from the topographic edge or vegetative edge of the hillside swale containing the creek or the edge of the creek channel or vegetative corridor. The FFF program staff can assist with these determinations on the site.

- ❑ The potential stream setbacks should be outlined on the potential vineyard areas to determine the most likely footprint.

Vegetation

- ❑ Some vegetation removal is required for most projects. Clearance of coniferous forest can require permits from the California Department of Forestry. Filling of wetlands, disturbance of listed species, or their habitats, will require mitigation. Review the locations of any of these features within the proposed vineyard areas and consider methods to avoid these features. If avoidance renders the project unworkable delineate on-site areas for mitigation of wetland, or listed species. A CEQA document will likely be needed for projects with major tree removal, effects to wetlands or listed species habitat. Additionally, major conversions of timber to vineyard will need to meet the BMP limiting increases in peak flow discharge (page 52).

- ❑ If there are large oaks scattered over the potential vineyard areas, retention should be considered. The oak should have a 15-foot buffer, left undeveloped, measured from the canopy drip line. If the oaks make portions of the project unworkable, compromise by removing some of the oaks and choosing an area on-site for a replanting area. A single oak surrounded by vineyard has a lower value to wildlife than contiguous oaks making up oak woodland habitat on another part of the property.

- ❑ Other types of vegetation such as grassland, chaparral shrub, and oak woodland shrub are not necessarily rare and depending upon the condition of the property, may be degraded from years of grazing. Clearing of this vegetation within the proposed vineyard areas coupled with replanting and enhancement of other areas outside the footprint can result in an overall increase in wildlife values and little to no contribution to cumulative effects in the watershed.

Cultural Resources

- ❑ The recommendations of the archaeological survey if applicable to the proposed vineyard areas should be incorporated.

Erosion Sites

- ❑ Existing erosion sites, if part of the proposed vineyard areas, should be repaired (see page 64) as part of the vineyard development or if outside the vineyard area included in the Farm Conservation Plan for repair.

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Summary

- ❑ Using the site inventory and preliminary evaluations, the vineyard areas can be determined. Complete the summary table in the Farm Conservation Plan.

  The proposed vineyard areas defined through this process should have a minimal level of environmental impact. The summary table of potential impacts and mitigation needs provides an outline of measures to reduce environmental impacts. Now the vineyards can be designed to allow for a minimum of effects and other areas of the site can be reviewed for repair and restoration actions.

11. DESIGNING FOR SOIL CONSERVATION AND EROSION CONTROL

Background: Types of Erosion and Vineyard Layout

Soil erosion is caused by the ability of raindrops, flowing water and wind to move soil particles. Although erosion is natural, human uses of land often increase the rate of soil erosion and increase the amount of sediment moving into creek and river channels.

There are several types of erosion. Sheet erosion involves the loss of a thin layer of topsoil across the overall hillslope and is also called sheetwash. This type of erosion is often not noticeable, but is the largest cause of soil loss. Rain striking bare unvegetated land causes the surface inch of soil to become mobile and particle by particle the soil flows off the land. This type of soil erosion is typical with farmland if careful soil conservation is not practiced and soil productivity will be lost over time. Slope plays a major factor in sheet erosion, particularly the length of the slope. Vegetation has a major effect in reducing sheet erosion.

Rill and gully erosion is easier to observe and represents the loss of soil in one location, not layer by layer as in sheet erosion. Rills and gullies usually occur due to concentration of water flow. Flows become concentrated through changes made to drainage patterns on a hillside such as roads, soil compaction, and vegetation removal. This type of erosion is prevalent when swales and ephemeral streams are cleared and are then subject to concentrated flows as a part of the natural drainage system but without protective vegetation. Gullies are expensive to repair and can be difficult to control once started. Careful consideration before vegetation clearing, or road construction, is the best way to avoid creating these problems. Rapid response to gully formation can repair small problems before they get huge.

Erosion is measured in the loss of tons of soil per year. One ton of soil loss per acre is a thickness of 2 to 3 sheets of paper. Sheet and rill erosion rates reach 8 to 15 tons or more of soil loss per acre per year.

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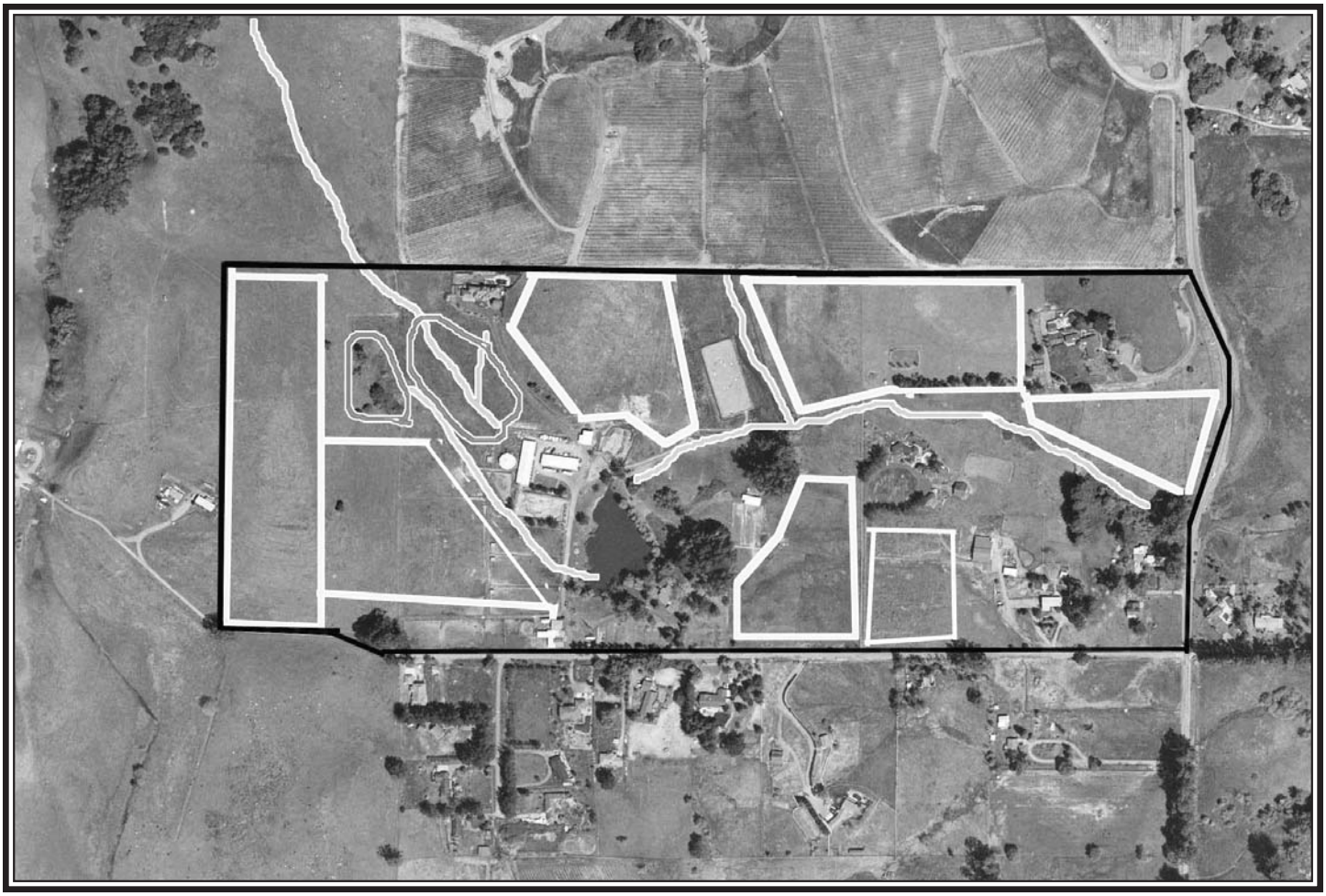

EXAMPLE OF AERIAL MAP WITH POTENTIAL VINEYARD AREAS DELINEATED IN WHITE BOXES

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Slope has an enormous effect on soil erosion, drainage, and land use. Slope magnifies the effects of rainwater runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage.

The vineyard site design should address grape production as well as soil conservation to keep the vineyard productive over the long term. The design should incorporate soil conservation measures including: retention of natural drainage features including ephemeral streams/swales, all year round and seasonal streams; evaluation of the site in small enough drainage units to design a drainage system with a large number of inlets and outlets to avoid concentration of flow and erosion; and avoiding increases in stormwater volumes. Use of mulch, cover crops and other practices to protect soil. Soil protection should be a focus and a goal at all times in the development phase of the vineyard and into the management of the vineyard floor, all roads and avenues.

The Sonoma County Hillside Vineyard Ordinance defines two types of sites that require a permit:

"Level I authorized vineyard planting… has either highly erodible soils and an average acreage slope of less than ten percent (10%), or less erodible soils with an average slope of less than fifteen percent (15%)." Development of Level I new vineyards requires the filing of a notice with the Agricultural Commissioner's office.

"Level II authorized vineyard planting means any vineyard planting… which has either highly erodible soils and an average slope of ten percent (10%) to not more than fifteen percent (15%), or less erodible soils with an average slope of less than thirty percent (30%)."

"Level III authorized vineyard planting means any vineyard planting… which has either highly erodible soils and an average slope of more than fifteen percent (15%) to not more than fifty percent (50%), or less erodible soils and an average slope of more than thirty percent (30%) to not more than fifty percent (50%)."

The ordinance limits vineyard development on slopes of more than 50% to no more than 7.5% of the total vineyard site.

For development of Level II and III vineyards an erosion and sediment control plan must be prepared by a civil engineer approved by the County and the plan must be approved by the Agricultural Commissioner.

The Sonoma County Ordinance requires a level of site review and engineering to reduce soil erosion. The ordinance allows for development of slopes in excess of 30% and for an analytical process of "averaging" the measurement of slopes. Neither of these practices is used in the Fish Friendly Farming program. New vineyards are not recommended on slopes in excess of 30% with slopes measured in actual, not average, slope in order to achieve a high level of protection for water quality and habitats.

Mendocino County currently (Jan 2007) does not have a vineyard or hillside ordinance.

Vineyard Layout

There are several types of vineyard layout – cross slope, on the contour and up and over the hill. The decision of which layout is best for a site is primarily a function of the percent

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slope, the slope length, aspect and the soil type. The vineyard rows must be laid out to be safely accessible to farm equipment working on a sloped hillside. Most tractors cannot operate on slopes over 25% without the danger of rollovers. Therefore the site must be terraced to create a flat and safe surface for the tractor to operate, or the vineyard is laid out up and down the contour if this layout provides for safer operations. In addition, the tractor must also be able to turnaround at the end of each vineyard road without incurring a safety problem, or slipping down the hillside.

Another effect of steep slopes is the reduction in the number of vines that can be planted. Terracing steeper slopes requires more land for the terrace benches and will accommodate fewer vines per acre. Up and over the hill layout may allow for a greater number of vines on a moderate slope than terracing the same site.

With any vineyard layout for a site, the drainage system must include an evaluation of slope length and include adequate numbers of inlets and stormwater diversions to avoid concentration of flow and erosion of the slope. In terraces the bench can be cut to accommodate interception of flow into inlets and underground pipes at frequent intervals.

For up and over the hill layout, frequent diversions or inlets across the vineyard slope may be used to break up flow that will move down the vine rows and middles causing rill or gully erosion. In all cases cover crops over the entire vineyard floor (including all portions of the terrace – both bench flat and face) are needed. Even if the vine row is stripped sprayed or cleared, some mulch should be left particularly for up and over the hill layout. Otherwise the vine row can become an avenue of flow and erode soil from around the vines.

APPLYING SITE DESIGN BMPS: SOIL CONSERVATION AND EROSION CONTROL

- The Sonoma County Hillside Vineyard Ordinance requires an Erosion and Sediment Control Plan for many new vineyards. The ordinance requires that a civil engineer, approved by the County, prepare the erosion control plan and that the erosion control plan should include:
    - Narrative and graphic information describing the project
    - The name of the preparer or civil engineer
    - A description of the site including topography, soil types, vegetation, streams, lakes, reservoirs, roads, homes and existing drainage improvements. Identification of areas on the vineyard site that may have significantly more or less potential for erosion.
    - A summary of temporary and permanent measures to protect disturbed areas and manage storm water runoff on the vineyard site and minimize the discharge of sediment from the vineyard site. A schedule for implementation, maintenance and upkeep of the temporary and permanent measures and provisions for responsibility of maintenance

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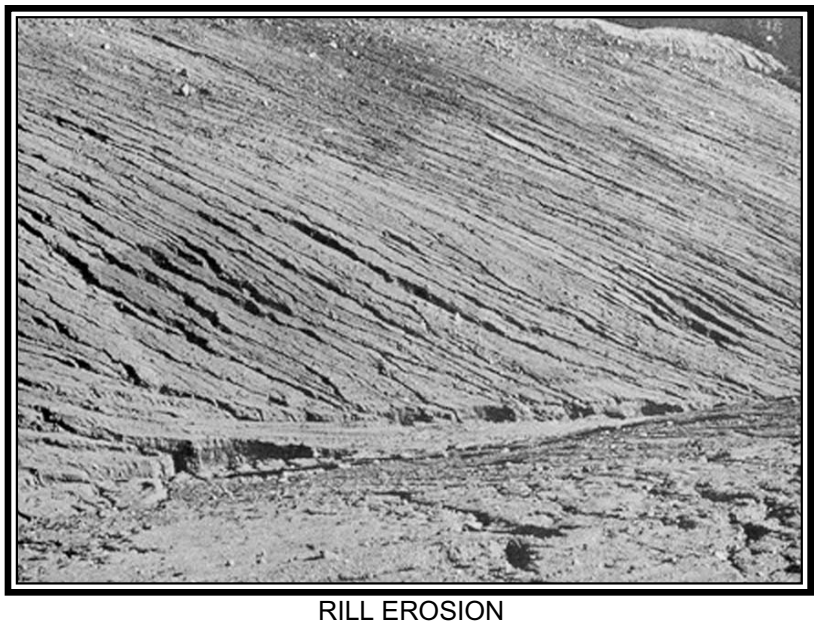
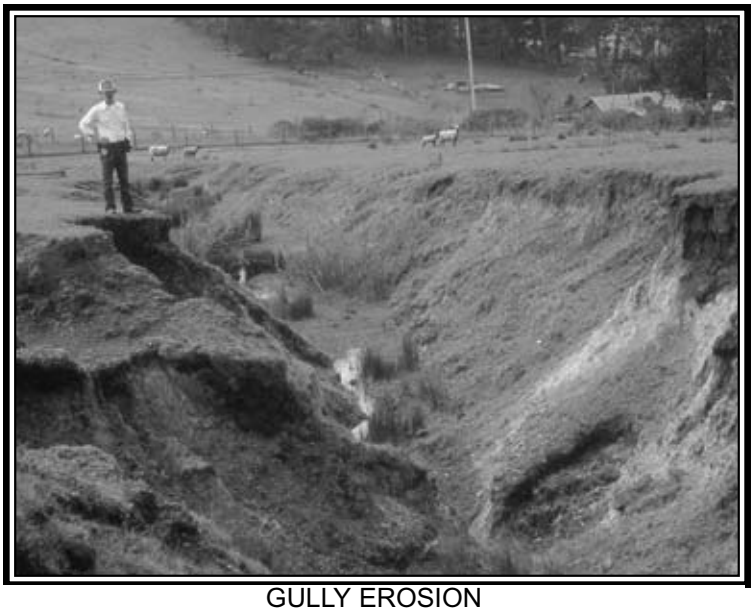
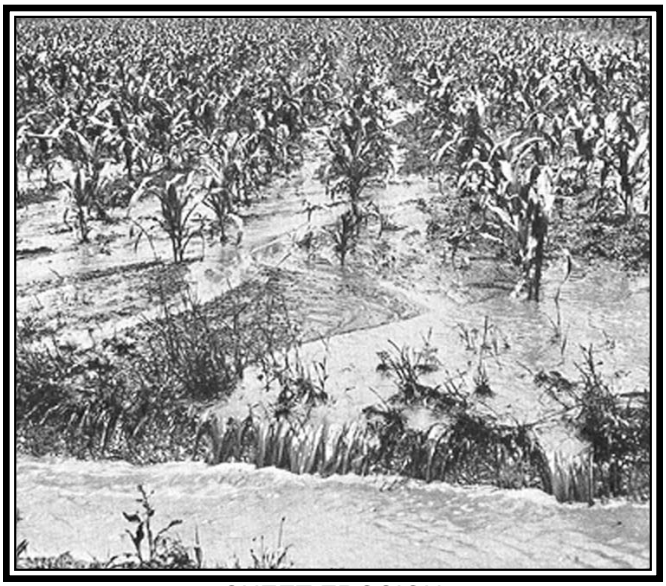
RAINSTRIKE OR SHEET EROSION



RILL EROSION



GULLY EROSION



SHEET EROSION

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LEANING TREES CAN BE AN INDICATION OF A MOVING AND UNSTABLE SLOPE

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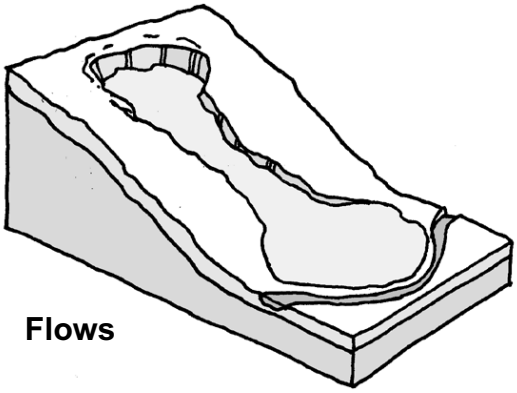
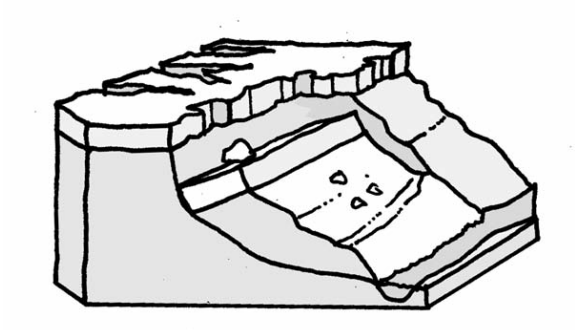
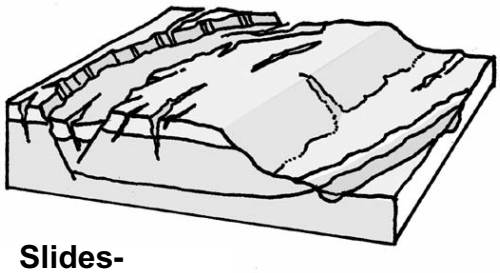


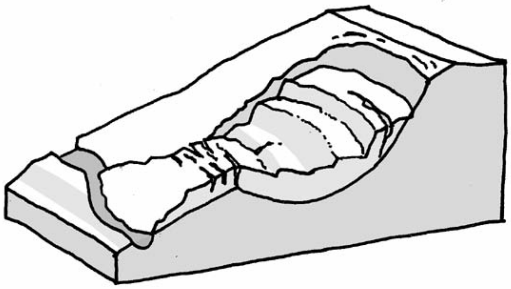
Flows



Slides-Rotational



Slides-Translational



Complex-Slump-Earth Flow

Fish Friendly Farming Environmental Certification Program	TYPES OF LANDSLIDES

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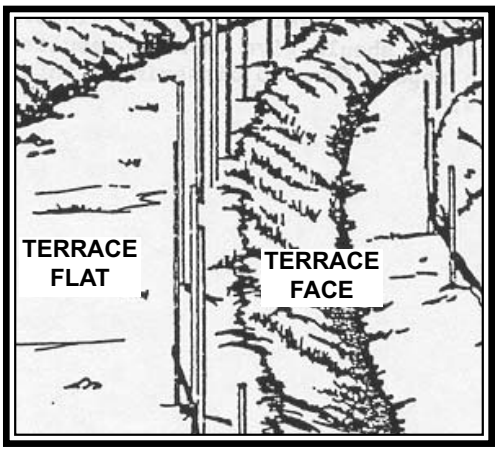
CROSS SLOPE OR WITH THE CONTOUR LAYOUT

UP AND OVER THE HILL LAYOUT



TERRACE OR BENCH LAYOUT

Fish Friendly Farming Environmental Certification Program	VINEYARD LAYOUT

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- ❑ A location map of the vineyard site

- ❑ A topographic map of the site at a scale of 1''=200' showing all the details of the project including vineyard layout and boundaries, existing and finished contours, soil types, stormwater flow lines, creeks and setbacks, vegetation, buildings, wells and utilities, proposed soil protection measures, proposed stormwater management and sediment control measures and calculations for each measure, construction details, drainage area of the stormwater management system

The Fish Friendly Farming Program recommends that an Erosion Control Plan be completed for all new vineyards or areas of vineyards over 5% slope and that in addition to the above features the Erosion Control Plan include:

- ❑ An analysis of sheet erosion from the proposed vineyard using the Universal Soil Loss Equation (USLE) included in Appendix 1 should be completed if not done as part of the Erosion Control Plan. The USLE evaluates the potential for sheet erosion of a particular site with a set of proposed practices. The USLE predicts soil loss over a relatively small area such as a vineyard site by evaluation of rainfall conditions (R), the susceptibility of soil to erosion (K), the length and steepness of slope (LS), the erodibility of soil under various cover cropping scenarios (C), and the effectiveness of the vineyard layout (contour, for example) on erosion control (P).

  The predicted sheet erosion or soil loss is then compared to the T value or soil loss tolerance for specific soil types. Acceptable T values are relatively low at 2 to 4 tons per acre per year. Erosion Control Plans are reviewed to assure they include a variety of practices such as row alignment, drainage improvements, cover crops and tillage, sediment basins and grassed waterways to attain the acceptable soil loss tolerance for sheet erosion.

  The Erosion Control Plan should also review the potential for concentrated flows and rill and gully erosion that is discussed in the following sections. The plan also includes temporary erosion control measures for assuring that any soil loss from the site is contained.

- ❑ If the site appears to have evidence of unstable slopes, a geologist should be hired to carefully evaluate the site before developing a vineyard. Unless the hillside can be completely stabilized, the vineyard could be lost. Smaller slips and erosion sites should be repaired as part of the site development.

- ❑ Attach the Erosion Control Plan to the Farm Plan and fill out the Farm Plan regarding the project features.

- ❑ Using the detailed slope measurements, evaluate revising the proposed vineyard footprint to avoid developing areas over 30% slope.

- ❑ All slopes over 5% require the vineyard be managed using soil conservation BMPs (see Element III).

- ❑ The layout of the vineyard in relationship to slopes should provide for tractor safety, grape production and maximum soil protection.

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- When considering the use of terraces and benches the need for soil conservation requires cover crop on the terrace flat and the berm, or face, of the terrace. Additionally the terrace flats can be easily damaged if tilled when soil is wet. These ruts can create changes in drainage and localized failures in the terrace.

- Filter strips are a strip of dense grass or vegetation between the vineyard slope and waterways. The vineyard design should incorporate filter strips or allow for perimeter vineyard roads to be managed every winter as filter strips.

12. DRAINAGE IMPROVEMENTS

Background: Drainage Improvements

Once the natural drainage pattern is delineated, the need for drainage improvements in the proposed new vineyard areas can be determined. It is important that stormwater be carefully managed to avoid creating concentrated flow that can cause both soil erosion and slope failures. In some hillside vineyards stormwater is routed through diversions and underground pipes. The concept in using diversions and underground systems is to reduce the potential for concentrated surface flows by reducing the distance (slope length) over which the water flows and diverting it into a drainage system. Reducing soil erosion is necessary to protect water quality, fish habitat and the viability of the vineyard.

Benched and terraced vineyards are designed to divert flow from the bench into a series of drop inlets and underground pipes. This system creates numerous points of diversion along the slope significantly reducing the concentration of flow on the slope. There are other types of drainage systems used in terraced vineyards as well. A diversion ditch at the top of a hillside vineyard may be used to limit the volume of water flowing through the site and move a portion of the stormwater into a creek or waterway. In general, the steeper and longer the slope of the vineyard, the greater the speed of the runoff produced and the more diversion points required.

The preferred system for hillside vineyards is to retain natural swales and ephemeral streams to the greatest degree possible. The swale is managed for dense vegetative cover such as native woodland, chaparral, or perennial grassland with some structural components, such as rock check dams, if needed for grade stabilization control. In the case of sites with heavily vegetated oak and woodland swales, dividing the site into distinct blocks of vineyard and retaining the swale with natural vegetation may be the best option. For sites with smaller ephemeral creeks in the proposed vineyard area, grassed waterways with a rock tractor crossing may be advisable. Rock or cement lining swales to increase flow into streams is generally not a good practice as erosion problems will be created downstream.

For some sites, re-contouring has reduced slopes to a gentler gradient and reduce overall soil erosion from concentrated flows. Re-contouring with installation of drainage systems and use of permanent cover crops can reduce soil erosion over the long term. However to achieve this change in the landscape involves a significant amount of initial land movement and disturbance.

While diverting and undergrounding water removes concentrated surface flow from eroding soil, it will increase flow volumes at the pipe outlet. The location of the drain, or diversion outlet, and its potential effect on the creek or waterway where it discharges should be evaluated. The energy and erosional force of the drain water will need to be mitigated with

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the placement of large rock, stilling basins or other structures to act as an energy dissipater. In some instances the installation of stormwater spreaders can dissipate concentrated flows. Stormwater spreaders are pipes with holes staked onto the contour and attached to the outlet of the vineyard drainage pipe. The spreader will not function correctly if water volumes are too great or if holes in the pipe are too small and clog.

Placing many smaller drainage outlets with energy dissipaters, rather than one large one, is another preferred option. If necessary, creating a stilling, or detention, basin to temporarily hold the stormwater before releasing it may reduce effects on a creek. Detention basins should be located off-channel and their use can alleviate the issue of a vineyard increasing the volume of floodwater downstream in smaller (2-, 5-, 10-year) frequency storm events.

The size and configuration of the vineyard drainage system is different for each individual site. There are varying concerns regarding the removal of vegetation and the potential for changes in the volume and timing of runoff from the site. Changes in runoff volume can affect the form and habitats in the creek downstream. This is a complex issue. The slope, vegetative cover types, rainfall volumes, and soil types on a site play major roles in the volume and timing of stormwater runoff from a hillside. Vineyards with dense cover crops do not differ greatly in their infiltration of stormwater from the same site covered in natural grassland. Heavily grazed or compacted lands may have less infiltration and more runoff than the vineyard. A forested site converted to a vineyard can have reduced infiltration and greater runoff.

However for any increase in runoff volume created by the vineyard to affect flood levels in the creek or river, the increase would have to represent a major portion of the total runoff volume in the creek. In general, it is more likely that vineyard development in a tributary watershed could affect the flow levels in the creek over time as many vineyards are put in and all of the conversion added together has an effect. To avoid this cumulative problem each vineyard should create no more than a 10-15% increase in the volume of peak stormwater discharges over the pre-project condition. As part of the FFF program, a Science Advisory Group was convened and discussed peak stormwater discharges. The group agreed that a figure of 10-15% increase could be used if particular models and methods were used in the evaluation. The science group also agreed that monitoring and adaptive management to revise the figure would be needed.

In general, drainage systems are installed to avoid soil erosion and thus reduce the amount of sedimentation in the creek and negative effects on fish habitat. However the system can be made more fish friendly by incorporating the following BMPs.

APPLYING SITE DESIGN BMPS: DRAINAGE IMPROVEMENTS

Consult with NRCS or a qualified engineer or professional to design a drainage system for the vineyard that includes the following:

- ❑ Remove from the vineyard footprint the areas of the site that are natural drainage channels - year round and seasonal creeks and their riparian corridor areas and all major ephemeral streams.

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- For those areas where improvements such as underground pipes or grass-lined waterways must be installed, be careful to address all the features of the drainage in the design for the new vineyard.

- Size and design vineyard drainage systems for the 50- to 100-year frequency, 24-hour duration rainfall event. Diversion ditches are typically designed for a smaller storm ,the 25-year frequency, 24-hour duration event.

- Use a long record of rainfall data and make sure it is close enough to the location of the site to be applicable. Review the information for the highest intensity rainfall event (the greatest amount of rainfall over the shortest period of time) and make sure that this amount does not differ a great deal from the 24-hour figure. This comparison is done to assure that the system will not fail in a very intense, but short, storm event as well as a longer duration rainfall event. This information is available from the National Weather Service at http://www.wrcc.dri.edu/pcpnfreq.html.

- Plans for the system should address whether the soil types on the site are subject to piping. Piping is the movement of water through porous soil types. The water increases erosion and blowouts of the drainage system. Some types of soils are more inclined to undergo piping than others.

- Plans should address inlet clogging with installation of screens, grates or other measures.

- Design the outlets of the system to result in no erosion in swales, streams or creeks. The drainage system should spread the flows out into as many outlet locations as practicable rather than concentrating all the drainage into a few pipes and outlets. Stormwater spreaders may be appropriate in some systems.

- The system should address more than just the drainage produced by the vineyard. The larger upslope areas and the storm flows produced that enter the site need to be included.

- Design the system to result in only very small increases in peak stormwater volumes. The drainage system should not increase peak stormwater discharge over pre-project conditions by more than 10-15% for the 2-, 5-, and 10-year events. If such increases are unavoidable, then detention or water spreader facilities should be included to mitigate the increase. Reducing the volumes and the potential for erosion of creeks is in the vineyard operators' favor. Remember that incision of the creek from increased flows can create failures in the banks of ephemeral streams and undercut and damage the vineyard. The stormwater discharge from the site for various sizes of storms (2-, 5-, 10-, 50-, 100-yr frequency 24-hour duration events) under its pre-project condition whether in agriculture, forest, grazing or other land uses and the post-project conditions needs to be evaluated. The TR-55 model used by the NRCS, or other hydrologic models such as the HEC-1 can be used by the professional designing the drainage system to demonstrate that changes in stormwater from the vineyard are within the 10-15% increase level. Attach the model results and assumptions to the Farm Conservation Plan.

- Winter cover crops are always needed in conjunction with drainage improvements to reduce surface flows and soil erosion.

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- ❑ Indicate the features of the drainage system on the Farm Conservation Plan.

- ❑ All designs and plans need adequate detail to install the drainage system and other features very precisely. These plans will serve to guide annual maintenance and management efforts for outlets, inlets, terraces and other features in Element III.

13. LAND TREATMENT

Background: Land Treatment

Soil testing is a part of evaluating a new vineyard site. The test will determine the soil pH, depth, texture, composition and need for certain amendments such as gypsum for high pH and magnesium for low pH. These amendments are mixed into the soil by disking or ripping the site. The soil is also evaluated for the need to change its structure and increase root penetration. Deep ripping consists of using heavy equipment to break up the deeper soil horizons that may have less porous soil to allow the vine roots to penetrate. Both disking and ripping of the site disturb the soil and can result in great amounts of erosion if not done properly. However, should this practice be used, all disking and ripping should be completed and a dense cover crop established prior to October 15. The cover crop should be irrigated if possible particularly in critical erosion areas and emergency erosion control and winter field inspection by the farmer should be planned out.

APPLYING SITE DESIGN BMPS: LAND TREATMENT

- ❑ Indicate the type of land treatment to be used for each vineyard area in the Farm Conservation Plan.

- ❑ Each area to be graded re-contoured or ripped should be sized so that all soil grading is completed, drainage, irrigation and other improvements are installed and cover crops are seeded and irrigated to produce a dense ground cover prior to October 15. This may require separating a large vineyard area into phases.

- ❑ The last pass, or set of passes, by the grading, ripping or tilling equipment must be a cross-sloped pass to avoid creating any rills up and down the hillside and increasing erosions.

- ❑ All emergency erosion control and a winter inspection program should be in place by October 15.

14. FIELD ROADS

This section addresses the locations of roads through and along the edges of the vineyard and those that connect blocks of vineyard as part of the site development footprint. The primary road system and the design and installation of all roads including these field roads is covered in detail in Element V.

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APPLYING SITE DESIGN BMPS: FIELD ROADS

- ❑ The site design should avoid locating field roads close to stream channels. Floodwaters may create a waterway out of the field road and severely erode it. The main roads should be located through the vineyard with turnarounds along the edge of the vineyard/creek corridor or swale. All turnarounds and field roads adjacent to creek corridors and swales should be winterized and managed as vegetated filter strips.

- ❑ Minimize the number of creek crossings. Construct those crossings necessary for the site at right angles to the creek channel. Construct them to create the least disturbance to the natural form of the channel. Plan to have one, or at most two, seasonal crossings or bridges for larger creeks. Seasonal at-grade crossings can be the least impacting if the banks of the channel allow this design, and the use of the crossing will not disturb in-stream uses of the creek by the fish. Culverted crossings, concrete fords and other types of crossings should be carefully evaluated.

- ❑ Indicate in the Farm Conservation Plan the features of the vineyard field roads.

15. VEGETATION REMOVAL

Background: Vegetation Removal

Potential vineyard sites will typically have vegetation covering the hillside. Removal of vegetation over large areas can increase soil erosion and change drainage patterns. However changing some types of vegetative cover, such as heavily grazed hillsides to vineyard with permanent cover crops can result in a net increase in vegetative cover and reduction in soil erosion. The preliminary evaluation and determination of the vineyard footprint takes vegetation removal into account.

APPLYING SITE DESIGN BMPS: VEGETATION REMOVAL

- ❑ Remove only the minimum of vegetation for the vineyard footprint. Do not overclear the area, as it will require replanting with other vegetation to stop soil erosion. Minimize the road width around the outside perimeter to allow for vegetation retention.

- ❑ Never clear creeks or drainageways of any type – year round, seasonal, or ephemeral, as this can cause severe erosion, sedimentation and directly impact fish habitat.

- ❑ As part of the preliminary evaluation heritage oaks, redwoods and other large native trees are considered for retention. If oaks are removed, replanting in other areas should be done at a ratio of 10:1 using locally derived stock of the same species. Summer irrigation at a three-week interval for the first 3 summers will assist the oaks to grow. Do not water frequently in the summer as oaks are prone to root rot. Swales or outer riparian corridors are often good areas of the site to replant oaks. Some vineyard sites may not be able to retain oaks and replanting should be done elsewhere. There are several theories regarding the spread of oak root fungus into vineyards and whether the removal of the trees helps or hinders the spread of the fungus.

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- ❑ If you have a vernal pool or wetland on your site you will need to apply for a permit to develop the area. Contact the Sonoma and Mendocino County Planning Department, NRCS, Regional Water Quality Control Board and California Department of Fish and Game for information on this permit process.

- ❑ If you plan to remove coniferous forest, you may need a permit. Check with the California Department of Forestry.

- ❑ Evaluate the vineyard design to retain the maximum amount of vegetation in swales/ephemeral streams. Swales hold ephemeral creeks that serve as stormwater channels in large storms and leaving the vegetation intact reduces erosion and drainage problems. It may be possible to break the site into several operational blocks with natural creeks in between. Tractor crossings of the swale or creek should be minimized on the site.

- ❑ Evaluate the vineyard site for the type of vegetation being removed and other areas of the property where vegetation could be planted or enhanced. Past land use may have resulted in a loss of native understory species, forest of dense, even aged stands with little biodiversity or loss of native plant cover in steep areas. Revegetation of areas outside the vineyard can create higher value habitat over the total property.

- ❑ Development of some sites to vineyard may also affect wildlife migration corridors. Deer, for example, move from the canyon bottom to the ridgetop and from the very upper areas of a watershed to its outlet. Evaluate how an animal can cross through the site with the vineyard and accommodate vegetated migration corridors in the design. Wide, well-vegetated creeks and unfenced corridors, or an adequate area of natural vegetation for the animals to easily go around the vineyard site may be incorporated. Appendix 3 includes some considerations for wildlife friendly fencing.

- ❑ Indicate the features of the project vegetation removal/retention and fencing in the Farm Conservation Plan.

16. EROSION SITES

Repair of existing erosion sites should be integrated into the vineyard development of the site. Element III contains an extensive discussion of erosion site repair methods.

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STEEP SLOPE OF ABOUT 50% CLEARED OF VEGETATION IS ERODING EVEN THOUGH PLANTED WITH COVER CROP. EPHEMERAL STREAM/SWALE WAS CLEARED AND IS NOW ERODING AND CREATING MAJOR GULLY.

THIS SITE WAS RIPPED BUT THE EQUIPMENT LEFT FURROWS GOING UP AND DOWN THE SLOPE RESULTING IN EROSION. THE FURROWS SHOULD HAVE BEEN ORIENTED CROSS SLOPE.

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VINEYARD ACCESS ROAD ALONG BOTH SIDES OF STREAM CAN EASILY ADD SEDIMENT TO STREAM AND BE ERODED BY FLOOD FLOWS. ACCESS ROAD SHOULD BE RELOCATED AWAY FROM CREEK EDGE.

RAILCAR BRIDGE IN BACKGROUND IS A GOOD MEASURE FOR STREAM CROSSINGS.

SOME COVER CROPS ARE LOW GROWING AND GOOD FOR ROAD WINTERIZATION.

VINEYARD ROAD LOCATED AWAY FROM WATERWAYS

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VIEW LOOKING DOWN STEEP HILLSIDE SWALE - REMOVAL OF VEGETATION CAN RESULT IN EROSION AND POTENTIAL SLOPE FAILURES.

EPHEMERAL STREAMS WITH DENSE VEGETATION

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Fish Friendly Farming Environmental Certification Program	TWO VIEWS OF VINEYARDS WHERE THE EPHEMERAL SWALES ARE RETAINED IN NATURAL VEGETATION

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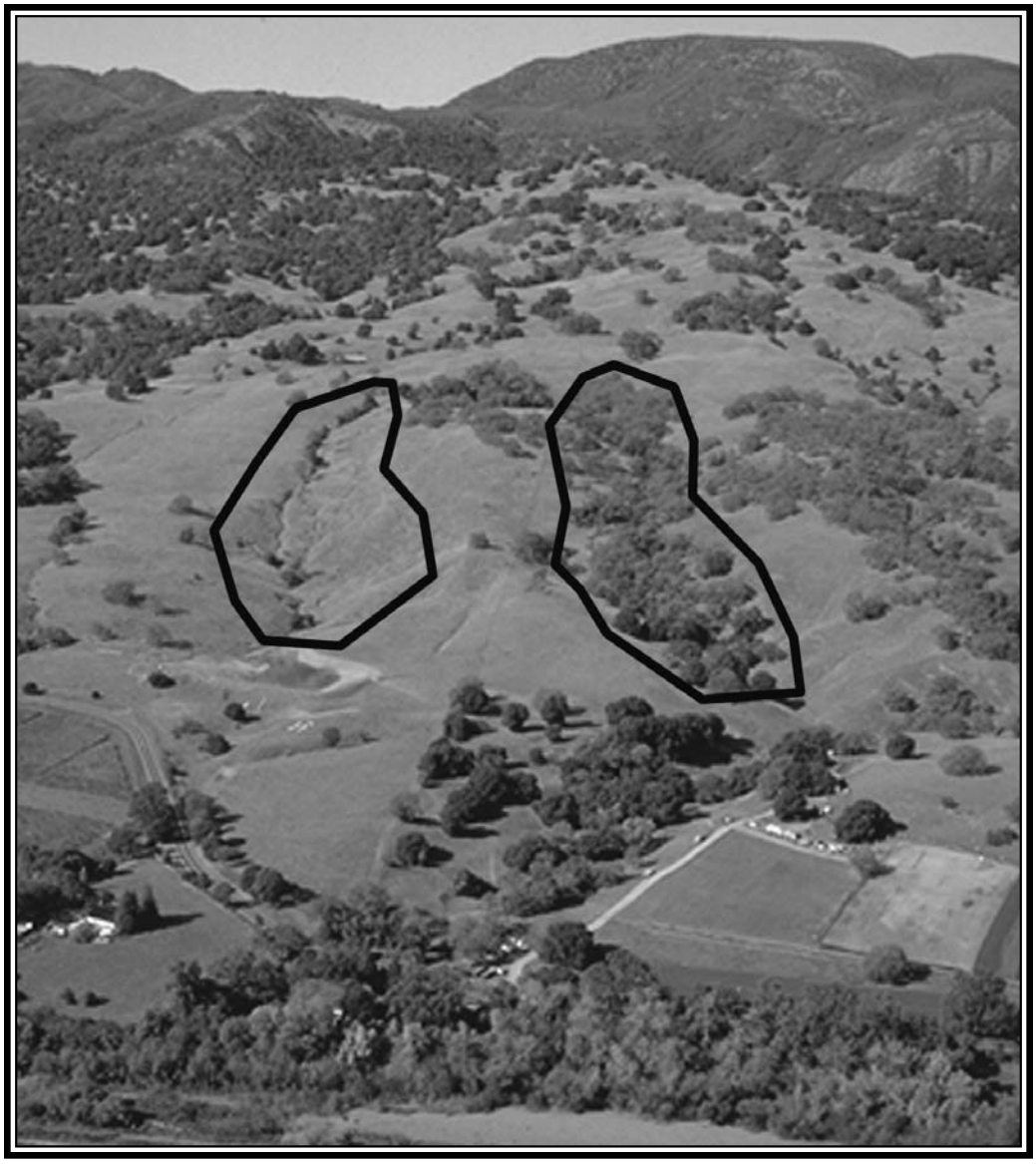

TWO EPHEMERAL STREAMS. LINES INDICATE THE APPROXIMATE OUTER EXTENT OF THE SWALES. GRASSY SWALE ON LEFT NEEDS EROSION CONTROL AND REVEGETATION. SWALE ON RIGHT IS WELL VEGETATED AND SHOULD REMAIN UNDISTURBED.

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THESE PHOTOS SHOW THE RETENTION OF OAK WOODLAND AND SWALES AND THE DEVELOPMENT OF GRASSLAND AS VINEYARD.

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APPLYING SITE DESIGN BMPS: EROSION SITES

- ❑ With assistance from NRCS, or a qualified engineer or soil scientist, evaluate potential solutions for existing erosion sites within the new vineyard footprint or other areas of the property. The evaluation should review drainage on the site, the erosion problem and its cause.

- ❑ The new vineyard development may be able to decrease soil erosion and peak discharge over the previous land condition as long as the cause of the problem is corrected. Otherwise the new vineyard may suffer similar damage.

- ❑ Particular attention should be paid to any terracing or benching of the site and the possibility of concentrated drainage and its effect on already unstable areas. Some soil types are more prone to gully erosion from concentrated drainage.

- ❑ If erosion sites are primarily streams and swales, be very careful to consider fish friendly restoration techniques. Lining streams with rock riprap damages creek habitats downstream due to the effect of rock riprap on increasing the velocity of stormflows. Vegetative solutions, or if the problem is severe, vegetative and structural components combined which will not increase peak flow volumes into downstream creeks are preferred.

- ❑ Once again consider the drainage patterns on the site when fixing erosion problems. Don't fix one problem only to create a bigger problem downstream. As a rule, repairs should stop the cause of the problem, not just repair the symptoms or translate the problem downstream.

- ❑ Fill in the erosion site section of the Farm Conservation Plan.

17. WATER SOURCES/WATER CONSERVATION

Background: Water Sources

You should have a permitted or licensed water source prior to installing your project. In general, for surface water diversions only off-channel reservoirs filled through diversions between December 15 and March 31 will receive new appropriative water rights. If the property has an existing reservoir or diversion review the water right permit and license for potential limitations on transfer to vineyard irrigation. Additionally, the proposed diversion must be considered in the context of all the other diversions and impoundments in the watershed. Appendix 4 includes the guidelines and study requirements for new water rights applications for reservoirs and diversions. These guidelines require that the proposed new diversion, or impoundment, along with the already existing diversions and impoundments not exceed 15% of the “winter 20% exceedence flow” at a location downstream of the property. The “winter 20% exceedence flow” is the 20% exceedence value of the streams daily average flow curve for the period of December 15 to March 31. The studies and analyses required as part of the water rights permit are complex and will require a hydrologist, or engineer, to complete all the necessary studies.

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TOP PHOTO SHOWS GULLY HEADCUT FROM CONCENTRATED DRAINAGE.
BOTTOM PHOTO SHOWS PLACED ROCK WITH VEGETATION REPAIR.

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CHECK DAMS CAN BE MADE OF ROCK, REDWOOD OR OTHER MATERIALS. THEY STABLILIZE THE GRADE AND MUST BE INSTALLED PROPERLY.

Fish Friendly Farming Environmental Certification Program	CHECK DAMS ARE USED TO STABLILIZE GULLIES AND REDUCE SOIL EROSION

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APPLYING SITE DESIGN BMPS: WATER SOURCES/WATER CONSERVATION

- ❑ New reservoirs must be off-channel reservoirs with winter diversion and filling (December 15 – March 31) to gain a state water rights permit to impound surface flows. New water rights must evaluate all the existing diversions and impoundments to determine if there is sufficient water available for a new water right. The analysis needed for permitting this type of reservoir is described in Appendix 4.

- ❑ Use of riparian diversions for irrigation of new vineyards is not advisable. A 1600 permit from the California Department of Fish and Game is required for riparian diversions and seasonal limitations on diversions are likely to be included in the permit conditions. Riparian diversions for frost control may be possible, if surplus flows are available as demonstrated by a study, as defined in Appendix 4 and a regulatory pond is used (see page 169 for additional information on frost control practices).

- ❑ Review your irrigation system and proposed vineyard block size to assure water conservation is maximized (see page 174 for further information on irrigation practices).

- ❑ Review your frost control methods and make sure they minimize the use of water and that the water rights studies and application include rights for frost control water and any diversion site or storage.

- ❑ There are approaches to collecting water from a subsurface system and from frost control applications by installing subsurface perforated pipes, or French drains, and cisterns/sumps which collect and the subsurface water which is then pumped into off-channel reservoirs. In some locations, reservoirs can be designed to collect subsurface flows directly. Some of these approaches represent on-site water recollection allowing water to be conserved and reducing the need for additional diversions or wells.

- ❑ Screens must be placed on all direct riparian diversions according to the NMFS criteria in Appendix 2.

- ❑ Wells can also have an impact on stream levels if they are too close to an alluvial stream channel. If the well affects water flows in the stream, it will need to be permitted as a surface water diversion and go through the same process as an appropriative water right application. If the well is not near the stream, very deep (>100 ft.) or does not affect stream flows, it may be a good source of water with less impact to the fishery than stream diversions or reservoirs.

- ❑ If wastewater is available for irrigation, it may represent another alternative for a portion of the site's water needs.

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Fish Friendly Farming Environmental Certification Program	ON-CHANNEL RESERVOIRS

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TWO AERIAL PHOTOGRAPHS SHOWING OFF-CHANNEL RESERVOIRS

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THIS IS A BYPASS STRUCTURE FOR A RESERVOIR TO ALLOW CONTROL OF WHEN THE RESERVOIR FILLS AND PROVIDE FOR STORMWATER TO GO AROUND THE RESERVOIR INLET THROUGH ADJUSTMENT OF THE OUTLETS AND INTO THE CREEK.

VINEYARDS HAVE ONE OF THE LOWEST LEVELS OF IRRIGATION, USING AN AVERAGE OF ONE ACRE-FOOT OF WATER PER ACRE PER YEAR. BY COMPARISION, SUBURBAN LANDSCAPING CONSUMES UP TO 6-10 ACRE FEET OF WATER PER ACRE PER YEAR. ALMOST ALL VINEYARDS USE HIGHLY EFFICIENT AND WATER CONSERVING DRIP IRRIGATION SYSTEMS.

PHOTO ABOVE SHOWS A CISTERN WHICH COLLECTS FROST CONTROL WATER AND ALLOWS IT TO BE REUSED; PHOTO TO LEFT SHOWS A MICROSPRINKLER

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DESIGN DETAILS AND INSTALLATION: APPLICATION OF BENEFICIAL MANAGEMENT PRACTICES

Once designed, the vineyard must be installed correctly using the BMPs to avoid soil erosion and additional costs. Review the BMPs for vineyard installation with the responsible contractors and workers. Make sure your plan includes:

- ❑ Plans and specifications with the necessary installation details to avoid mistakes or misinterpretation
- ❑ Seasonal restrictions
- ❑ Erosion control preparedness and winterization programs
- ❑ Adequate supervision and inspection
- ❑ Winter site observation, inspection and maintenance with immediate erosion control if needed.

18. TIMING

Background: Timing for New Vineyard Installation

Soil left disturbed and barren after vegetation removal is highly susceptible to erosion from both wind and rain. Few hillside vineyard sites have deep enough soils to withstand major erosion and still remain productive. The most effective method for reducing soil erosion is to protect soils though careful planning and scheduling. The rainy season is predictable and stretches from October 15 to April 15 for most years. During the rains, disturbed and bare soil will be lost if the site is not completely winterized. Any form of grading during the rainy season is sure to result in erosion and soil loss and violates local and state regulations.

Once the potential vineyard site has been thoroughly evaluated, a plan for the vineyard development is prepared. This plan will outline the physical layout of the site, the activities to be completed and the time period for each phase of the development. In general, the development should involve several years and include:

Phase I

- Evaluation of site and preparation of plan, completion of CEQA, water rights permits, local permits and other requirements

Phase II – Year One

- Clearing the land - retaining natural vegetation in drainage areas as much as possible
- Grading, terracing or other major soil disturbance
- Field road construction
- Installation of underground drainage system, grassed waterways, diversion ditches or other drainage improvements in the vineyard

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- Installation/development of primary elements of water supply system
- Planting of temporary cover crop
- Installation of temporary erosion control
- Installation of permanent erosion control
- Observation of site drainage system performance, erosion problems and use of temporary control measures

Phase III – Year Two

- Repair and replacement of any drainage problems erosion sites and problems
- Fine grading of terraces and installation of drip lines
- Planting of vines/installation of trellis
- Planting of permanent cover crops
- Installation of additional permanent erosion control

APPLYING SITE INSTALLATION BMPs: TIMING

- ❑ All Phase II and III activities including the installation of temporary and permanent erosion control for the site must be completed between April 15 (or the end of the rainy season if later) and October 15.
- ❑ Seeding of a temporary cover crop should occur in September. For steep slopes and highly erosive soils, straw mulch should also be applied and irrigation used to promote vigorous growth prior to the rains. If the seeds are planted earlier than September and birds may eat them, seed can be drilled and covered with straw mulch. For terraces make sure all parts of the site are covered with erosion control including cover crops, erosion blanket and other materials.
- ❑ The first winter season allows the grower to watch site drainage, soil movement and perform temporary erosion control as needed. These observations allow the grower to improve on the site system and design if needed prior to planting vines.

19. LAND TREATMENT

<u>Background: Land Treatment</u>

Certain soil types and vineyard sites may require disking and grading of surface and subsurface layers, removal of rock or re-contouring. Erosion control practices must be applied following this amount of soil disturbance. Grading and subsoil chiseling is done to reduce hardpan conditions, to add soil amendments or to improve soil texture and is not recommended for most steep slopes.

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APPLYING SITE INSTALLATION BMPs: LAND TREATMENT

- ❑ Phase the project such that all earthwork and installation of all drainage improvements are completed prior to the end of September to ensure that cover crops, filter strips and other erosion protection practices are completely installed before the rains begin.

- ❑ Make sure that final grade and equipment passage leaves cross-sloped soil contours. If equipment leaves up and down slope trenches, erosion is almost a certainly with expensive re-grading and potential siltation for creek areas.

- ❑ Cover crops should be seeded at higher densities and applied with fertilizers and mulch and irrigated to assure the maximum coverage possible by October 15.

- ❑ Sites that undergo extensive soil disturbance should be carefully monitored over the rainy season with immediate attention to any small erosion problem and installation of temporary control practices before the problems become large.

20. COVER CROPS FOLLOWING INSTALLATION

Background: Cover Crops Following Installation

The soil layers of the cleared and graded site need protection from the winter rain. According to the NRCS, soil loss that is observable, as in a rill or gully, is already in excess of 15 tons per acre. Soil loss of 1-2 tons per acre is barely noticeable. However all soil loss will reduce agricultural productivity over time. Cover crops serve to directly protect soil from rain-strike erosion and surface flows as well as holding the soil with dense fibrous roots, and improving infiltration.

APPLYING SITE INSTALLATION BMPs: COVER CROPS FOLLOWING INSTALLATION

- ❑ A primary goal of planting a cover crop is to create a dense protective cover of plants to protect the soil. Grasses alone or a combination of grasses, legumes and natural vegetation will protect soils. You may also want to evaluate using a perennial cover crop that may take longer to establish but is less water consumptive, requires less tillage, and less maintenance. See Tables IIIA, B, and C for details on types of cover crops.

- ❑ Seed the cover crop between September 15 and October 15 to assure that sufficient coverage is achieved before the rains.

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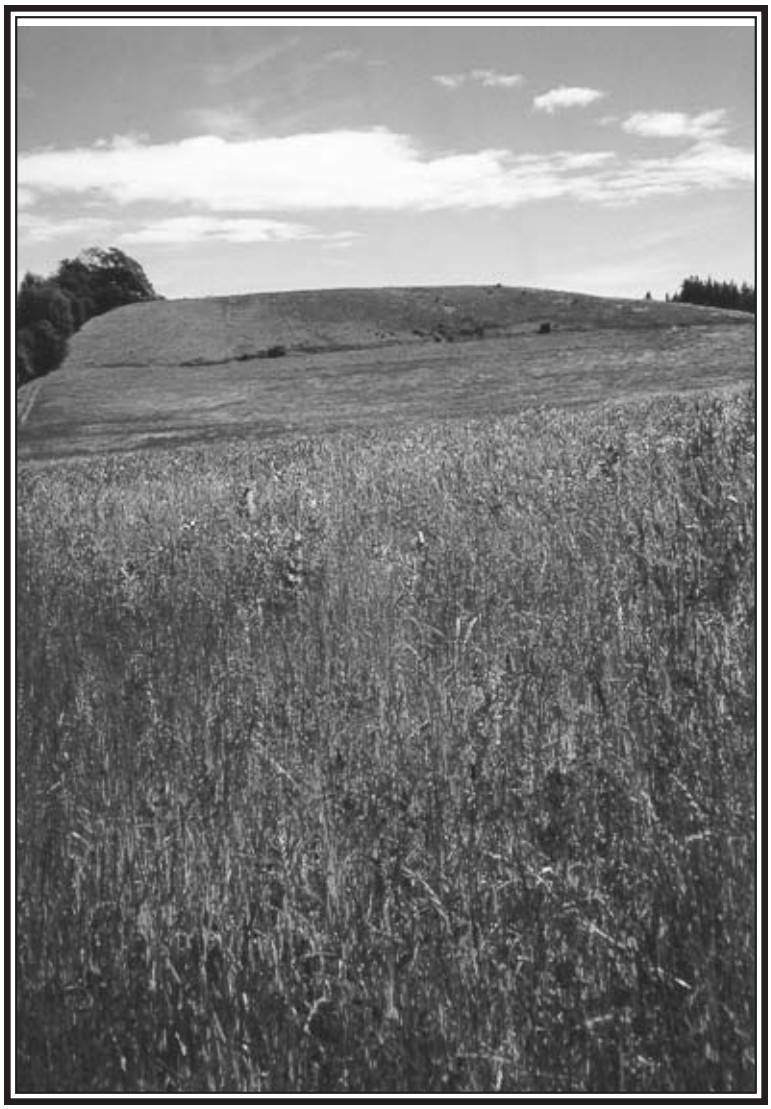
COVER CROPS SHOULD BE SEEDED AFTER LAND PREPARATION TO PROVIDE A DENSE PROTECTIVE COVER FOR SOILS.



Fish Friendly Farming Environmental Certification Program	COVER CROP ON GRADED NEW VINEYARD SITE

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- ❑ Cover crops should cover "all areas" of the new vineyard site during the winter from October 15 through the end of April or later if the rainy season is longer. "All areas" is defined as the "middles" or the area between the vine rows, in the vine row and, for terraced vineyards, both the flat and the slope or face of each terrace. Turnarounds or headlands, roads and buffer areas should also be planted or covered with straw mulch as part of the winterization process. If winter access is needed, gravel should be placed on road.

- ❑ Fertilizer may be needed to stimulate growth and be applied with the cover crop seed. All legume seeds should be inoculated with rhizobium. Check the PLS (pure live seed) rating of your cover crop seed to make sure you are using a rating of 80% or better or germination may be poor. Adjust the planting rate in proportion to the PLS percentage to assure desired coverage.

- ❑ Planting methods include broadcasting seed mix and fertilizer over the site, drilling with a seed drill and broadcast over steep areas with a helicopter. Broadcast seed with an ATV, tractor-mounted seeder, or hand equipment for small areas. Mulching with straw and rolling of mulch should also be done if seed is planted late in the season. Compost can also be used as mulch if readily available.

- ❑ Hydro-seeding involves application of seed, fertilizer and a tacking agent in a slurry sprayed onto the site. This method allows for the slope face of the terrace vineyard to be seeded. This method requires very specific mixes of seed, tacking agent, fertilizer and water for different equipment and materials. Check with a hydro-seed and fertilizer manufacturer. If legume seed is used it should be inoculated with rhizobium. Mulch may also be included in the hydro-seed mix and may be required if applications are made after October 15.

- ❑ Certain erosion control blankets combined with seed, hydro-seeding or erosion control products that include seed can be the most effective method for establishing a cover on the terrace face and other steep areas. A broadcast seeder that is fully opened and mounted on an ATV can also seed the terrace face, if a high concentration of seed with fertilizer is used.

21. DESIGN DETAILS AND INSTALLATION: THE DRAINAGE SYSTEM

Background: Designing and Installing the Drainage System

Developing a hillside vineyard usually requires installing some type of drainage system. In general retaining the natural drainage features and vegetation is highly advisable. On some sites, surface flows need to be collected and diverted around or through the vineyard area.

There are different measures that can be used. The application of various measures to a vineyard site depends upon the layout of the vineyard, the slope and length of the slope, the area of the contributing watershed, rainfall amounts and maximums, and soil types. The BMPs for this element of a new vineyard address the installation of the system and a few of the most important design considerations; however, all drainage system designs should be prepared by the NRCS, a civil engineer, or other qualified professional.

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APPLYING DESIGN DETAILS AND INSTALLATION BMPs: DRAINAGE SYSTEMS

Diversion ditch - Diversion ditches are used across the top of the site to intercept runoff and move it away from the developed slope. The ditch reduces the total amount of water moving down the vineyard slope. The diversion ditch usually crosses the slope along the contour at the top of the vineyard or mid-slope between vineyard areas. The features of the diversion ditch should include:

- ❑ Design the ditch to carry a 25-year frequency, 24-hour duration rainfall event.
- ❑ A gentle (less than 5%) slope to allow the water to flow at non-erosive velocities.
- ❑ Diversion to an underground outlet or other facility designed to accommodate the flow volume.
- ❑ Construction of the diversion ditch requires that all fills are compacted thoroughly and the ditch is sized larger in cross-sectional area than needed for stormflow to avoid overflow and gully formation.
- ❑ Berms for the diversion ditch should be four feet thick to reduce the potential for piping.
- ❑ Install culverts if crossings of the diversion ditch are needed.
- ❑ Revegetate the ditch area and line the ditch with rock if erosion becomes a problem.

Underground drainage system - A system of drainage collection pipes and inlets are installed with terraced and hillside vineyards. The water flows from the inside of the bench into an inlet and downward into the pipe. The underground pipes collect flow and direct it down the slope to a protected outlet.

The benches of the terraced vineyard and inlet locations are designed to allow for a limited amount of water to concentrate before it is directed into the drainage system. This constant diversion of flows over the entire vineyard area and at short intervals along the slope keeps water flow from concentrating and gullying the slope. Installing an underground drainage system should include the following features:

Inlets

Install inlets to provide positive hydraulic flow into the pipe system. If the inlet is set too high or too low it will affect the flow in the pipe and from the bench. The inlet should line up with the ditch on the backslope of the bench and be at, or slightly below, grade.

- ❑ Protect inlets from siltation, equipment, trash, and animals. Mark inlets with a painted post to reduce equipment damage.
- ❑ Install inlets large enough to carry the runoff from a 50 to 100-year frequency, 24-hr. duration rainfall event from the area drained. Install more inlets and drain smaller areas of vineyard rather than larger areas. Do not substitute smaller sizes of pipes or inlets during construction from the designed size.

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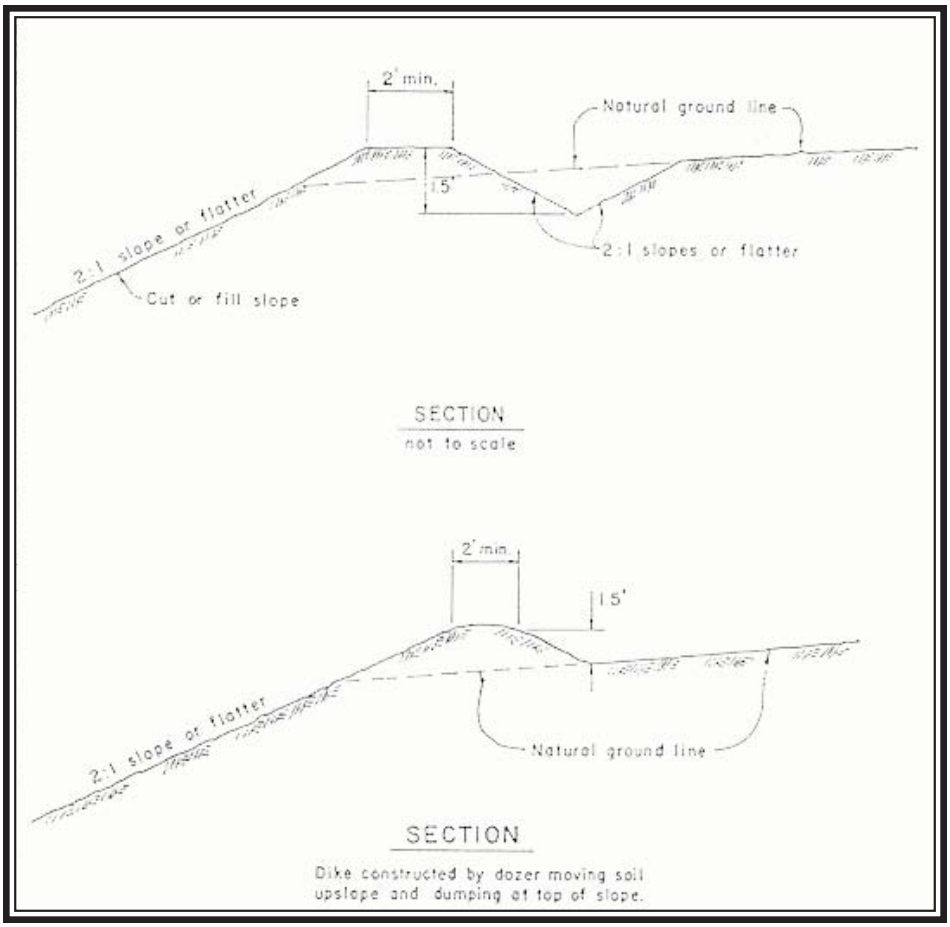

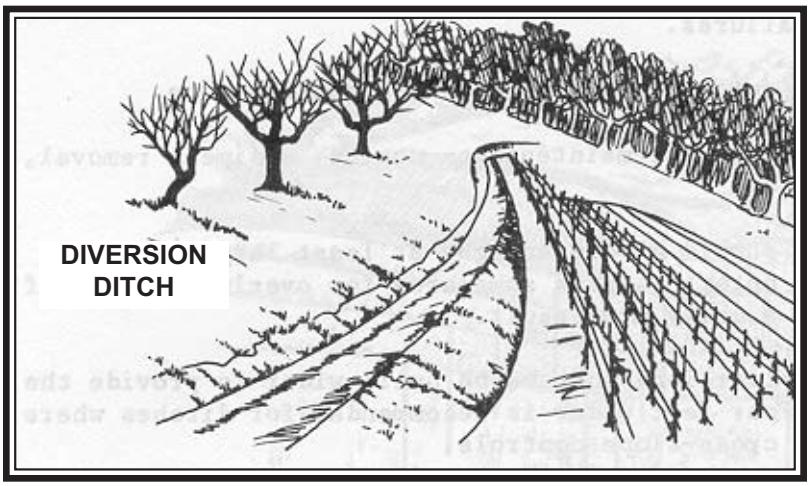

Fish Friendly Farming Environmental Certification Program	DIVERSION DITCHES ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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- ❑ Backfill around the inlets to create a tight seal between the structure, the soil, and the bench ditch. The water should not be able to flow around the inlet and down the slope.

Underground outlets

- ❑ Pipe sizes should be adequate to carry the runoff from a 100-year frequency, 24-hr. duration rainfall event to avoid overflows and erosion.

- ❑ Designs must consider water pressures. Pipe joints and the inlets can blow out due to pressure differences in the system. An adequate number and distribution of inlets should be placed to avoid this problem. The connection of the drop inlet to the underground pipe should always be installed at a 90-degree angle.

- ❑ The pipe should be placed on compacted soil and supported by an adequate number of cutoff collars. The cutoff collar holds the pipe in place. Should the water flow around and along the outside of the pipe and erode the soil, the pipe can loose its support base and collapse. The cutoff collars support the pipe regardless of erosion of the soil around the pipe and reduce the likelihood of a major failure.

- ❑ If the pipe alignment is within an equipment use area compact the top fill to assure the pipe is not crushed. A minimum of 36 inches of top fill is recommended.

- ❑ The pipe must be installed at a uniform grade, no bumps.

- ❑ Install an energy dissipater, rock basin or other facility to reduce erosion from concentrated flow at all pipe outlets, spread the flow or detain it if possible.

- ❑ Use more outlets and drain smaller areas of vineyard to each outlet to reduce water concentrations and erosion at the outlets.

- ❑ Include detention facilities at the outlet if site development increases stormwater runoff by more than 15% over pre-project conditions for stormwater volumes for comparable storm events.

The discussion of terracing includes additional information of relevance to the drainage system installation.

Flexible pipe drop - This drainage practice can be installed in small swales within the vineyard where flows are relatively small. The practice consists of a small section of flexible plastic pipe set in a barrier made of sacks of concrete. The stack of concrete sacks temporarily ponds surface flows and directs the flow into the pipe and to the next downhill stack and pipe. The practice creates a stair-step of pipes down through the vineyard to conduct surface flows off-site and avoid erosion.

- ❑ The sack concrete barriers should be grouted with the pipe to avoid leakage and be secured into the slope with rebar.

- ❑ Do not use this practice where water flows may be too great for the pipe and blow out any of the pipe drops.

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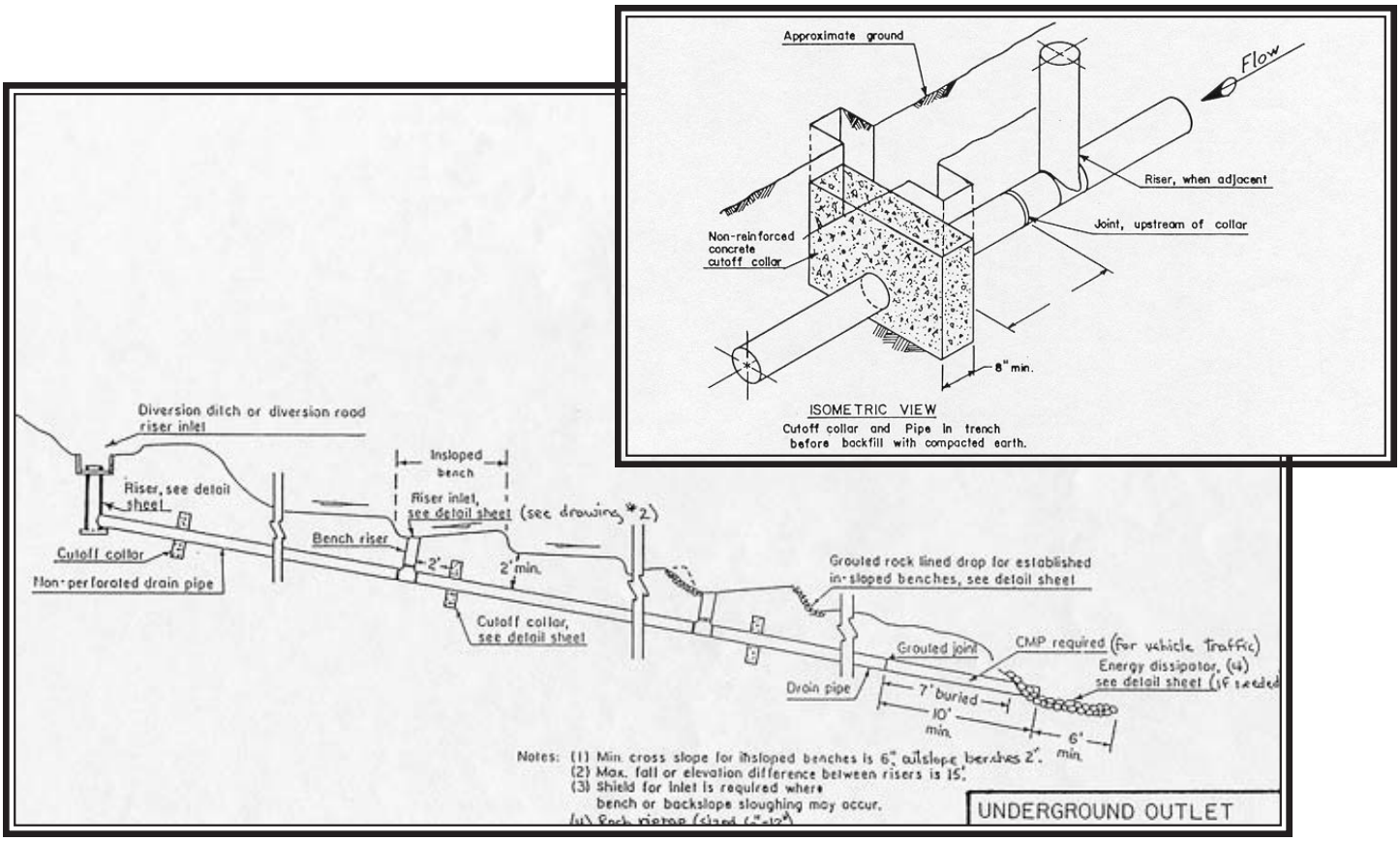
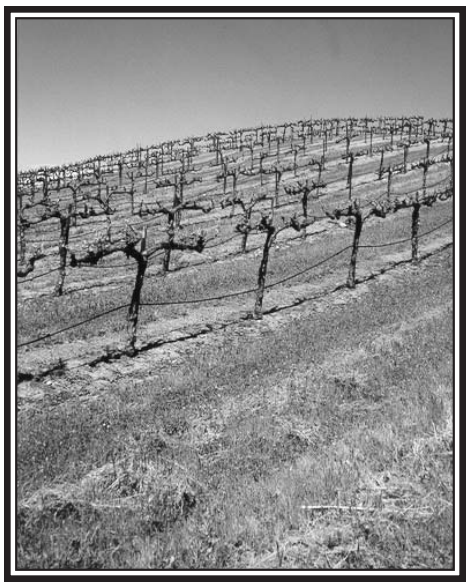


INSTALLING AN UNDERGROUND PIPE



Fish Friendly Farming Environmental Certification Program	UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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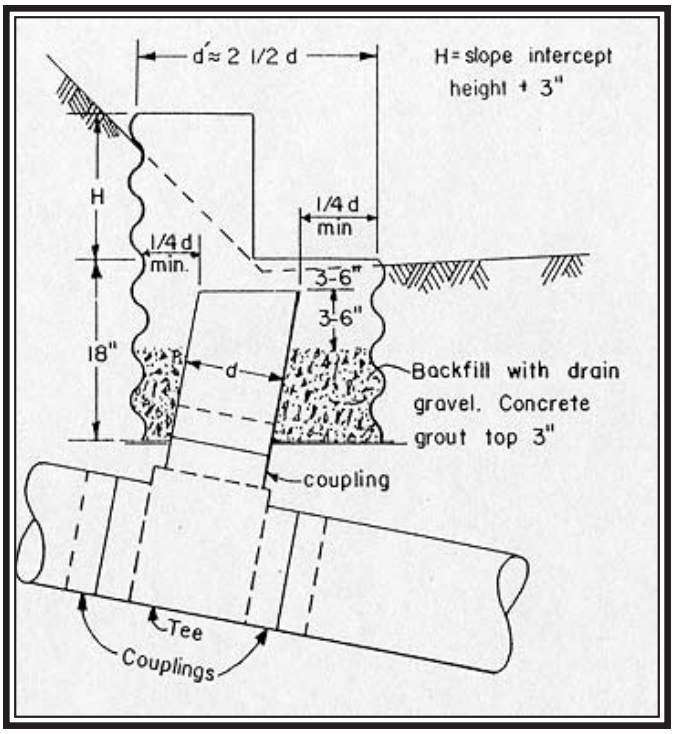
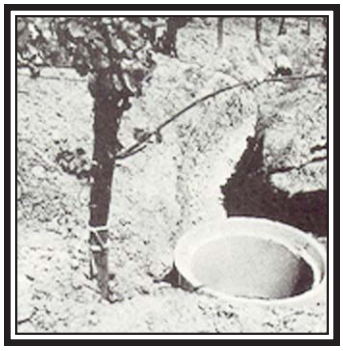


DROP INLETS MUST BE SET IN THE GROUND PROPERLY OR WATER WILL ERODE AROUND THEM. TRASH RACKS ARE ALSO NEEDED AS WELL AS CONSISTENT MAINTENANCE AND WINTER INSPECTIONS.



Fish Friendly Farming Environmental Certification Program	INLETS AND UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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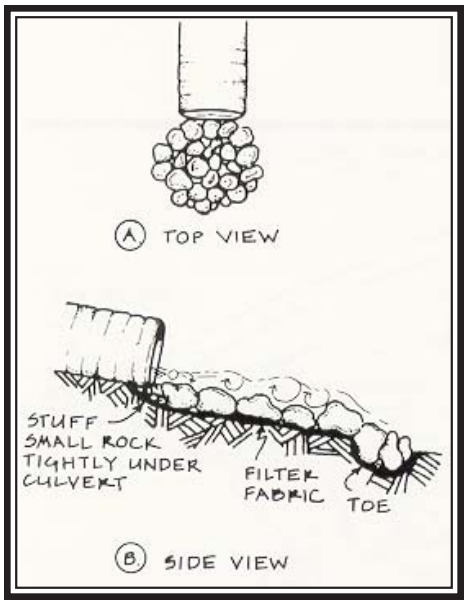
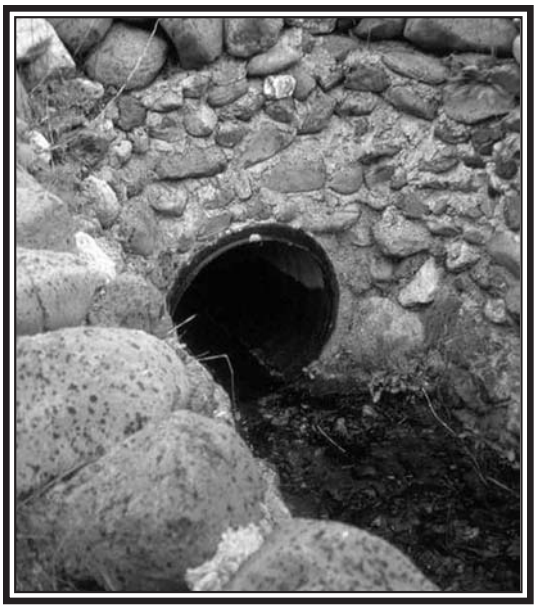
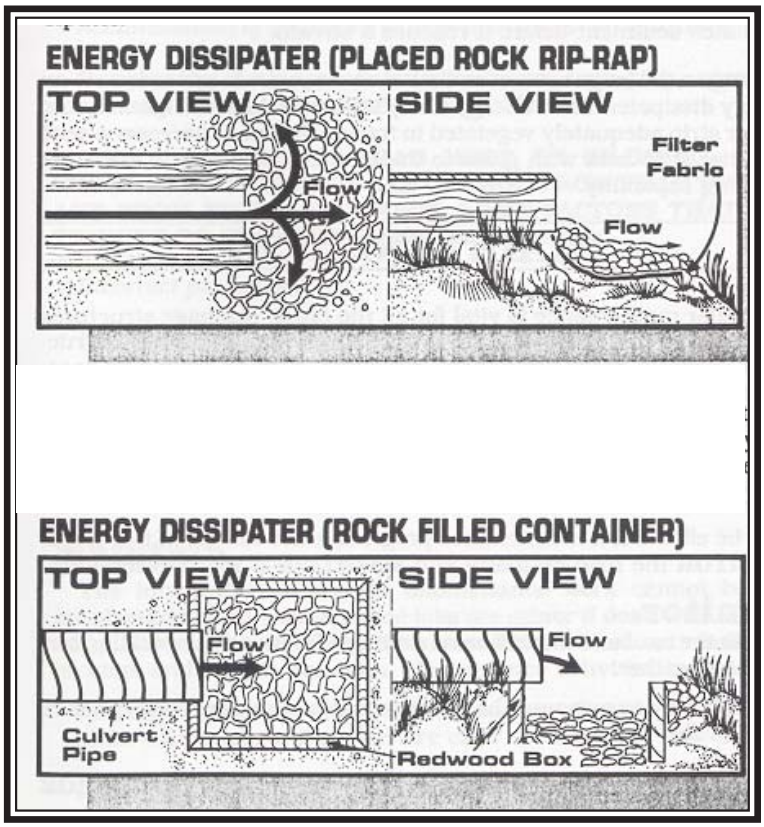
OUTLETS WITHOUT
ENERGY DISSIPATERS
CAN RESULT IN EROSION.







Fish Friendly Farming Environmental Certification Program	PIPE OULETS AND ENERGY DISSIPATERS ALL OUTLETS MUST HAVE A PROPERLY SIZED ENERGY DISSIPATER

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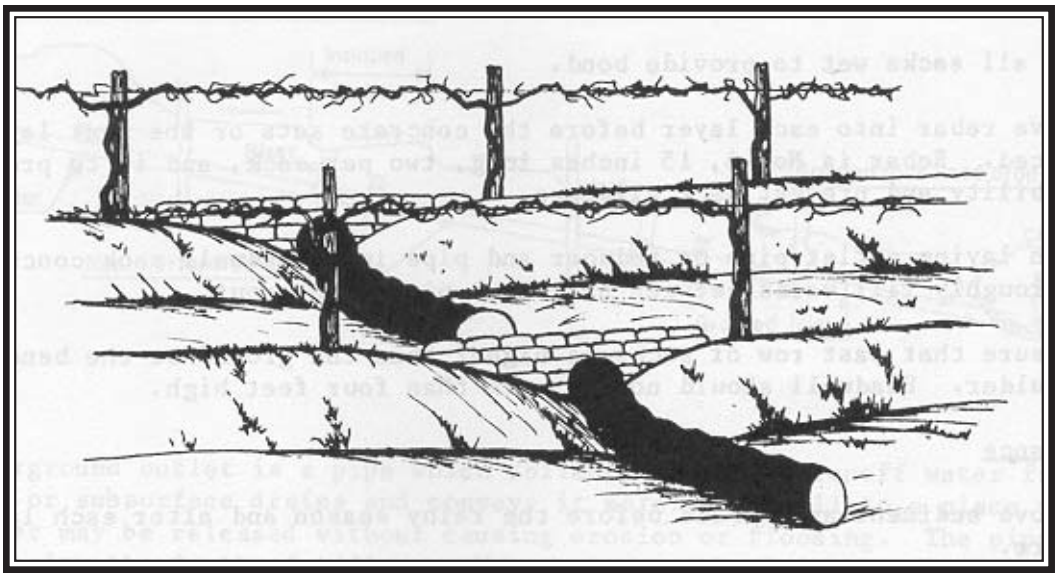

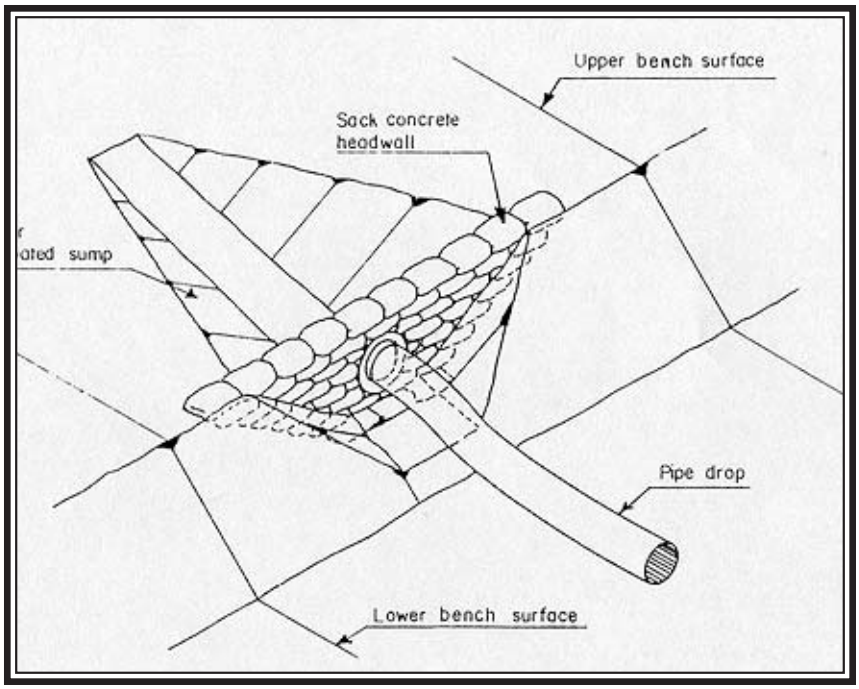

Fish Friendly Farming Environmental Certification Program	PIPE DROP SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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- ❑ Place the sack concrete barrier at the outer edge of the vineyard bench to avoid damage from equipment.

Grassed waterway - Grassed waterways can be used in vineyards with gentle slopes to convey stormwater in areas of concentrated flow such as swales. Grassed waterways are applied to areas with seasonal short-term waterflow. Areas with extended periods of seasonal flow from springs should not necessarily be approached using this practice. The grassed waterway should connect to a natural drainage feature or the vineyard drainage system. Use of the grassed waterway can result in a more natural approach to site drainage, but is generally not applicable to sites with slopes over 12%. Grassed waterways can be combined with a diversion at the top of the vineyard. The grassed waterways should include the following features:

- ❑ Design the grassed waterway to accommodate predicted stormflow amounts at non-erosive velocities for the slope of the waterway. Maximum flow velocity should not exceed 5 ft. per second with dense grass or 3 ft. per second with annual grasses. Greater velocities may require use of geotextile fabric or other erosion control features. If non-erosive velocities cannot be achieved this practice may not be applicable to the site, or may require diversions, grade control structures or other additional practices.

- ❑ Designate one to several equipment crossings on the waterway if needed and install rock or other materials for the equipment to drive over. Do not allow equipment to cross the waterway at any other point. The vineyard layout should accommodate adequate tractor turnaround outside the grassed waterway.

- ❑ Plant perennial deep-rooted grasses to achieve the greatest degree of stability. Annual grasses are shallow rooted and cannot withstand as much flow velocity as deep-rooted grasses.

- ❑ Plant the waterway immediately after clearing and grading to avoid gully formation.

- ❑ Avoid use of herbicides or disking of the grassed waterway as part of the overall vineyard management.

22. TERRACE OR BENCH DESIGN

Background: Terrace or Bench Installation

For vineyard sites in excess of 15% slope terracing of the slope is often done. A large part of the design and installation of a terraced vineyard involves assuring positive drainage to the underground outlet system and a reduction in concentration of flow across the vineyard slope. Concentrated drainage can cause the terraces to fail and the vineyard to gully.

Terrace vineyards are expensive to install and great care should be taken to assure the drainage features will function, the benches are adequate in width for equipment use and vine growth, and tractor turnaround and access roads are adequate, but not oversized. Because they require cut and fill of the hillside terraces have a greater potential to cause slope failures. Alternative designs for up and over the hill layout should be considered. The following BMPs summarize some of the most important design and installation issues;

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however, all terrace construction designs should be prepared by the NRCS, a civil engineer or other qualified professional.

APPLYING DESIGN DETAILS AND INSTALLATION BMPs: TERRACE OR BENCH

- ❑ All drainage features of the site - springs, swales and ephemeral streams must be addressed in the bench and drainage system design. Frequent inlets to the underground drainage system may be necessary particularly on long slopes to assure that surface flows do not concentrate and cause the benches to fail.

- ❑ Diversion at the top of the slope above the benches may be used to divert the flow from the watershed area above the vineyard and reduce the total volume of water moving through the vineyard site.

- ❑ Benches should be designed to avoid excessive ponding leading to overflow and erosion. The features of the bench design should include:

- ❑ The number of inlets and underground outlets should be adequate such that no single bench and inlet has too much flow and either overflows, or slides.

    - o Runoff collected by one bench should not exceed 1.0 cubic feet per second (cfs).

    - o The bench back slope should not exceed 1.5 horizontal to 1 vertical.

    - o If the site has lenses of impervious material, such as clay, a subsurface drain may be needed. Areas of greater instability due to springs or saturated conditions may also require additional drainage improvements.

    - o Flow over the bench face is not recommended as part of the design. Every bench should have inlets to collect stormflows form that bench.

- ❑ The slope of the ditch on the in-sloped bench should be 1-5%. A slope greater than 5% may create water flow velocities high enough to erode the bench.

- ❑ Compact fill areas around inlets and pipes after installation as changes in grade through settlement that may lead to erosion problems.

- ❑ All areas of the bench - the flat and the face, should be seeded with cover crops and mulched. The face may require erosion blanket or other materials to protect soil from erosion.

23. EMERGENCY EROSION CONTROL MEASURES

<u>Background: Emergency Erosion Control Measures</u>

During the first rainy season a new vineyard is the most vulnerable to erosion. There are a number of temporary, or emergency, erosion control measures which can be installed both prior to the onset of winter and during the rainy season as problems arise. These measures provide soil protection, or reduce the movement of soil into waterways, and protect fish

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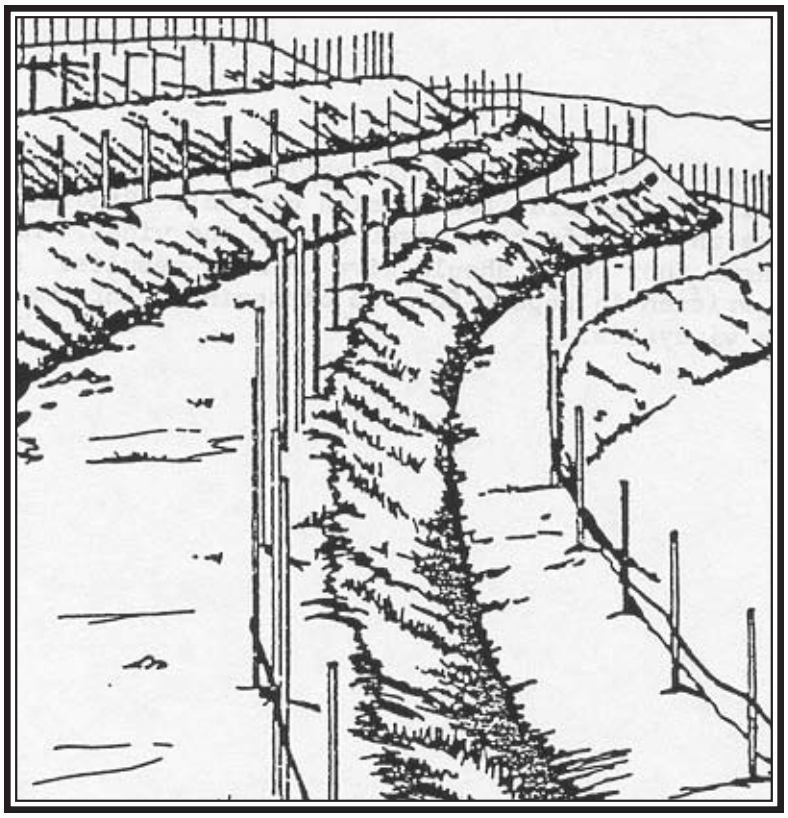

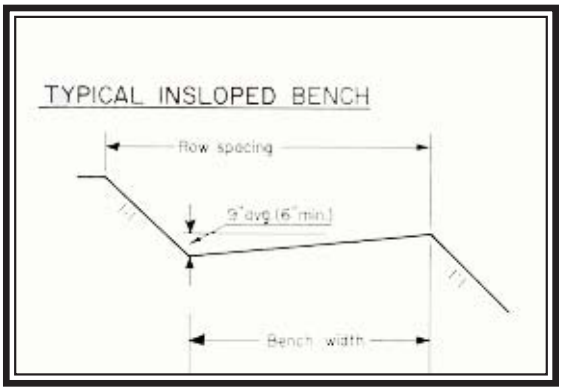

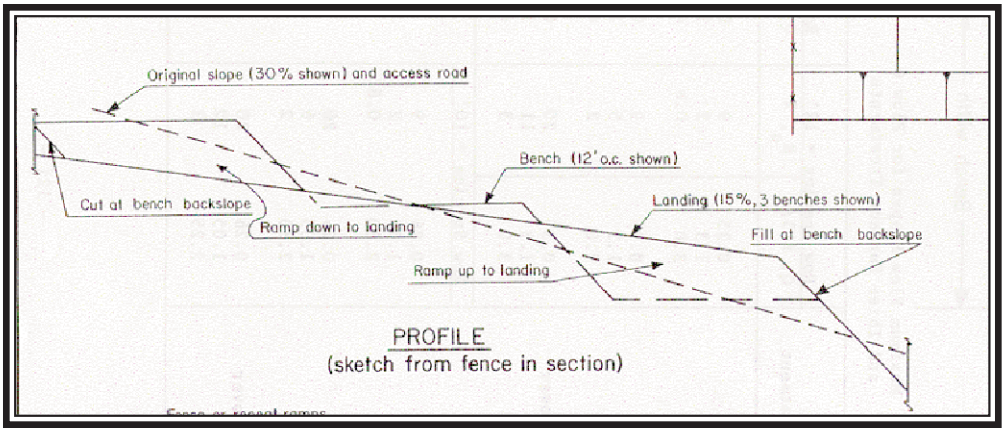

Fish Friendly Farming Environmental Certification Program	SPECIFICATIONS FOR TERRACE BENCH

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PHOTOGRAPHS SHOWING VARIOUS PROBLEMS WITH TERRACED VINEYARDS. YEARLY INSPECTION AND MAINTENANCE OF TERRACE AND DRAINAGE SYSTEM IS REQUIRED. YEAR ROUND COVER CROPS PROVIDE ADDITIONAL PROTECTION FOR SOILS.

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habitat for the rainy season. These measures are short-lived and only last for the rainy season, or even one large storm event.

The most important part of using temporary measures is to have materials on-site and be familiar with installation methods before the rainy season. It is also important to inspect the new vineyard often to make sure small erosion problems are addressed quickly.

APPLYING SITE INSTALLATION BMPs: EMERGENCY EROSION CONTROL MEASURES

Soil surface protection

- **Mulching**- Straw mulch should be spread over the vineyard site after the cover crop has been seeded. The mulch provides an extra-added layer of protection until the seed germinates. The mulch should be applied at a rate of 2 tons per acre, cover 80-100% of the ground surface and be anchored, or punched, using hand tools, rollers or other non-compacting equipment. The straw can also be sprayed onto the site with a tacking agent to bind it together. Field roads may also be mulched.

- **Composted Clean Green Mulch** – This type of mulch is effective in the control of erosion from hillside vineyards. The mulch is spread under the vine row and in the avenues to protect surface soil layers. Care should be taken to avoid piling mulch against vines. The mulch is created from municipal garden waste and is composted to kill weed seeds. Studies from the California Integrated Waste Management Board have found that the composted mulch is effective for 2 years.

- **Jute Netting** - Jute netting can be used on steep areas where straw cannot be anchored. This practice is appropriate for bench terrace faces and the netting should be anchored with staples or pins. Anchor pins should be rigid galvanized wire with a minimum length of 10 inches. Staples should be U shaped and have two prongs of 6 inches in length. Netting should be overlapped by 12” along the edges to assure coverage of soil.

- **Erosion control blankets** –These blankets are made of biodegradable material that covers over the soil. These are also used on steep sites such as the faces of terrace benches. The treated areas must be reasonably smooth and the blanket must be anchored over the site with an overlap of several inches between each blanket. Each manufacturer has slightly different directions for anchoring the blanket.

Intercepting surface soil movement

- **Silt fence** – A barrier of filter fabric cloth stretched between fence posts is called a silt fence and is placed across a slope to reduce surface soil movement. The posts need to be firmly anchored three feet into the ground, or an adequate depth for the soil type and slope. The fabric is stretched tightly and firmly trenched several inches into the slope surface. Posts should be four feet apart or less and staples on the fabric should be on the uphill side of the silt fence. Silt fences are often used at the base of the slope. A series of cross-slope silt fences can be used from top to bottom of the slope.

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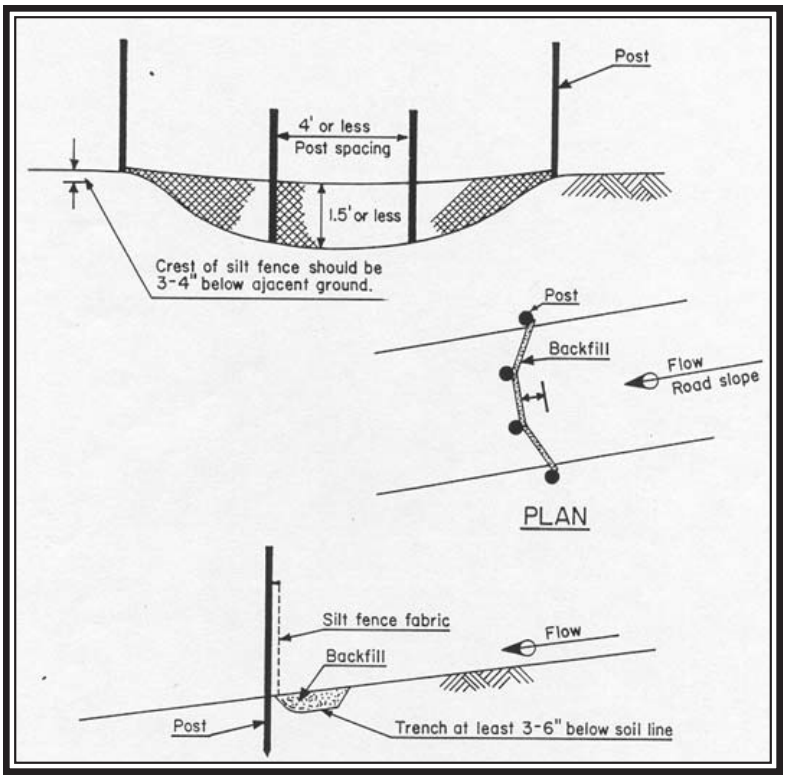

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL SILT FENCE

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- **Straw wattles** – Straw or other fibers bound in a cylindrical casing can be used in a similar manner as strawbales. The wattles can be transported by hand and have to be anchored by stakes, or rebar, driven into the ground 1.5 to 2 feet. The wattle needs to be set into the ground and two can be staked together. They can be installed in a series on the contour of a slope, or perpendicular to the flow path.

- **Strawbale waterbars** - Strawbales can also be used to create a temporary water bar across a road or a temporary sediment barrier to protect a drop inlet from siltation. A series of strawbale checkdams, or waterbars, may be needed for a long slope. They should cross the entire width of the slope and be spaced to allow for sediment accumulation between. There are also erosion control products such as "sediment logs"which can be used in the same way as the strawbales. The length of slope, or area above each strawbale waterbar should not exceed 100 ft. or one acre.

- **Temporary sediment basin** – A temporary sediment basin is used during the first winter to catch and settle out sediment before it can enter a waterway. These are usually placed at the base of a slope, or drainage area. Sediment basins are designed for small watershed areas (no greater than 5 acres) and small storm sizes (10-year recurrence interval). A small basin can be created from compacted soil, rocks, or straw bales. The embankment should not exceed four feet in height and a drain, or outlet, restricts flow from the basin to allow for sediment to be trapped. A small berm, or square of strawbales, can be created around the drop inlet of the new vineyard drainage system to reduce siltation. Be sure that the strawbales are securely anchored with stakes or rebar.

- **Plastic-lined ditch** - When a vineyard field road, or road ditch, begins to erode plastic can be placed over the eroding site to reduce soil loss temporarily. Strong plastic should be used to avoid puncture by rocks and sticks. The plastic sheets should be anchored so that surface runoff, or wind, cannot move the plastic. Stakes, or rebar, are preferable; placing rocks on top of the plastic is not sufficient. Sheets of plastic should be overlapped a minimum of 12 inches and tightly staked at the overlap. The maximum length for the plastic lining is 400 ft.

There are many other erosion control products on the market. Always use them as the manufacturer recommends and install them according to directions.

24. ADDITIONAL EROSION CONTROL

Background: Additional Erosion Control

Steep hillside vineyards can incorporate several types of permanent erosion control: permanent cover crops over the entire vineyard floor, terrace flat and face, adequate sized filter strips between the vineyard and all waterways, permanent sediment basins to intercept soil and protect waterways. Cover crops are discussed in Element III and are a required part of the Farm Conservation Plan. Filter strips and sediment basins must be designed into each project and sized accordingly.

APPLYING SITE INSTALLATION BMPs: ADDITIONAL EROSION CONTROL

Filter strip - A strip of dense grass, or other vegetation, between the vineyard site and waterways serves as an additional protection against siltation in streams. Surface flows

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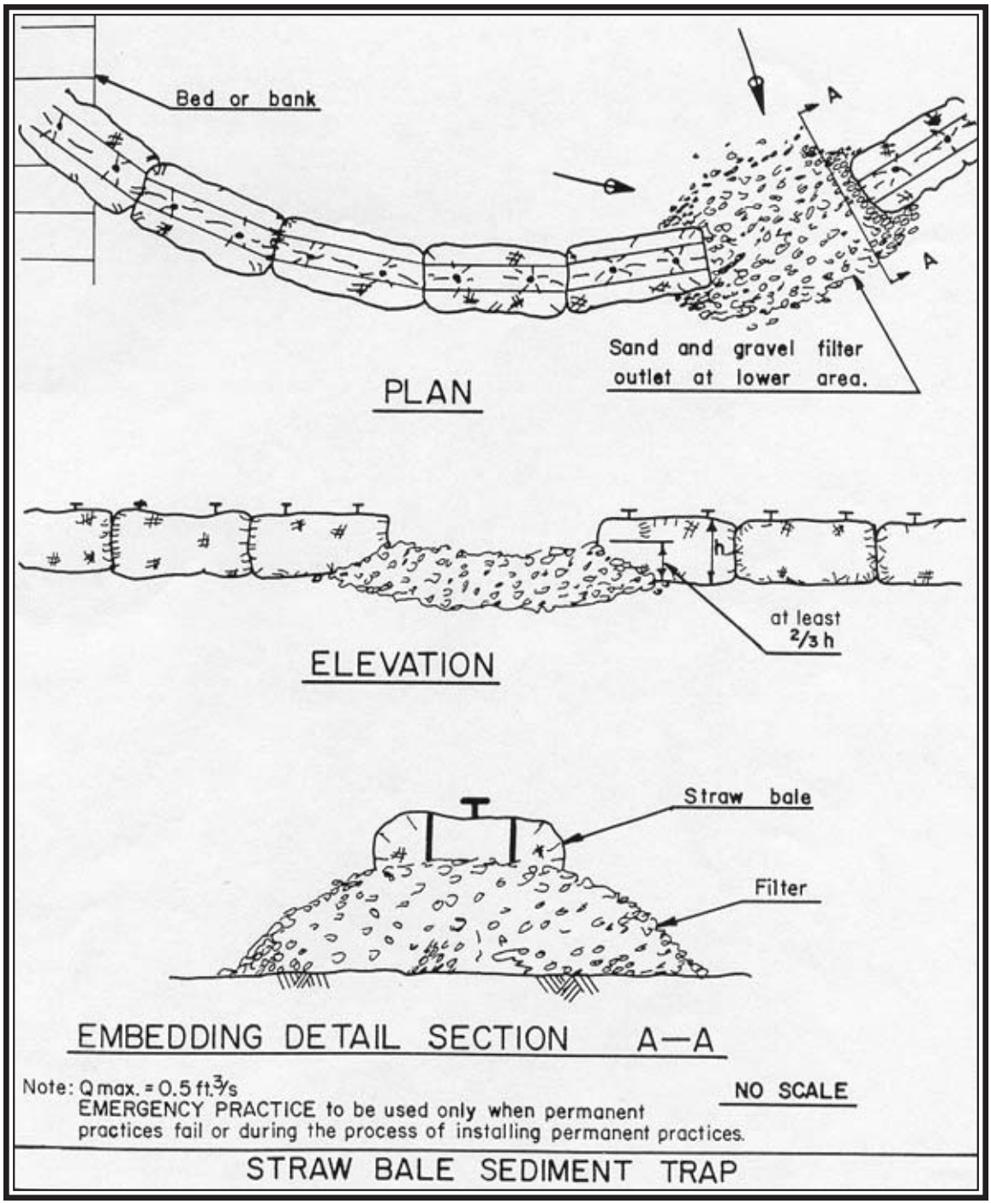

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE SEDIMENT TRAP

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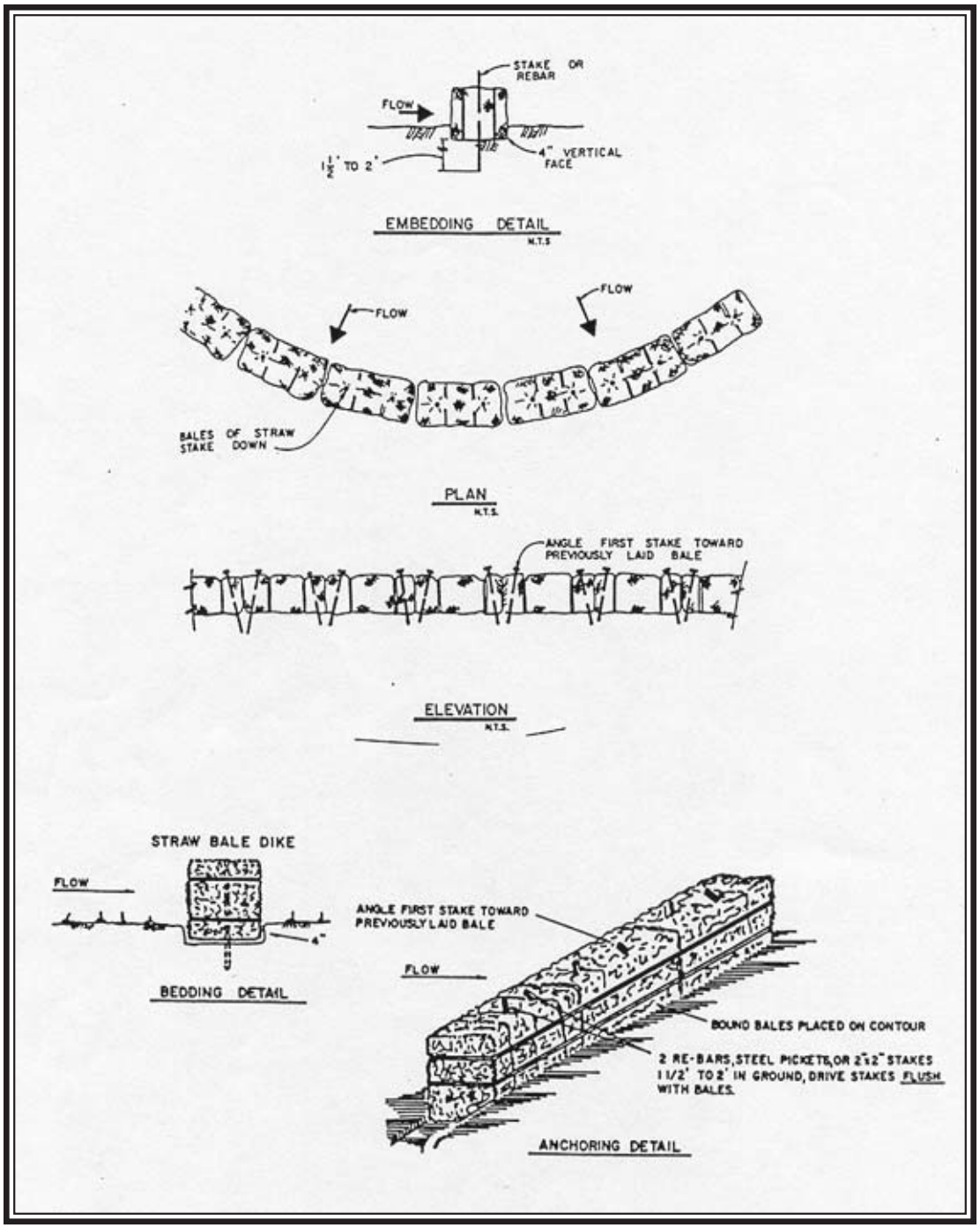

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE BERM

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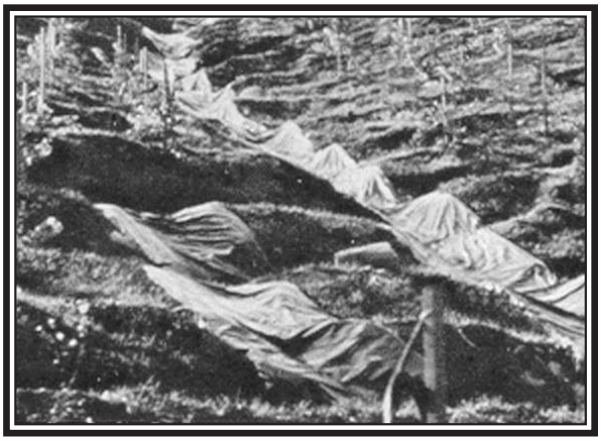
INSTALLING EROSION BLANKET - A TEMPORARY FORM OF EROSION CONTROL- BLANKET MUST OVERLAP AND AND BE INSTALLED WITH STAPLES OR STAKES.

PLASTIC SHEETING CAN PROVIDE SOME EMERGENCY EROSION CONTROL FOR ONE STORM BUT MUST BE CHECKED FREQUENTLY AND REPLACED.



STRAW WATTLE STAKED IN EROSION SITE

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carry soil through the filter strip before reaching the waterway. The dense grass slows the water and catches the sediment providing another protective measure. The filter strip should include these features:

- ❑ Filter strips should be planted along all the waterways adjacent to the vineyard. Filter strips may also be used across the vineyard slope between blocks of vines as an additional practice to reduce sediment movement though sheet flow.

- ❑ The size of the filter strip varies according to the slope of the area draining to the strip. For slopes of less than 1%, the strip should be at least 10 ft. in width and increase proportionate with the increase in slope up to 25 ft. in width for slopes of 30%.

- ❑ Plant the filter strip in September to allow for adequate vegetative cover to develop. Plant density should be a minimum of 80% and may consist of annual grasses or native bunchgrasses. Fertilization and irrigation may be needed.

- ❑ Do not till the filter strip until after April 30 to provide the greatest degree of protection. If frost is a concern and the strip is near to vines, it can be mowed.

- ❑ Depending on the site the filter strip area may be further enhanced as a permanently vegetated buffer. Native species should be used and chosen carefully to promote beneficial insects or block the movement of pest insects. Additional amenities such as bat boxes, raptor and owl roosts may increase wildlife values and take advantage of the benefits of these animals for control of insects and rodents. However the use of these additional plants should not reduce the basic cover of grasses needed for catching sediment.

Sediment basin – Sediment basins are usually located at the downstream end of a vineyard drainage system and meant to settle out eroded soil. Basins can be effective in some locations, but also require frequent clearing out. Temporary sediment basins, during and for several years after, vineyard development can be effective in reducing movement of sediment into waterways. Typical sediment basins are designed to accommodate the runoff from a 10-year frequency 24-hr duration rainfall event without overtopping. The basin is created by constructing an embankment, basin emergency spillway and a release structure, such as a standing pipe. Sediment basins may be located at the bottom of the vineyard slope where drainage enters a natural waterway. These basins should be designed by NRCS, or a civil engineer, on a site-specific basis and installed using proper construction and compaction for the berm and correct sizing and construction for release structures and spillways. The basin should not be located on a stream.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share and grant funds.

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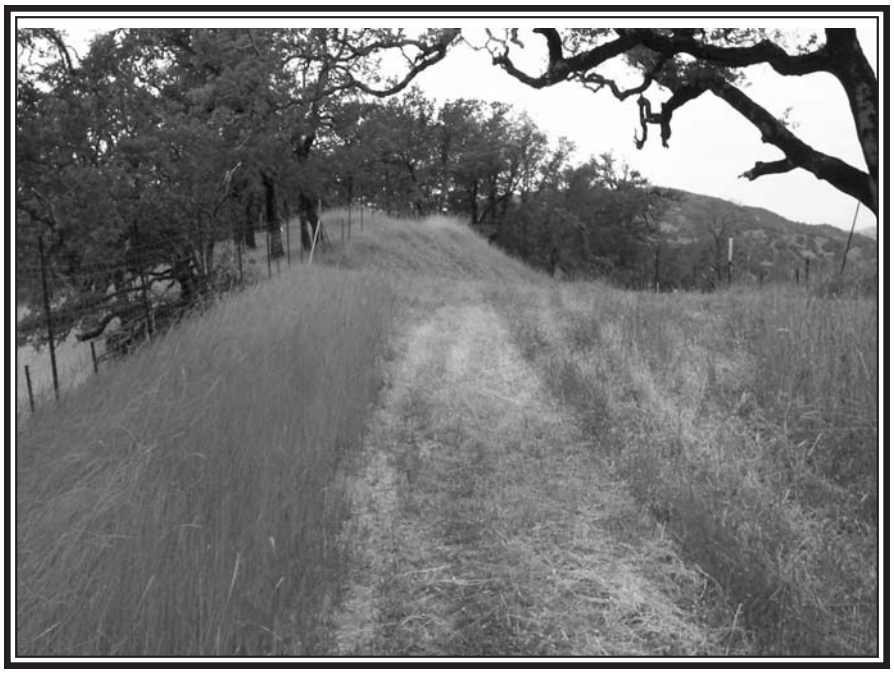

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FILTER STRIPS OF DENSE GRASSES AT THE BASE OF A VINEYARD CAN PROTECT WATERWAYS FROM SEDIMENTATION.

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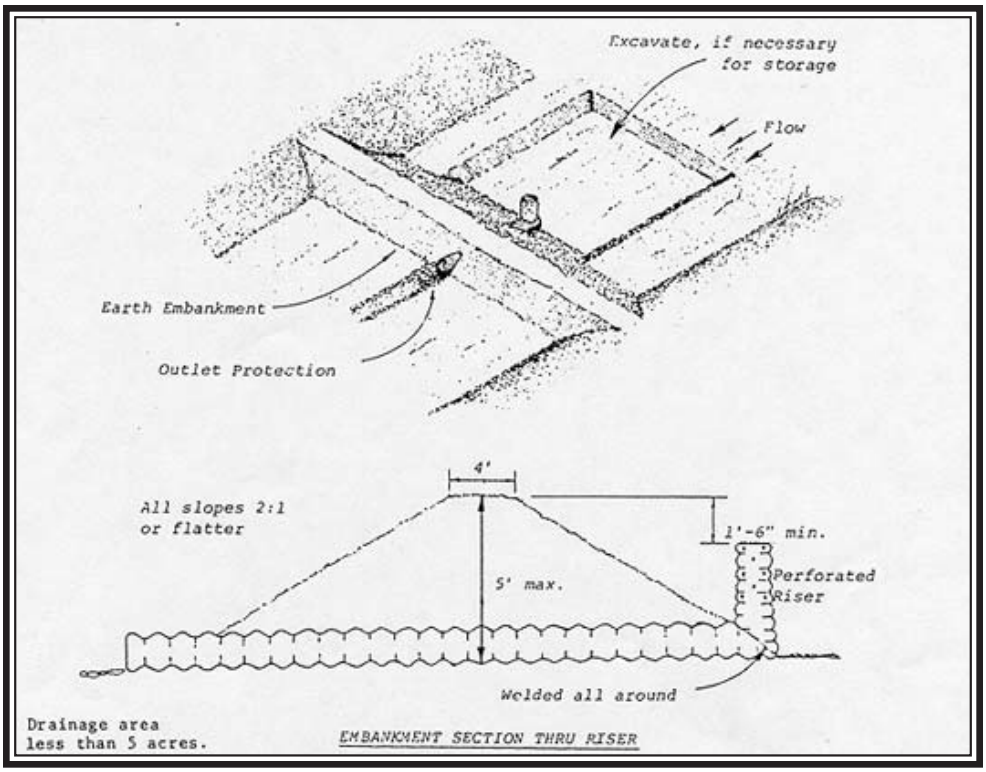

Fish Friendly Farming Environmental Certification Program	SEDIMENT BASIN

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APPENDICES

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APPENDICES
Available upon request

Appendix 1	**Universal Soil Loss Equation** (Source: *The Universal Soil Loss Equation: Special Applications for Napa County, California. 1994. USDA Natural Resources Conservation Service.*)
Appendix 2	**Modeling of Stormwater Discharges** (Source: *Laurel Marcus and Associates*)
Appendix 3	**Wildlife Friendly Fencing Concepts** (Source: *Wildlife Friendly Fencing Guidelines v05.19.02. California Department of Fish & Game.)*
Appendix 4	**Water Supply** (Sources: State Water Resources Control Board *Policy for Maintaining Instream Flows in Northern California Coastal Streams Status Update. December 2008. State Water Resources Control Board.*
Appendix 5	**Guidelines for Salmonid Passage at Stream Crossings** (Source: *Guidelines for Salmonid Passage at Stream Crossings. September 2001. National Marine Fisheries Service.*)
Appendix 6	**A Method for Determining the Width of the Riparian Corridor: Adapted for the Napa River Watershed** (Source: *A Methodology for Determining the Width of the Riparian Corridor Adapted for the Napa River Watershed. Dennis Jackson.*)
Appendix 7	**Certification Process** (Source: *Fish Friendly Farming Program*)

FISH FRIENDLY RANCHING™
ENVIRONMENTAL CERTIFICATION PROGRAM
BENEFICIAL MANAGEMENT PRACTICES WORKBOOK

CALIFORNIA LAND STEWARDSHIP INSTITUTE

Fish Friendly Ranching® Environmental Certification Program

Fish Friendly Ranching® Environmental Certification Program is a project of the California Land Stewardship Institute (CLSI) a not for profit organization.
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Funding for the implementation of the Fish Friendly Ranching® Environmental Certification Program is provided by:

Ca. State Water Resources Control Board

ELEMENT 1 SITE FEATURES
RANCH CONSERVATION PLAN

INTRODUCTION

The Fish Friendly Farming (FFF) Environmental Certification Program started in 1997 in the Russian and Navarro River Watersheds to address water quality and aquatic and riparian habitat improvements on vineyard properties. The California Land Stewardship Institute (CLSI) now runs the FFF program in 5 counties for a large number of crops.

The primary water quality concerns in the north coast and San Francisco Bay Area are fine sediment and pathogen pollution and high water temperatures. Various water bodies are listed by the State Water Resources Control Board (SWRCB 2010) as impaired by these pollutants including:

- Russian River - fine sediment and temperature; and in some locations, pathogens (also termed indicator bacteria) and nutrients
- Navarro River - fine sediment and temperature
- Gualala River - fine sediment and temperature
- Garcia River - fine sediment
- Eel River - fine sediment and temperature
- Napa River - fine sediment, pathogens and nutrients
- Sonoma Creek - fine sediment, pathogens and nutrients
- Tomales Bay - fine sediment and pathogens

In most of these watersheds, there are numerous sources for each pollutant distributed over the drainage basin. In the majority of these watersheds, TMDL studies have identified dirt roads as a major source of fine sediment. Livestock operations may have sediment sources depending on site topography, soil types and management practices.

The purpose of the Fish Friendly Ranching (FFR) Environmental Certification Program is to provide a voluntary certification program that will provide compliance with the TMDL and provide for improvement to aquatic and riparian habitats while sustaining economically viable ranching operations.

As part of developing this version of the FFR program, a Technical Advisory Group (TAG) was formed. Table 1A lists the members of the TAG. Between 2010 and 2011, the TAG reviewed and approved a set of goals (Table 1B) for the program, reviewed and discussed draft versions of the ranch plan template and Beneficial Management Practices (BMP). Regulatory waivers of waste discharge requirements (WDRs) for dry land grazing and other issues were also discussed. The California Land Stewardship Institute has always run the FFR program as a voluntary program and collaboration with landowners and will continue to do so even if a FFR certification serves as a regulatory approval.

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Table 1A Technical Advisory Group

Technical Advisory Group		
Name	**Affiliation**	**County**
Dave Garden	rancher	Napa
Ted Hall	rancher	Napa
Erica Ahmann	rancher	Napa
Christina Roberts	rancher	Napa
Dan McQueeney	rancher	Napa
Mary Keilman	rancher	Napa
Bill Hardin	rancher	Napa
Rico Duazo	RWQCB2	Napa
Carmen Fewless	RWQCB2	Napa
Jim Ponton	RWQCB2	Napa
Joe Dillon	NOAA	both
John Harper	UC Coop Ext.	Mendocino
Larry Ford	consultant	both
Devon Jones	Mendo Farm Bureau	Mendocino
Jack Rice	CA Farm Bureau	Mendocino
Amy Trainer	environmental org.	Mendocino
Ben Zabinsky	RWQCB1	Mendocino
Scott Gergus	RWQCB1	Mendocino
Carol Mandel	NRCS	Mendocino
Sarah Bennett	rancher	Mendocino
Lisa Weger	rancher	Mendocino
Larry Mailliard	rancher	Mendocino
Peter Bradford	rancher	Mendocino
Janet King	rancher	Mendocino
Ruthann Schulte	The Buckeye	Mendocino
Karin Strykowski	rancher	Mendocino

Table 1B Goals for Fish Friendly Ranching Program

List of Goals
Maintain good water quality and aquatic and riparian habitat conditions
Create a program to comply with environmental rules but which also sustains economic use of the land
Create one program that addresses many regulations to reduce paper work and time expended
Keep compliance costs down by seeking cost share and grant funding to cover technical and project costs
Create a program which will provide a long term defensible plan for owner and which sustains water quality
Maintain privacy of detailed ranch information

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SOURCES OF SEDIMENT

Soil erosion is a natural process that can be significantly increased by changes to the landscape and land management practices. There are several different physical processes that move soil off the land and can produce fine sediment pollution in waterways. Management measures to address erosion problems are selected based on the erosion process occurring so it is important to properly diagnose the erosion problem.

Sheet Erosion

When raindrops strike bare ground, particles of soil are loosened from the soil surface. Runoff then may move the soil off the ground surface in a sheet of water or as sheet flow. Sheet erosion is not visible, but can generate tons of soil loss per acre each year. The soil moved by rain strike and sheet wash may not immediately move into a creek, but can be transported by subsequent storms into a waterway.

Sheet erosion is difficult to measure, but it is often estimated using the Universal Soil Loss Equation (USLE). This equation is stated as:

$$A=R*K*LS*C*P$$

Where

A= potential long term average annual soil loss in tons per acre per year

R= rainfall and runoff factor

K= soil erodability factor

LS= slope length/gradient factor

C= crop/vegetation management factor

P= support practice factor

Another factor used is the Tolerable Soil Loss or T value which is the maximum soil loss that can be tolerated and still allow a sufficient level of soil productivity.

Many of these factors, such as R and K, are provided in the County soil survey. The R factor is based on the intensity and duration of rainfall events. The K factor is the susceptibly of soil particles to detach and transport by rainfall and runoff. Soil texture is the principal factor affecting K values. The slope length and gradient factor (LS) is site specific. The steeper and longer the slope, the higher the erosion risk. The R, K and LS factors are defined by the physical features and climate at a particular site.

The C factor is most affected by land management practices and the amount of vegetative cover protecting the soil. The P factor is also affected by land management practices and represents the use of practices that effect water movement, runoff and erosion.

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Once the value for A is calculated, it is compared to the T value for the soil type. Typical tolerable rates of soil loss are in the range of 2-3 tons/acre/year.

Specific management measures to reduce sheet erosion are described in Element 2 for grazing operations and Element 3 for dirt road surfaces.

Rill Erosion

Unlike sheet erosion, rill erosion is visible as small channels or rills on the land surface. Runoff concentrates into small channels on bare or nearly bare ground. If sheet erosion occurs, it may progress to rill erosion during more intense or long duration rainfall events or due to a lack of management measures to protect the bare soil surface.

Rills occur when the ability of stormwater runoff to erode exceeds the shear strength of the soil or its ability to resist erosion. Slope has a major effect on the velocity of runoff and therefore its ability to erode soil. Soils made of sand and loam are more susceptible to rill formation than soils with large amounts of clay or rock/gravel.

If rills are left untreated, they can become gullies. Management measures to address rills are discussed in Elements 2 and 3.

Gully Erosion

Gullies are large erosion sites, up to 75 feet deep, which can form at the outlets of culverts and pipes where flow is released at a high velocity and thus has an increased ability to erode. Gullies may also form in ephemeral creeks, or swales, on hillsides where the surrounding drainage area is changed significantly through soil compaction, paving or vegetation removal. These changes to the drainage area increase the speed and volume of stormwater runoff into the ephemeral creek channel and can cause erosion. Rilling along a dirt road can result in a gully if not treated. Inadequate stream crossings where water over flows and goes down the road can also be a cause of rilling.

Gullies erode at the head cut and move up slope. A gully will deepen and then widen and may become very large if erosion control is not implemented. Management measures for gully erosion are discussed in Elements 2 and 3.

Landslides

Landslides, also termed mass movements, are of different types but are all large visible erosion sites. Landslides usually occur from a geologically unstable feature in a hillside. Landslides occur during prolonged wet periods and can be affected by roads, the removal of woody vegetation and the structural support provided by the root system, changes in the direction or volume of runoff or stream flow, and other activities. Landslides are a natural feature and certain geological formations in our region are more prone to mass movements, including Franciscan Formation and Great Valley Sequence.

Management measures related to roads and landslides are discussed in Element 3.

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Channel Entrenchment

Stream channels are formed by the flood flows and sediment supply from their watersheds. When flood water volumes are increased due to changes in a watershed, such as urbanization or deforestation, or sediment supply is reduced due to on-stream reservoirs, the channel may start to incise or erode into its floodplain. This type of channel erosion typically occurs in alluvial unconfined channels as in valleys and the location of the erosion can be distant from the cause of the erosion. As channel erosion occurs, the channel deepens first eroding the bed and creating a trench-like form. In this entrenched condition, flood flows no longer spread out and slow down on a floodplain and erosion rates increase. Channel erosion can remove the riparian canopy resulting in high water temperatures. Eventually, as the entrenchment progresses, the banks of the channel become too steep and vertical and begin to fail. The channel becomes wider and the collapsed banks may form a new floodplain in the deepened channel. Flood flows can spread out and slow down and the entrenchment process can slow down or end. The full cycle of this process can take decades. If the channel erosion is treated with riprap, erosion will worsen. Specific management measures for channel erosion are discussed in Element 2 for ephemeral creeks and Element 4 for seasonal and perennial streams.

Potential Effects of Livestock on Soil Erosion

The effects of livestock grazing on soils and erosion derive from two basic factors: herbivory and animal hooves compacting soils. Animals eat grasses and herbs differently, so the type of livestock, number within a grazing area, and duration and season of use will affect the level of vegetative cover and thus the sheet and rill erosion potential. These differences also extend to hoof size and weight of the animal causing soil compaction. Compacted soils infiltrate less water and have increased runoff rates causing rills and other types of erosion. Larger heavier animals, like cattle and horses, compact soil to a greater degree than sheep and goats. However the most important factor in soil compaction is the number of animals confined within an area and the duration and season of use.

The effects of herbivory and compaction are discussed in Element 2 for grazing and service areas, and Element 4 for creeks. Another potential effect of livestock operations on soil erosion are roads on the property. Element 3 addresses roads.

RANCH PLAN APPROACH

The approach we have taken to the ranch plan is to focus the field assessment on areas of the ranch where soil erosion and delivery of sediment are most likely to occur. With the assistance of Dr. Lawrence Ford, a rangeland specialist, we have collected an extensive set of references and research on rangeland, and the effects of grazing on water quality and aquatic/riparian habitat. Many of these studies have been carried out by the University of California Cooperative Extension (UCCE). Here are some of the results of these studies:

- Grazing management practices which provide an adequate level of residual dry matter (RDM) for the wet season are protective against sheet and rill erosion (Bartolome 2006)

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- Soil compaction along cattle trails can act as conduits for runoff to deliver sediment to streams and as a cause of sheet and rill erosion, but grazing areas are not major sources of sheet erosion (George et al. 2004); trampling of the trails keeps the soil surfaces bare, loosens sediments, and reduces infiltration. Cattle trailing increases as the distance between forage sites and watering sources increases, especially in steep terrain, and can be particularly evident where the trails cross stream channel; trailing can be reduced with addition of stock watering facilities away from the streams and near forage sites.
- There are some indications that historic or legacy erosion sites are a larger source of sediment than current grazing practices (Lewis et al 2001).
- Grazing management in riparian areas can reduce effects on riparian plants and stream bank erosion if livestock use is limited in animal numbers, time and duration (Ward et al 2002).
- Large scale removal of oaks and chaparral to increase grassland area can result in slope instability and mass movements (Dahlgren et al 2001).
- A study using a qualitative assessment of stream and riparian habitat conditions and the effects of grazing in meadow/valley unconfined channels found the greatest improvement in habitat where grazing practices were employed that rested fields (no grazing) between grazing periods, herded animals away from streams, placed attractants away from streams, and spent time placing and repairing those attractants (Ward 2002); the data for confined channels was too small for similar conclusions.
- The effects of livestock on soil erosion and water pollution at a particular site depend upon features of the site and the planning of grazing management strategy and practices to both achieve conservation objectives and sustain the grazing operation; key manageable parts of the plan should include appropriate stocking rates, season of use, arrangement of fences and grazing fields, distribution of off-stream watering sources and attractants, distribution of service areas where livestock congregate, location of compacted livestock trails and creek crossings, and location and size of vegetated buffers (George 1996; Tate 2010).

We have incorporated these research results into the Beneficial Management Practices (BMPs) for this program. The ranch plan will be comprehensive but focused on areas of high erosion potential. A general inventory will be done of the entire ranch documenting natural features such as slopes, creek network and soils. Then grazing areas, service areas, water sources and other facilities are mapped. The FFR staff will review the maps with the rancher and map areas inaccessible to livestock, such as steep-sided creek canyons and swales. In these areas only livestock crossings would need to be evaluated. Roads will also be evaluated by level of use to identify those with the highest likely level of sheet erosion. Roads will also be evaluated for slope and unstable slope conditions. Blue line creeks will be evaluated for sediment sources, canopy cover and wildlife habitat.

The plan is completed by the FFR staff in conjunction with the rancher. The FFR program consists of several steps:

- The rancher enrolls the property with the program.

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- The FFR staff create custom aerial photo maps and slope, soil, creek network and topographic maps of the property.
- The rancher attends several workshops to review the BMPs and the ranch plan template.
- A site visit is scheduled and the FFR staff work with the rancher to complete road and creek assessments and mapping and collect the information needed for the ranch plan.

A sediment source inventory is included to provide for compliance with the fine sediment TMDL. For each identified sediment source, BMPs are discussed with the owner/manager and are listed with a time table for implementation. If there are major erosion sites, the FFR program will seek funding for a repair project.

Once the ranch plan is complete, the rancher can have the site certified. A certification team made up of resource agencies, Regional Water Quality Control Board, National Marine Fisheries Service and the _____ will evaluate the farm plan and perform a site visit. The FFR program staff assists the rancher in presenting the Ranch Conservation Plan. The certification is based on the completeness and accuracy of the site inventory in documenting the natural resources of the site, current practices and all needed BMPs and a reasonable timeline for implementation of additional BMPs and projects as needed. The certification process is meant to provide assistance to the rancher and result in a collaborative effort to improve water quality.

Following this review each certifying agency issues a letter specific to the property reviewed stating the Ranch Conservation Plan is certified. If the Ranch Conservation Plan is not certified, then the agencies provide detailed comments on the steps necessary to become certified. Continued monitoring will allow for the landowner to document their practices and land stewardship and demonstrate implementation of the plan. Re-certification will occur on a 5-10 year cycle for most sites.

Use the following directions to complete Element 1 of Ranch Plan template.

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1. LOCATION AND CONTACT INFORMATION

This section should summarize the address and contact information for the property.

2. TOTAL ACRES

This is the acreage of the entire ranch.

3. RANCH HISTORY

Describe the history of the site in particular past land uses that are different from the current use and any major alterations to the ranch such as large scale clearing of woody vegetation.

4. WATERSHED LOCATION

What river drainage is the site located in? List the main tributary creeks located on the site.

You will receive aerial photographs and topographic maps of your property as part of enrolling in the FFR program which includes this information.

5. MODULES

Depending on what watershed the site is in different modules may need to be part of the ranch plan. The modules include: fine sediment, pathogens (indicator bacteria), water temperature.

6. ADDITIONAL INFORMATION

This is an area to explain any site feature that needs more elaboration or to describe previous ranch plans that have been completed and site improvements or changes in management practices implemented on the ranch.

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ELEMENT 2 - MANAGING GRAZING AREAS AND LIVESTOCK RANCH CONSERVATION PLAN

FINE SEDIMENT MODULE

INTRODUCTION

This element of the Ranch Plan focuses on inventorying the natural features of the ranch, the current grazing management system and any soil erosion problems. The FFR staff work in collaboration with the ranch owner/manager to complete this element. The owner/manager has the best knowledge of the site. The ranch plan will document Beneficial Management Practices (BMPs) already in use on the ranch and determine the need for any additional BMPs. The needed BMPs will address only those sediment sources which currently deliver sediment to waterways or which have a very high likelihood to do so. The needed BMPs are determined in collaboration with the ranch owner/manager, and the most economically viable methods will be used. The Ranch Plan covers a 20 year timeframe, allowing the FFR program to work with the owner to seek grant funds and any additional costs to be spread out over many years, reducing economic effects on the operation.

The natural features of a property - its soils, slopes, vegetation and creek network define both the potential for soil erosion and the capacity to support grazing livestock. Each property has a unique set of features which the ranch owner/manager will know best. As part of the grazing operation the rancher makes numerous decisions which can affect water quality positively or negatively. The layout of the ranch facilities such as the proximity of corrals to waterways or the distribution of developed watering sources over the ranch can affect fine sediment generation. Operational decisions regarding the type and number of livestock, timing and duration of grazing in various grazing areas can affect sheet and rill erosion. In most operations there is some flexibility to change the facility location and the grazing operation to address soil erosion and sediment delivery. The ranch owner/manager is the key person in making decisions to meet both livestock production goals and protect water quality. Economic considerations have to be taken into account along with environmental improvements. The focus of this element is to document the features of the entire ranch and then reduce the areas needing field assessment to those where soil erosion is occurring or likely to occur and assess these more vulnerable sites.

INVENTORY OF NATURAL FEATURES

This first step is completing an inventory of the features of the ranch. This section provides the directions for filling in Element 2 of the Ranch Conservation Plan template. FFR staff will create the needed base maps of the ranch and assist the owner/manager to complete this element.

1. FEATURES OF THE RANCH

FFR staff will provide aerials and topographic maps for the ranch with the property boundary on them as available from the County Assessor. Work with the FFR staff to delineate the following areas on an aerial. FFR staff will complete the final digital versions of the ranch plan maps following the site visit, including calculating acres for each area.

- If needed, correct the property boundary on the aerial or topographic map.

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During the site visit, the owner/manager will work with the FFR staff to outline the following on the aerial photo. Give each area a number or name.

- Grazing areas – outline grazing areas on the property
- Special management areas these may include:
  - sensitive soils - highly erodible, high clay content
  - special status species or communities, riparian corridors
  - herd management fields (for example for separation of weaners, bulls, or heifers)
  - auxiliary fields that are fenced off from other grazing areas for livestock grazing under a less restrictive prescription
- Service areas – these are within grazing areas and may include:
  - livestock feeding, loafing, and gathering areas
  - areas adjacent to gates or water troughs
  - staging areas, corrals and truck turnarounds
- Buildings
- Fences
- Watering sources and water distribution system
- Livestock crossings on major creeks
- Manure stockpile areas
- Supplemental activity areas

For each of the numbered grazing areas of the ranch describe your grazing operation (cow/calf, stockers, sheep, goats or horses) and the typical months used for grazing.

Additional Information and Wildlife Issues
Please describe any problems with wildlife, such as wild pigs plowing up hillsides or locations or excessive grazing by deer.

2. SOIL TYPES AND EROSION RATING

Background: Soil Types

Soil is the fundamental resource for all types of agriculture and determines the potential for erosion. Soil is formed through the slow weathering of the parent rock material through physical and chemical processes. Soils take thousands of years to develop and vary greatly in their depth, texture and properties including erosion potential. Livestock producers are economically dependent on protecting soils and managing for long-term soil health. One ranch will have a number of soil types.

As part of enrolling a ranch, the FFR staff will prepare a soil map for the ranch. Soil types and other information on soil features can be viewed at the NRCS Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/websoilsurvey.aspx)

How to find soil information using the Web Soil Survey (WSS):
- Go to: http://websoilsurvey.nrcs.usda.gov/app/
- Click on the green “START WSS” button.
- Click on the Area of Interest (AOI) tab on the top left.
- Click on down arrows to expand “Quick Navigation” and enter the site address.

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- Above the Area of Interest Interactive Map to the right, you can zoom in, out, or pan so that your entire site is in view. Select a red AOI button to draw a polygon that represents your site.
- • Click on the “Soil Map” tab at the top to get a table of the soil types, slopes, and the acres and percent in your AOI below the map.

To find the erosion hazard rating:

- • Click on the Soil Data Explorer tab, select “Suitabilities and Limitations for Use.”
- • Click the down arrows to the right of “Land Management” to expand the list and select
- “Erosion Hazard (Off-Road, Off-Trail). Check all the boxes.
- • Click the “View Rating” button. The Rating column in the table below the map will give

you the erosion hazard.

To find the permeability rating:

- • Under the Soil Data Explorer tab, click on the “Soil Properties and Qualities” tab.
- • Click on the down arrows next to the “Soil Qualities and Features” heading to expand the list and select the “Drainage Class” heading.
- • Check all the boxes and click the “View Rating” button. Permeability rating appears below the map.

Soils are grouped into series according to their physical properties. Within each soil series are various soil types. For example, the Haire soil series has several soil types: Haire loam, 0 to 2 percent slopes, Haire loam, 2 to 9 percent slopes, Haire clay loam 0 to 2 percent slope, Haire clay loam 2 to 9 percent slopes, Haire clay loam 9 to 15 percent slopes and Haire clay loam 15 to 30 percent slopes. These soil types are also called mapping units in the Soil Survey and their extent is delineated on the maps included in the Soil Survey (USDA 1972; USDA 1996).

Each soil series and type is described in the County Soil Survey. For example:

"Haire Series

> *"The Haire series consist of well-drained soils on old terraces and alluvial fans. Slope is 0 to 30 percent; elevation is 20 to 300 feet. These soils are formed from alluvium derived from sedimentary rock. The vegetation in uncultivated areas consists of annuals grasses and forbs.”*

The description of each type of Haire soil includes a description of runoff and erosion hazard characteristics. For example:

> *"Haire clay loam, 9 to 15 percent slopes (149). Runoff is medium and the hazard of erosion is moderate.*
> *Haire clay loam, 15 to 30 percent slopes (150). Runoff is rapid and the hazard of erosion is moderate."*

Soil types also include a range of slopes. The change in slope for a soil type changes the erosion rating. The slope classes typically used are:

0 - 5 % or 0 - 9%
5 - 15 % or 9 - 15%
15 - 30 %
30 - 50 %
50 - 75%

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Range management information is also available from the NRCS Soil Survey. The NRCS Web Soil Survey can be accessed on the Internet (http://websoilsurvey.nrcs.usda.gov/app/), and can be used to obtain soils information, including and erosion hazards.

Site Inventory: Soil Types

- The FFR staff will create soil maps for your ranch and a table of soil types and features for each grazing service and special management area.

- Review the soil features - slope classification, permeability, runoff, and erosion rating and list in the template for each grazing area, special management area and service area.

3. SLOPE

Background: Slope

Slope has an enormous effect on soil erosion. Slope magnifies the effects of water runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage and mass movement. Steep slopes (greater than 30%) have high to extreme erosion hazards for most soil types. The slope classifications listed in the Soil Survey are generalized and a more specific measurement of slope is often needed for site evaluation.

USGS topographic information is available in digital format. As slope is such an important part of soil erosion, the FFR staff will produce a map of slopes for enrolled ranches. The map will depict lands in a range of slope classes 0-10%, 10-20%, 20-40%, >40%. The resolution of the data used to create maps is defined by the area covered by one pixel on the computer screen. The topographic information, called a Digital Elevation Model (DEM), typically has a resolution of 10 meters (38.3 ft.) per pixel. This resolution is useful for the ranch plan and for evaluating general erosion potential in grazing and other areas. This level of resolution, however, will not depict small areas of steeper or flatter land.

Site Inventory: Slopes

- Using the slope classification map created for the site, determine the primary slope class for each grazing, special management and service area and fill in the template. This would be the slope class that covers most of the area. The maximum slope class should also be listed.

- Slope can be field checked during the field assessment for subareas by using a clinometer.

4. NATURAL DRAINAGE FEATURES

Background: Natural Drainage Features

Watersheds include a network of creeks and channels that stretch from the ridge tops to the main river channel. This network conducts surface water flow and sediment and consists of a variety of channels. Creeks that only carry water during and shortly after storms are called ephemeral streams. Many hillside channels are steep and carry water only during large storms.

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Steep ephemeral creeks may have dense woodland, chaparral or large boulders. In flatter areas, ephemeral creeks may be grass swales.

Downstream of ephemeral creeks are intermittent or seasonal streams and perennial, or year round creeks. Seasonal streams often flow well into the dry season.

Assessing the location and condition of this drainage network and its relationship to a grazing operation is an important part of the Conservation Plan. Fish bearing streams are typically perennial and seasonal creeks with summer pools. Ephemeral drainage networks supply sediment and flood flows to fish bearing streams. Restoring and managing ephemeral drainages is often the best method to reduce sediment delivery to larger creeks. Ephemeral creeks can erode to large gullies and become major sources of fine sediment. A major change in the creek such as vegetation removal, or increased volumes of storm runoff from a road culvert or compacted soil area, can initiate erosion and head-cutting in the ephemeral creek channel. Over time, the channel will deepen and widen, forming a gully.

Since the drainage network of a large ranch will have numerous creeks, we need to eliminate all the areas which are inaccessible to livestock. Steep sided canyons and swales limit livestock and do not need assessment. Some creeks may have a livestock crossing that needs assessment, but the remainder of the creek is inaccessible. This approach will serve to simplify the field assessment and ranch plan.

Site Inventory: Natural Drainage Features

- On a USGS topo map, year-round streams are indicated with solid blue lines. Seasonal creeks are indicated with dashed blue lines. Although the topo quads are very accurate maps, it is not unusual for a creek indicated as year-round to dry up in the summer. The maps are based on aerial photographs from a particular year and season and are field checked for general accuracy. Each map does not necessarily depict creek flow conditions for every year correctly.

- Ephemeral creeks are not indicated in blue on USGS topographic quads but can be delineated by reviewing topographic contour lines on the map. An ephemeral creek occurs where the contour lines on the topographic map indicate a set of V's pointing up the slope. As part of the FFR program, a map of the creek network will be generated.

- Tell FFR staff about any major seeps, springs, or wetlands on the property.

- The FFR staff will use a computer GIS program to generate maps of the ranch with the creek network delineated. This network includes the blue line creeks and ephemeral creeks. FFR staff will also delineate the creeks that are confined and over 20% slope or have other conditions that limit livestock access and review the maps with the owner/manager to refine the network assessment. Only the unconfined and lower slope creeks, where livestock have access, will be assessed. Depending on the type of livestock using the ranch (sheep, goats, cows) the stream slope considered inaccessible may vary.

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ASSESSMENT AND SEDIMENT SOURCE INVENTORY

5. GRAZING AREA MANAGEMENT

Background: Livestock Grazing

The type and number of livestock along with grazing area management will determine sheet and rill erosion on the site.

Kinds of Livestock
Ranchers select livestock to efficiently and productively utilize their rangelands, and sometimes to follow their family's tradition or preference. Livestock are distinguished by kind, breed, and class. Kind refers to the species of livestock, such as cattle, sheep, goats, horses, and numerous specialty grazing animals, including bison and llamas. Free-range chicken can also be included under specialty grazing animals. Breed refers to genetic heritage, such as Hereford cattle or Black Angus cattle. Class refers to sex, age, and functional distinctions, such as steer, heifer, or cull cows. Kind, breed, and classes may be segregated or mixed.

Livestock suitability for a grazing site differs mainly due to the topography, soils, climate and vegetation of the affected rangeland as well as the presence of predators and socio-economics of the operation.

Landscape and Climate
Cattle and horses are adapted for level and moderately sloped terrain, leaving the steeper terrain less utilized. European cattle breeds are better adapted to cooler climates while African cattle breeds are better adapted to hot humid climates.

Sheep and goats are better adapted for steep and rocky landscapes and can utilize all kinds of terrain. Sheep and goats require less water and are better adapted to dry desert climates than cattle.

Forage
Cattle, horses, sheep, and goats all utilize forage primarily composed of grasses, but utilize forbs and shrubs (also termed browse) in different proportions depending on the rangeland, season, weather (especially drought), and management. Cattle and horses are better adapted to forage dominated by tall coarse grasses. Sheep are better adapted to rangelands with a diversity of forage, including grasses, forbs, and shrubs. Goats are better adapted to shrub lands.

Cattle and horses more frequently uproot forage plants than do sheep and goats. Cattle and horses are heavier with larger hooves, and thus can cause more tramping of plants and disturbance to the soil surface that can result in erosion.

Herding Behavior
The presence of predators, such as coyotes and mountain lions, increase the need for protection of sheep and goats in shelters and by their herders. Sheep and goats are managed to stay in close herds. Cattle and horses are generally able to defend themselves from predators, and thus are rarely grazed in close herds.

The type of grazing operation determines management actions and possible water quality effects. For example a cow/calf operation vs. a stocker operation will need different grazing

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areas at various times of the year, The young stockers are more likely to run-up hills and utilize these areas whereas pregnant cows would be more likely to rest under trees in the shade. These behavioral differences must be taken into account when evaluating the grazing operation.

The effects of livestock on soil erosion on a particular site depends upon a number of site features, including:

- Acreage, number of animals, quantity and quality of forage and period of use of each designated grazing area including fenced enclosure areas
- Distribution of watering sources, supplements and shade area
- Location of supplements and feeding areas such as corrals, loading areas and other sites where livestock congregate
- Location and number of compacted livestock trail and creek crossings
- Location and size of vegetated buffers

It is often possible to adjust the location of a few features of the grazing operation and remove a source of soil erosion. However, the rancher needs to have flexibility in their livestock operation and not incur excessive costs, so changes need to be carefully reviewed and discussed with the rancher.

Management planning for livestock grazing areas includes development of information on type and locations of areas sensitive to grazing, water sources for livestock, and areas vulnerable to erosion. This information is used to guide operational infrastructure and grazing management, including:

- The arrangement of grazing areas and associated facilities - stream crossings, corrals, feeding areas, fencing, and gates
- Development of stock ponds and off-stream watering facilities
- Grazing prescriptions to achieve the specified goals for the property

Such planning is usually comprehensive, addressing multiple goals and related objectives. The planning necessary to maintain and improve water quality on a California ranch with grasslands and savannas dominated by non-native annual grasses and forbs may be less comprehensive, but should address each of the potentially impacting mechanisms associated with grazing as well as incorporate BMPs that are known to benefit water quality in the region.

<u>Grazing Area Management</u>

Livestock grazing is usually managed within designated grazing areas that provide a combination of forage, water, and shelter to sustain the animals. Each grazing area will have access for the livestock operator to provide for the care and movement of the animals during their various daily, seasonal, and life stages. Grazing areas are usually fenced to contain livestock and prevent their escape onto roads or neighboring properties. Fenced areas can also be used to separate different classes of animals (cows, calves, heifers, bulls) and facilitate

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seasonal or rotational grazing management. Grazing areas are usually fenced with permanent posts and wires, but are sometimes fenced with movable materials (such as plastic posts and electrified wire or mesh) to allow more precise and short-term concentrations of the animals.

The arrangement of the grazing areas on a given site typically reflects the natural resources available, and may also accommodate specified management objectives including:

- Improved animal distribution and forage utilization such as increasing grazing of an under-utilized area, saving higher quality forage for pregnant cows, or seasonal rotations to different kinds of forage

- Maintenance of un-grazed filter strips along waterways

- Control of a stand of pest plants, or improving habitat quality for a special-status plant or animal

- Facilitate the care and gathering of the livestock

The primary types of erosion associated with grazing areas are sheet erosion due to a lack of adequate vegetative cover and rill erosion from compacted soils. Measures to reduce these types of erosion include:

- Managing grazing to maintain adequate grass, forb and woody vegetation cover (Residual Dry Matter or RDM) in fall necessary to prevent or minimize sheet erosion

- Locating service areas, watering troughs, and corrals away from stream channels and in low slope areas

- Reducing livestock creek crossings to the minimum number required

- Quickly repair sites where rills are forming and determine and change the conditions which caused the rills to form

<u>Residual Dry Matter (RDM)</u>
Maintaining residual herbaceous cover (also termed Residual Dry Matter or RDM) protects soil against sheet erosion in the fall just before rains begin and the next growing season starts (Bartolome, Frost, and McDougald 2006). Appendix 1 includes a publication which outlines both the method for RDM measurements and the minimum standards for various areas. RDM standards are set for:

- Dry annual grassland defined as land with 12 inches or less average annual rainfall and annual grasses and forbs as the dominant plants

- Annual grassland/ hardwood rangeland defined as areas with 12 to 40 inches average annual rainfall and annual grass and forb understory with oak or shrub canopy

- Coastal prairie defined as areas with more than 35 inches average annual rainfall and perennial grasses with variable woody plant overstory.

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The minimum RDM standards are listed for the three vegetation types and various slope classes in lbs/acre of residual grass/forbs which should remain in the fall prior to the first rains. The slope map includes these same classes. Appendix 1 describes several methods for measuring RDM, including clipping and weighing grass and forbs from a one square foot plot; using reference photographs and comparing them to field conditions; and clipping and weighing to develop visual estimating ability.

Studies of tree and shrub clearing have found that by maintaining 50% of the woody cover the rangeland was more productive than if 100% of the trees and shrubs were removed (Merenlender, Heise, Bartolome, and Allen-Diaz 2001). Woody plants reduce the volume of surface runoff and the incidence of landslides, which have been shown to occur on steep slopes for many decades after the removal of all native trees for rangeland improvement, a recommended management measure from the 1950s and 60s (Pitt, Burgy, and Heady 1978). The generally higher root tensile strength of woody plants compared to grasses provides greater stability to hillsides.

Watering Sources

Part of maintaining adequate RDM to avoid sheet erosion involves inducing livestock to use all of the forage in each grazing area. This goal can achieved by distributing watering sources over the ranch. An adequate and healthy supply of drinking water for rangeland livestock is usually supplied by a combination of natural and developed sources. The natural sources may be the pools and flowing reaches of streams, vernal pools, and lakes. The constructed sources may be troughs fed through pipes from developed springs, streams, ponds, lakes, wells, rainwater catchment devices and stock ponds developed to collect natural runoff. Water supplies are used for the drinking needs of the livestock.

Watering by livestock and wildlife at streams and other natural sources is typical of ranches on hilly rangelands, and because of the prohibitively high costs to develop other sources and construct the supply system. Livestock usually have access to streams and other water bodies that are located within the fenced grazing fields, unless exclusion fencing has been installed. Livestock will use natural watering sources, although they may prefer developed water from a watering trough if the latter is cleaner (Willms et al. 2002). Where livestock have unlimited access to streams and ponds, there can be negative effects on the stream or pond from livestock herbivory and trampling. Such impacts can be limited by abundant practices (see Element 4).

Off-stream watering at troughs requires construction of watering systems with hardware to collect, store, and supply the water to the livestock apart from any available natural watering sources. Water moves by gravity flow or is pumped through pipelines from the water source to water storage tanks. From the tanks, water is fed to livestock watering troughs through another set of pipelines. Trenching is usually required to bury the pipelines and thus to protect the pipelines from exposure to livestock and service vehicle traffic as well as the damaging effects of weather and sunlight, and to avoid heating of the water.

At least one functioning watering trough is needed within each grazing area during the grazing period. When the gates are open between the grazing fields, having multiple troughs will aid in the distribution of livestock and, if placed appropriately, attract them away from sensitive habitats like creeks, and toward upland habitats that will benefit from grazing. The watering systems should be designed to allow the system to be shut off both at the source and at the troughs during the non-grazing period, particularly to facilitate maintenance and to avoid

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undetected leaking and associated erosion. In addition, the livestock operator might be able to use these shut-off valves to focus livestock distribution by leaving only certain troughs working and the others empty. The trough water supply should have float valves in the trough to maintain the trough water level. Troughs should be located in areas accessible to both livestock and the livestock operator (for servicing the water system), and away from streams or highly erodible soils to reduce potential impacts.

Additional guidance on watering facility design and development would require the expert knowledge of the ranch manager, or assistance from a qualified engineer to assure the water facilities are effective, safe, cost efficient, and meet other objectives. Following an assessment of the existing livestock watering facilities and potential supplementary watering sources, such expertise would be needed to determine whether the existing watering facilities will deliver the required livestock water volumes to the desired locations during the grazing period, and whether any new facilities are needed. Some construction and all maintenance of the watering system are usually within the capabilities of the ranch manager and livestock operator.

Livestock Water Demand

Livestock require sufficient water for maintenance and growth. Livestock demand during the different seasons can be calculated based on average per animal consumption, which is affected by air temperatures, kind of forage, and kind, breed, and class of livestock. This demand may be calculated using a formula based on the physiological requirement of 10-20 gallons of water per day by one typical 1000-pound cow (Ingram 2001). Watering demand varies primarily with air temperature; summer air temperatures of 90° F would increase the watering demand of the 1000-pound cow to 20 gallons per day. Thus, the size of the water storage tanks should be based on the expected water supply rate and the water demand of the cattle. Cattle water demand can be computed by multiplying the number of cattle times the daily water demand during different seasons (winter <13 gals/day, spring and fall <17 gals/day, and summer <21 gals/day). This formula should be adjusted for different kinds, classes, and weights of livestock, and multiplied by the number of animals. The water source, storage, and delivery system to the trough must accommodate both daily demand (typically two drinking periods per day) of the livestock herd in the affected grazing field and loss of water due to leakage, fouling, evaporation (assume 25% over the grazing period), and wildlife use.

Table 2A. Livestock Watering Requirements

Kind	Class	Weight (lbs.)	Frequency of Watering (per day)	Air Temperature (F)		
				50° (winter)	70°	90° (summer)
				Livestock water needs in gallons/day		
Beef Cattle	Steers and Heifers	600	0.5-1	5.8	7.8	12.7
	Finishing	800	0.5-1	7.9	10.7	17.4
	Wet Cows	900	0.5-1	12.6	16.9	16.2
	Dry Cows	900	0.5-1	7.2	9.7	?
	Bulls	1600	0.5-1	9.4	12.6	20.6
Sheep	Non-lactating Ewe		0.5	1		12
Goats	Meat type		1	1		2
Horses	Mature working	1200	1-2	12		36
from Ingram 2001; Stoddart, Smith, and Box. 1975						

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Water conservation and water quality in the watershed are key when selecting among options for storing and moving water or for improving the efficiency of an existing livestock watering system. Drilling of vertical wells with power supplies from various electric sources for pumping are often the most expensive options, but these costs might be reduced by the use of solar power system or rehabilitation of an existing functional well. In a few cases, usually where the rangelands are located adjacent to a residential or industrial development, a domestic water system might be available to supply the needed water with very little watering infrastructure development required. The assessment of options is usually based on determination of water supply quality and reliability during the different seasons among the various natural and constructed sources, balanced with the needs of the livestock and ancillary operations and any environmental constraints.

The primary impacts on water quality associated with development and use of livestock watering systems include reduction in stream flow from water diversions and the use of creeks for livestock watering.

Table 2B. Permitting for Stock ponds

Agency	Law/Regulation	Comments
U.S. Army Corps of Engineers	Section 404 Clean Water Act	On-stream pond construction may require a permit
Regional Water Quality Control Board	Section 401 Clean Water Act	If a 404 permit is needed a 401 Water Quality Certification is also required
California Department of Fish and Wildlife	Fish and Game Code	A Section 1602 Streambed Alteration Agreement is required for an on-stream pond or major infrastructure in the channel or riparian corridor
U.S. Fish and Wildlife Service or National Marine Fisheries Service	Endangered Species Act	If a 404 permit is needed a consultation on the effects of the pond on listed species may also be required
California Division of Dam Safety	California State Water Code	Only applies to ponds over 50 ac-ft in size or with a dam of 25 ft or more in height
State Water Resources Control Board Division of Water Rights	California State Water Code	A water rights application process is required for construction of new stock ponds and a Stock Pond Registration is required for all existing stock ponds (Appendix 2)

<u>Supplements and Feeding Areas</u>
Another method to attract livestock to more distant or under grazed areas is to place supplements such as salt licks and molasses in these locations.

In years when forage quality or abundance is low due to drought, supplemental feed may be bought in. The location of feeding areas can be chosen to attract livestock away from heavily used areas to underutilized sites to reduce soil compaction.

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6. SPECIAL MANAGEMENT AREAS

Background: Special Management Areas

Special management areas are fenced to exclude livestock access year round, or to enclose an area for limited grazing during a specified season. Special management areas could be a riparian habitat field that is grazed only during the seasons when riparian vegetation and stream banks are least vulnerable to erosion or an area with highly erodible soils. Special management areas may also be used to improve conditions for rare plants and special status animals by reducing invasive, non-native plants, European annual grasses or other conditions (see Section 12).

7. SERVICE AREAS

Background: Service Areas

Service areas consist of locations where livestock are confined for a period of time such as a corral or loading area or where livestock congregate, such as a water trough or feeding area.

Livestock can trample and compact certain types of soils into a cement like surface. Soil compaction occurs when soil particles are pressed together, reducing the pore space between them. Soils with a high level of clay are most susceptible to compaction. The risk for compaction is greatest when soils are wet. Compacted soils are most likely to occur where livestock congregate, such as service areas. Horses, sheep, and goats are often kept in confined areas at high densities resulting in development of bare compacted ground vulnerable to erosion.

Compaction reduces the soils ability to infiltrate rainfall or support vegetation and increases rapid runoff. This increased runoff may cause rilling when it reaches non-compacted soils. Sediment or manure lying on top of the compacted soils will be transported by the increased runoff.

Livestock Trails

Livestock traffic areas and trails are also likely to be compacted. Cattle generally graze in large open fields with minimal if any herding, and have a tendency to move in lines that compact soils and create bare trails that can cause erosion. Horses, sheep, and goats do not tend to move in lines or compact trails. Livestock trails may follow fence lines, lead to a creek crossing or appear as terraces on a steep slope. The largest problem for sediment delivery are trails which lead directly into a waterway (George et al. 2004). When a hillside has numerous compacted trails across the slope these are called terracettes. Terracettes can contribute to gully formation and in certain locations can result in rotational landslides and block slides. Restoring highly compacted soils to a friable state is done with deep ripping of the soil in several directions and seeding of grass or other plants. This approach is not applicable to steep hillsides and there are no recommended measures to address restoration of terracettes.

Vegetated Buffers

Vegetated buffers or filter strips can serve a number of functions to protect water quality. Dense grasses and herbaceous growth, if located between a service area with sheet erosion and a waterway, will filter fine sediment out of the sheet flow reducing sediment delivery into the waterway.

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Establishment and maintenance of vegetated buffers between grazing–related service areas and adjacent waters and riparian woodlands can reduce the delivery of sediment, nutrients and pathogens to waterways. However, the existing scientific literature is not comprehensive for all kinds of terrain, pollutants or impacts on riparian areas, and unverified measures must often be used. Such gaps in guidance indicate that additional research on these topics would be very useful. A review of the scientific literature, coupled with information from a University of California Cooperative Extension workshop and interviews of specialists is summarized below.

A vegetated buffer is defined here as natural rangeland that is left un-grazed, and has, for at least several years, not been grazed by livestock, tilled, excavated, fertilized, planted, developed with any buildings or roads, used for storage of materials or manure, or in any way used for recreation, agriculture, or other purposes that would have altered it from the natural characteristics (Tate 2010). The width of the vegetated buffer is measured from the edge of the stream channel, edge of wetland vegetation, or edge of riparian forest, to the uphill edge of the unused and undeveloped natural vegetation.

There are a number of ways to establish and maintain vegetated buffers:

- Fencing
- Use of distributed alternative water supplies
- Use of livestock attractants such as mineral supplements
- Changing kind and class of livestock
- Culling misbehaving livestock
- Herding
- Installation of barriers

Vegetated exclusions may be created by fencing. One approach is to fence closely around an area considered sensitive to the impacts of grazing to exclude livestock access to the specified sensitive resources. For example, a hillside gully might be vulnerable to further erosion if grazing continued, especially if restoration plantings were installed. Such an area might be effectively excluded with a fence encompassing the planted zone until the plantings have matured, and the site can resist erosion. Another kind of fencing configuration is to establish a special management area on a larger scale, such as a riparian habitat field, with fences encompassing the sensitive resources as well as other grassland areas to be grazed according to a prescription more narrowly focused on the improvement of the sensitive resources within that field. This approach would require a grazing space large enough with forage adequate and a watering source appropriate to allow grazing of this area for a reasonable period of time by a reasonably-sized herd of livestock. If grazing by livestock in this special management area was for a short period only, then the resulting vegetation could be considered a vegetated buffer, and function effectively to protect water quality.

Practices other than fencing to establish buffers or reduce the impacts of grazing livestock rely on behavioral modifications in livestock including strategic placement of attractants, culling,

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changing kind and class of livestock, herding, and installation of barriers (George 1996; Atwill 2010; Tate 2010; O'Geen 2010; and L. Ford, personal observation).

Attractants, such as mineral licks, supplemental feeding stations, shade structures, and alternative off-stream water development, can effectively reduce the time livestock spend in a sensitive resource zone. Attractants should be arranged to avoid creation of livestock trails or movement zones that are hydrologically connected to streams. Supplementation should be used to attract livestock during seasons when the herbaceous forage is less preferred (mostly autumn).

Culling refers to removal of individual animals from the herd that, unlike their herd-mates, habitually "misbehave," such as to spend too much time causing excessive damage in the sensitive resource zone.

Adjusting the kind or class of livestock can similarly reduce impacts. Older cows and calves are typically less aggressive and destructive, but also less willing to leave a habituated area than their male or yearling counterparts. Thus, a stocker operation might be more suited for increasing grazing in the uplands and to reducing grazing impacts in bottomland or riparian areas. Sheep grazing may be more suited to reduce grazing impacts in bottomland or riparian areas because they are usually herded by a shepherd, who can keep them out of such sensitive areas. Sheep are also reluctant to spend time in or near surface waters and flooded wetlands.

Herding can be used with all kinds of livestock to improve distribution and reduce impacts in sensitive resource areas.

Barriers, such as dense forests, brush piles, and rock piles, may occur naturally or be strategically installed to redirect livestock use from compacted trail or herbivory away from a sensitive resource area or to discourage livestock use of sensitive areas behind the barrier.

In many hilly locations using these livestock behavioral measures would be preferable to extensive fencing to create needed buffers.

8. EPHEMERAL CREEKS

Background: Ephemeral Creeks

Ephemeral creeks typically carry water only during storms and may be steep and filled with woody vegetation. Due to their limited period of flow they are often overlooked. However, if vegetation is removed or soils become compacted, the ephemeral creek channel may become unstable.

Livestock trails in ephemeral creek swales accompanied by unrestricted herbivory, can result in gully formation in the creek. Early repair can forestall a large and expensive erosion control project. Section 9 discusses emergency measures to take for stabilizing gullies. It may be necessary to temporarily fence off the site from livestock use to stabilize and revegetate the gully.

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9. EMERGENCY EROSION CONTROL MEASURES

Background: Emergency Erosion Control Measures

During the rainy season even the best-managed ranch is vulnerable to erosion. There are a number of temporary, or emergency, erosion control measures that can be installed both prior to the onset of winter and during the rainy season as problems arise. The measures provide soil protection and reduce the movement of soil into waterways. These measures are short-lived lasting only for the rainy season, or even one large storm event. The most important part of using temporary measures is to have the materials on site and be familiar with installation methods. It is also important to inspect the ranch often to make sure small erosion problems are addressed quickly.

10. MAJOR EROSION SITES

Background: Major Erosion Sites

Major erosion sites consist of actively eroding gullies, landslides and significant or widespread rilling. These types of problem sites need to be carefully analyzed to determine the cause of the problem and treat the cause first before attempting to repair the site.

A lack of an energy dissipater at a culvert or drainage outlet can start rills and gullies as can a lack of water bars on roads. Prior land uses that left old logging roads or denuded swales can get a gully started and require major repair. Careful consideration before vegetation clearing or road construction is the best way to avoid creating these problems. Rapid response to gully formation can repair small problems before they get huge.

Mass movements of soil and rock such as slope failures, debris flows and landslides involve the downhill flow of water and soil. The causes of mass movement are complex and can involve natural geologic instability or the exacerbation of an unstable situation through road building, vegetation removal or drainage changes. It is never wise to build anything on an unstable slope without expert advice from a geologist or engineer.

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ASSESSMENT AND SEDIMENT SOURCE INVENTORY

5. GRAZING AREA MANAGEMENT: SEASON OF USE, STOCKING RATES, WATER SOURCES AND OTHER MANAGEMENT MEASURES

Fill in the template to answer these questions:

- What is the season of grazing use in most years for each grazing area on the map? If the area has variable seasons or types of use, list by first and second time period per year.
- Approximately how many and what kind and class of livestock are typically grazed in each area?
- How many watering sources are available in each grazing area and what type of watering source (trough, creek) are they?
- What is the season each waters source is available
- How are salt licks, feeding areas, shade shelters and other attractants used in each grazing area?
- What methods are used for herding the livestock or other behavioral management in each grazing area?
- Are ephemeral creeks in the grazing area accessible to livestock? If so, complete Section 8 . Are there portions of the grazing area with sensitive habitats, highly erodible soils or special species that should be a special management area?
- Are there portions of the grazing area needing additional developed watering sources? If so, where are these?

Additional Grazing Area Management Measures

- There are a number of other management measures which can minimize soil erosion listed in this table. Indicate those that are used in each grazing area.

Infrastructure Changes

- Answer the questions regarding any planned or needed changes to infrastructure

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6. SPECIAL MANAGEMENT AREAS

If special management areas have been established, fill out the table describing the purpose of each area, time period(s) used for grazing each year, number, kind and class of livestock using the special management area.

7. SERVICE AREAS

- Each service area will be field reviewed as these areas can be sources of sediment and increased runoff. Field review will document the use of the area, proximity to waterways, if vegetated buffers are present around the service area and if erosion is evident.

8. EPHEMERAL CREEKS

- As part of mapping the site, the FFR staff will designate the ephemeral creeks which are steep and largely inaccessible to livestock and eliminate them from the field assessment. Ephemeral creeks in grazing areas accessible to livestock will be evaluated for erosion using aerial photos and field assessment.
- Work with FFR staff to complete the template table on major erosion sites and livestock crossings on ephemeral creeks. Element 4 addresses intermittent and perennial blue line streams.
-

9. EMERGENCY EROSION CONTROL MEASURES

- Whether you regularly have materials available for emergency erosion control
- Whether you complete regular winter inspections
- Whether the ranch workers are aware of how to implement emergency erosion control measures

10. EROSION REPAIRS

- Describe existing erosion problems, including gullies, rilling, and hillside slippage.
- Describe repairs made and success of repairs to any erosion problem.

APPLYING MANAGEMENT MEASURES

5. GRAZING AREA MANAGEMENT

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General

- The goal of the FFR ranch plan is to adjust grazing practices and facilities to protect water quality while sustaining the ranching operation. This balancing is accomplished by having the ranch manager/owner evaluate various features and potential changes. As the ranch manager is the key person to implement the plan, the changes to operations and facilities must be feasible and reasonable.

- Table 2E describes the relationship of types of erosion to potential causes and suggests needed management measures. Suggested site monitoring to demonstrate implementation of management measures is also included.

- For each ranch the grazing area management measures need to be evaluated to demonstrate: grazing areas, livestock type, number, duration and season of use, watering sources and attractants, service areas and other ranch features are arranged to provide for adequate RDM over each grazing area to protect against sheet erosion. Needed changes in watering sources, grazing area, livestock numbers, season or duration of grazing are identified.

- Special management areas are delineated and managed to protect sensitive habitats, wetlands, riparian zones and highly erodible soils.

- Service areas and other sites with compacted soils have adequate vegetated buffers to intercept fine sediment in sheet flow and to forestall rilling due to increased runoff from the compacted surface

- Livestock trails near creeks are managed to reduce sediment delivery to waterways

- Ephemeral creeks are well vegetated and stable. Erosion sites, compacted trails and road crossings are assessed in the inventory.

- RDM is evaluated on an annual basis and if evaluations show less than minimum requirements (Appendix 1) changes to management measures are made.

- Clearing of woody vegetation particularly on steep slopes is minimized to avoid long term slope instability

- Movement corridors are identified to enable efficient livestock access between and within grazing areas.

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Table 2E. Types of Erosion and Management Measures			
Type of Erosion	**Potential Causes**	**Management Measures**	**Monitoring**
Sheet erosion in grazing areas	Too much vegetation grazed, leaving soil exposed	Manage the number, type of livestock and duration and season of use in each grazing area or change size and configuration of grazing areas to achieve adequate RDM (Residual Dry Matter) to protect soil surface from erosion during rainy season.	RDM measured at end of dry season; photo-monitor grazing areas
	Uneven grazing with too much vegetation grazed in some areas and not enough in others	Distribute watering sources to attract livestock to under-grazed portions of grazing area Distribute supplements to attract livestock to under-grazed portions of grazing area	RDM measured at end of dry season; photo-monitor grazing areas
Sheet and rill erosion due to soil compaction	Soil compaction in service areas where livestock congregate or along livestock trails	Create vegetative buffer between compacted area or trail and waterways reducing delivery of fine sediment	Visually inspect service areas and livestock trails and the ground around them for rills. Photo document vegetated buffer strips at end of dry season
Rill and gully erosion	Sheet erosion not treated	Apply management measures for grazing areas to distribute livestock and reduce soil exposure during the rainy season.	RDM measured at end of dry season. Implement emergency erosion control for rilling. Photo-monitor all improvements
Rill and gully erosion	Soil compaction in service areas and areas where livestock congregate along livestock trails, creek crossings and in ephemeral creeks and swales.	Create vegetative buffers around service areas. Relocate service areas away from waterways and create vegetative buffers.	Visually inspect service areas, livestock trails near creeks and creek crossings during the wet season for erosion. Review need for additional vegetative filters. Implement emergency erosion control for rilling. Photo-monitor all improvements

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Table 2E. Types of Erosion and Management Measures			
Type of Erosion	**Potential Causes**	**Management Measures**	**Monitoring**
Rill and gully erosion	Soil compaction in service areas and areas where livestock congregate along livestock trails, creek crossings and in ephemeral creeks and swales.	Reduce creek crossings to minimum number needed. If crossing is steep and eroding armor ramps to crossing. If livestock trails cause delivery of sediment into creeks, place large wood, brush piles, layer rock or other barriers to reduce number of trails to minimum needed for crossing. Revise season of use and duration of grazing.	Visually inspect service areas, livestock trails near creeks and creek crossings during the wet season for erosion. Review need for additional vegetative filters. Implement emergency erosion control for rilling. Photo-monitor all improvements
		Reduce livestock access to ephemeral creek/swale if erosion is occurring. Reduce season of use and duration of grazing. Stabilize and revegetate with native plants as appropriate. Seasonal and perennial creeks are discussed in Element 4.	Visually inspect service areas, livestock trails near creeks and creek crossings during the wet season for erosion. Review need for additional vegetative filters. Implement emergency erosion control for rilling. Photo-monitor all improvements

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Watering Sources

Stock Pond Improvement and Maintenance

Design each stock pond with capabilities to collect and safely store the needed amount for livestock, and to withstand a specified magnitude of storm (and associated flow) based on an analysis of each pond's current conditions, and the recommendations of a qualified hydrologist. Maintain existing stock ponds to provide those capabilities as well as any specified special habitats. Before such activities begin, any state and county permitting requirements must be determined and initiated.

Water Troughs

The precise location of troughs is important to minimize erosion, settling of the trough foundation, and ensure delivery of the water from the source to the trough. Troughs should be located in a relatively level place to allow maintenance vehicle access. Other considerations for the location of watering facilities include avoidance of sensitive habitat areas such as creeks, restoration planting sites, erosion sites, near to steep areas and near cultural resources.

Protect the soil within a 15 foot radius around the trough from compaction and erosion due to livestock trampling, congregating and water overflows, by installing gravel in a slightly elevated platform under and around the trough to form a hard semi-permeable surface.

Where trenching is necessary, the pipelines should be installed under existing service roads, or with the trenching aligned to minimize the risks of soil erosion associated with digging, collapsing of the native soil structure, and channeling of surface run-off into the excavated trench.

Distribution pipelines should be buried to reduce water temperatures. If plastic pipelines are used, direct sun can degrade the pipe. If water is allowed to become too hot, more algae will grow in the water cisterns and troughs, reducing water quality and increasing maintenance needs.

Wildlife Friendly Troughs

In general, watering trough design should include enhancements for wildlife use including avoidance of drowning or entanglement of grassland wildlife species, such as birds, bats, deer, rodents, coyotes, and butterflies. Wildlife-friendly trough design criteria (Taylor and Tuttle 2007; USDA-NRCS 2007) include:

- Use a water regulation device to maintain the trough water level just below the top rim to keep wildlife from falling into the trough when drinking.

- Provide for escape and access of small animals by using rough surfaces that provide traction for animals and secured ramps (concrete, composite plastic, or expanded metal with slope no greater than 45 degrees) from the bottom of the trough, up the perimeter (attached flush to the side, at one end if the trough is rectangular) of the trough, to the top rim of the trough; temporary or unsecured devices made of rocks, branches, or boards often fail, and thus should be avoided; install more than one ramp if feasible to increase the chances of wildlife escape (Sherrets 1989).

- Eliminate obstructions, such as plumbing housings or overhanging posts, wires, braces, and vegetation, in flight paths of birds and bats and entanglements for larger animals.

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- Design trough height as low as feasible [20 inches for access by low stature mammals, such as deer (Sherrets 1989)] and length as long as feasible. Trough length, minus any plumbing housing should provide at least four feet of open water surface for in-flight drinking by bats. Ten feet is preferred; avoid ground level or very low troughs which pose risks to livestock as well as likely fouling by animal wastes and contamination.

- Maintain the water supply to the trough sufficient for both livestock and wildlife use during the grazing period. Water supply for wildlife adds to the demand and the water delivery required during the grazing period; thus, total demand and capacity will vary during the non-grazing period.

- If regular maintenance is curtailed during the non-grazing period, and trough water levels and water quality won't be maintained, then the troughs must be drained to avoid attracting and harming wildlife.

6. SPECIAL MANAGEMENT AREAS

Special management areas are separated from grazing and service areas. There are numerous reasons for creating special management areas including:

- Areas with high soil erosion potential if exposed to grazing livestock. An example would be serpentine soils that often have limited plant cover and therefore erode readily.

- Areas with wetlands, riparian corridors or habitats for special status species. Special management areas should be designated to exclude livestock from the habitat and a 20 ft buffer around the habitat. For special status species, such as vernal pools or tiger salamander habitat, limited grazing may be needed to reduce European annual grasses (see Section 12).

- These areas may also be created to segregate certain classes of livestock of other needs.

7. SERVICE AREAS

- Define special management areas for highly compactable soils if located in areas with high livestock traffic or impacts near waterways.

- Avoid livestock grazing during the wet season where vulnerable soils can be compacted or eroded. Rotate livestock to uplands away from wet soils.

- If service areas are near creeks, wetlands or waterways, a minimum buffer of 50 feet width for sloping terrain, or 30 feet width for relatively flat terrain is needed for an ungrazed, vegetated buffer between the service area and the waterway.

The basic guidance for width of the vegetated buffer at all kinds of sites is no less than 45 or 50 feet (Castelle, Johnson, and Conolly 1994). Sites on relatively flat ground can have narrower buffers (30 feet) (Atwill, pers. comm. 30 March 2009).

Vegetated buffers can be effective in protecting water quality on rangelands grazed by livestock when:

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- Buffers are located adjacent to slopes of less than or equal to 20% (Tate, Pereira, and Atwill 2004); however, some guidance from the USDA Natural Resources Conservation Service (1995) limits slopes to 5% for functional buffers.

- Precipitation intensity (not necessarily amount) in the area has remained less than or equal to normal (Atwill pers. comm. 2010).

- Buffers are maintained with at least 800 pounds per acre Residual Dry Matter in the late autumn (Tate 2010).

- Buffers are not grazed, which is especially important where the affected water may be used as a human domestic drinking source; or if grazed, no calves are present, the grazing is short-duration, and no grazing occurs during the wet seasons (Tate 2010)

The existing scientific literature and specialist opinions do not address precise modifications to grazing management in the following situations (O'Geen 2010):

- Buffers have less than 95% herbaceous vegetation cover.

- There is a high degree of vulnerability of stream beds and banks to erosion.

- There is a high degree of erosion hazard for the soils in the grazed areas.

- There is a high degree of overland flow due of soil compaction, presence of a claypan, or ground water elevated to the surface during the wet seasons, in excess of runoff associated directly with precipitation events

- There is a high degree of leaching of water pollutants through the soil column as associated with porous soils.

Thus, the prescribed buffer for each situation should be increased in width, monitored to determine whether any significant impacts occur, subject to adaptation to assure those impacts are reduced to insignificant degrees, and tested through scientific research (O'Geen 2010).

- Identify Special Management Areas where risks of water pollution could occur due to livestock grazing, traffic, and deposition of wastes. Establish buffers and exclusions to prevent that pollution.

- Establish a grazing program that removes or rotates livestock to the uplands during wet seasons, when soils are wet, and during precipitation events, or that allows grazing only during the spring.

- Use attractants or herding to increase livestock distribution and increase the time spent in the uplands and away from the lowlands, waters, and riparian woodlands, especially during their more vulnerable seasons (summer and fall).

- Where drainage features are constructed, or will be constructed or re-constructed, use designs with channelized ditches and check-dams instead of grassed waterways.

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- An un-grazed vegetative filter strip should be created with the same dimensions (as above) between compacted soil areas and waterways.

Livestock Trails

- Review the location of compacted livestock trails near waterways for the potential to increase delivery of sediment to waterways and the need to re-orient livestock traffic patterns or armor trail or crossing near the creek.

8. EPHEMERAL CREEKS

- Ephemeral creeks in grazing areas should be fully vegetated and stable, not actively eroding. Livestock trails should be minimized to several crossing locations.

- If there are erosion sites located in the ephemeral creeks, review the proximity of grazing areas, special management areas, and other site features to determine possible causes of the erosion. Determine if erosion is severe and exclusionary fencing may be needed or if a revegetation and buffer approach will work.

- Temporarily repair any erosion in the ephemeral creek (see Section 9). If the erosion is severe you may need to use a structural approach to stabilize the erosion, and then revegetate. FFR program staff can assist you in evaluating erosion sites. Include woody vegetation in repair programs to increase the filtering and retention of fine sediment and structural stability.

- Revegetate with native plant species such as live oak, toyon, ceanothus, bay laurel and other appropriate species. The greater the amount of woody vegetation in a swale, or along an ephemeral creek, the more stable in a large storm event. As part of the Farm Conservation Plan process, an ecologist can determine the extent of the revegetation and the appropriate plants.

9. EMERGENCY EROSION CONTROL MEASURES

Surface Soil Protection

- **Mulching** - Straw mulch should be spread over any disturbed ground along with grass seed. The mulch provides an extra-added layer of protection until the seed germinates. The mulch should be applied at a rate of 2 tons per acre, cover 80-100% of the ground surface and be anchored, or punched, using hand tools, rollers or other non-compacting equipment. The straw can also be sprayed with a tacking agent to bind it together.

- **Jute netting** - Netting can be used on steep areas where straw cannot be anchored. Netting should be anchored with staples, or pins. Anchor pins should be rigid galvanized wire with a minimum length of 10 inches. Staples should be U shaped and have two prongs of 6 inches in length. Netting should be overlapped by 12” along the edges to assure coverage of soil.

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- **Erosion control blanket** - These blankets are made of biodegradable material that covers over the soil. These can be used on steep sites. The treated areas must be reasonably smooth and the blanket must be anchored over the site with an overlap of several inches between each blanket. Each manufacturer has slightly different directions for anchoring the blanket.

Intercepting Surface Soil Movement

- **Silt fencing** – A barrier of filter fabric cloth can be purchased and stretched across a slope to further reduce surface soil movement. The posts need to be firmly anchored into the ground, or an adequate depth for the soil types and slope. The fabric is stretched tightly and firmly trenched several inches into the slope surface. Posts should be four feet apart or less. Staples attaching the material to the posts should face upslope. Silt fencing is often used in several areas of a long slope as one silt fence at the bottom of the slope is not likely to be sufficient.

- **Straw bale check dam** – Bales of clean straw bound with wire or plastic twine can be placed across an area of surface sheet flow, or rilling, and anchored into the soil surface with rebar or stakes. Anchor the bales tightly together to form a barrier across the entire area of surface flow. Don't create a path for the water to go around the outside of the check dam. The stakes, or rebar, should be driven into the ground 1.5 to 2 feet and the bales should be set at least 4 inches into the ground.

- **Straw bale or straw wattle water bars** - Straw bales can also be used to create temporary water bars across a road, a temporary sediment barrier to protect a waterway or contain sediment along a creek edge. A series of straw bale check dams, or water bars, may be needed for a long slope. They should cross the entire width of the slope and be spaced to allow for sediment accumulation. The rebar should be driven into the ground 1.5 to 2.0 feet and the straw bales should be trenched at least 4 inches into the ground and set tightly together. There are also erosion control products such as sediment logs, or straw wattles, which can be used in the same way as the straw bales. Straw wattles can be carried to locations where straw bales cannot. The wattles are staked into a trench and can be stacked 2 wattles high. The length of slope, or area above each water bar, should not exceed 100 ft. or one acre.

- **Water bars** – Water bars consist of a berm and ditch to collect and direct water off the road surface before concentrated flow can cause erosion. Water bars are placed across the road at a 30-40 degree angle oriented downgrade to the road centerline. The water bars should be oriented to direct the storm water into vegetation. If a swale or creek is used, a vegetated area, or filter strip, should exist between the road and the creek channel and an energy dissipater of gravel should be placed at the outlet of the water bar. Water bars should be installed at a greater frequency on steeper roads (see Table 3G in Element 3).

  The water bar should extend from the inboard road cut to the outer edge of the road. The water bar consists of a berm and a ditch. The edges of the berm should be 4-6 inches above the roadbed and the ditch should be 4-6 inches deep. The ditch and berm should be approximately 3-6 feet in width along the longitudinal direction of the road.

- **Temporary sediment basin or barrier** – A temporary sediment basin is used to catch and settle out sediment before it can enter a waterway. These are usually placed at the base of

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a slope, or drainage area. Sediment basins are designed for small watershed areas (no greater than 5 acres) and small storm sizes (10-year recurrence interval). A small basin can be created from compacted soil, rocks or straw bales. The basin embankment should not exceed four feet in height. A drain or outlet is used to restrict flow from the basin to allow for sediment to be trapped. A small berm, or square, of straw bales can be created around the drop inlet of the vineyard drainage system to reduce siltation. A straw bale sediment barrier can be placed along the waterway edge prior to the rainy season to protect water quality and should be installed no later than Oct. 15. Be sure that the straw bales are securely anchored with stakes or rebar.

- **Plastic-lined ditch** - Plastic can be placed over an eroding site to reduce soil loss temporarily. Strong plastic should be used to avoid puncture by rocks and sticks. The plastic sheets should be anchored so that surface runoff, or wind, cannot move the plastic. Rebar is preferable for staking the plastic. Placing rocks on top of the plastic is not sufficient. Sheets of plastic should be overlapped a minimum of 12 inches and tightly staked at the overlap. The maximum length for use of plastic lining is 400 feet.

There are many other erosion control products on the market. Always use them for the situations the manufacturer recommends and install them according to the directions.

10. EROSION PROBLEMS AND REPAIRS

- If a rill, or gully, develops during a storm use emergency erosion control measures (Section 9) to stabilize the problem as soon as possible. Apply the emergency erosion control measures both to the erosion site, and if possible, identify the cause and try to correct it, even temporarily, during the wet season.

- Once winter ends, address the problem as soon as you can. If you have a large problem you may need a few months to get the equipment or materials to repair the cause of the problem and stabilize the erosion site before October 15. If you have a landslide, seek professional assistance as soon as possible from an engineering geologist, geologist or civil engineer.

- For gully and other erosion repairs, contact the NRCS, a civil engineer or other professional to get assistance in evaluation and repair design. Have a qualified contractor install the project, or do it yourself with careful and detailed guidance. The FFR program can assist to find grant funds for major erosion control projects.

- Evaluate the cause(s) of the erosion problem. Some examples include:

    - Drainage from a culvert or a drain outlet.

    - Vegetation removal in an ephemeral stream and gullying of the stream from storm flows.

    - The diversion of storm flows from one area into another and resulting erosion.

    - Compaction of soil surfaces, or new pavement and increased volumes of runoff

    - Saturation due to springs.

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- Failure of a drainage inlet due to clogging from debris, or overtopping and undersized inlet.
- Natural instability such as blue clay can cause landslides. Drainage in these areas needs to carefully constructed..

- Correct the cause of the erosion problem first.
- If the problem is gullying, or rilling near roads, evaluate the drainage on the road and install water bars, rolling dips and additional drainage to reduce the length of flow down the road (see Element 3 Roads).
- If the problem involves an ephemeral waterway, consider stabilizing structures such as check dams and restoring it to a fully vegetated condition with native plants such as oak, toyon, manzanita, ceanothus and other appropriate species.
- Gullies move upslope and the headcut should be stabilized first after the cause is addressed. Depending on the situation there are vegetative techniques and structural solutions:
- **Vegetative techniques** are most applicable to gullies with a headcut of less than three feet that is not getting rapidly larger. Willows and grasses can be sprigged and seeded after the headcut is reshaped to a flatter slope. Vegetation must be planted at the proper time of year to ensure growth without irrigation. Structural solutions include riprap placed on the headcut after it is reshaped and filter fabric is installed. Rock needs to be properly sized and placed. Willow can sometimes be sprigged in conjunction with the use of rock. With both techniques apply the following guidelines:
    - Reshape the head cut to a 2:1 or lower slope.
    - Apply a temporary cover crop by seeding if vegetation only repair is used.
    - Plant willow sprigs no smaller than one-half inch in diameter, (one inch to one and one half inches is preferred) and three to four feet long planted right side up (oriented as the stems were growing when pruned) driven into the soil 75 to 80% of their length and spaced 12 to 18 inches apart over the ground surface.
- For **structural solutions** use filter fabric properly installed under rock riprap. Use angular dense riprap rock sized to the expected storm flows for the site and installed in a matrix of large and small rocks to create a solid flat rock surface. Dumping surplus concrete, or other materials in the gully often hides the erosion underneath.
- Once the headcut is stabilized the rest of the gully can be stabilized. Check dams, or grade stabilization structures, keep the gully from deepening and widening and further eroding. For installation of check dams use the following guidelines:
    - There are many types of check dams, choose one that fits your site.

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- The toe of the uphill check dam must be even, or level, with the spillway of the next downhill check dam.
- More small check dams are preferable to a few large check dams.
- Install an energy dissipater at the downstream overflow for each check dam.
- Some types of check dams such as loose rock, cement and wood require spillways sized to the average storm.
- Key each check dam into the sides of the gully several feet so no water can flow around the edges and erode soil.
- The check dams must be installed perpendicular to the flow of the water wherever the check dam is located even if the gully meanders in course.
- Revegetate the gully walls.

11. SUPPLEMENTAL ACTIVITIES

- Each activity will be evaluated during the field visit for any potential soil erosion concerns.

GRAZING TO BENEFIT THE ENVIRONMENT

THIS SECTION IS OPTIONAL

12. GRAZING TO IMPROVE HABITAT

Background: Grazing as a Conservation Tool

In general, livestock grazing is an effective conservation tool for grasslands dominated by non-native aggressive herbaceous plants, including the annual grasses and forbs of California's Coast Range grasslands and savannas. Habitat for many special-status animals and plants of these grasslands is improved by some form of management to reduce the height and mass of the herbaceous plants, and to reduce the non-native competition with the native plants for space, sunlight, and nutrients. We can expect some reductions in the qualities of the habitat for some special-status species and natural communities if grazed during vulnerable times, such as summer grazing in riparian woodland and associated habitat. Thus the challenge of grazing management planning is to prescribe the grazing to maximize the benefits, and minimize the impacts.

The negative impacts of livestock grazing can include threats to special status animals and plants, facilitation of invasion by pest plants, reduction of the regeneration of woody plants, damage to wetland habitats and vegetation type conversion (Painter 1995). The effects of modern livestock somewhat resemble the effects of the potential prehistoric populations of

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native ungulates (hoofed mammals) in terms of the reduction of height and biomass of the grassland herbaceous plants and the reduced cover of native woody plants. However, the native grassland is long gone, and was replaced by a very different grassland dominated by aggressive non-native annual grasses and pest plants. Also, the behavioral patterns of livestock differ from the prehistoric behavior of native ungulates, and consequently the timing, intensity, and uniformity of herbivory and trampling effects also differ. Thus, the prospects of mimicking prehistoric grazing effects with livestock are uncertain, and not supported in the scientific literature. Livestock grazing can be ecologically beneficial if careful strategies and grazing prescriptions are devised to achieve specific conservation objectives in the non-native dominated grassland, and to minimize the negative impacts based on the conditions at the grazed sites (Edwards 1992; Ford 2001; Ford and Huntsinger 2004).

Historic livestock grazing and related grassland management in the region apparently provided conditions favorable enough for the persistence of the existing special status animals and plants dependent on grassland habitat. Invasion and increased density of non-native grassland plants, conversion of the historic habitat to urban land uses, and the change of traditional rangeland management have apparently caused the current degradation of the remaining special habitat sites generally. Continuation of traditional livestock grazing is likely to be beneficial to at least some of the special animals and plants, and its elimination would impact some of them. A small and growing science-based literature is available to guide the understanding and management of habitat for these special species.

Prescription of a grazing management strategy and practices to benefit the habitats of the special status animals and plants of the ranch should include:

- An assessment of the habitat conditions required,
- How the current grazing program can be continued or improved to achieve habitat conditions that would be at least adequate to sustain the special animals and plants,
- Factors that affect the feasibility of the grazing operation to function sustainably as a conservation management tool.

The grazing management plan will allow for practical testing of methods to maintain and enhance habitat quality, and then revision of the prescriptions based on the results of monitoring. For example, grazing management to benefit the California red-legged frog (listed as “threatened” by the US Fish and Wildlife Service) includes (Ford et al. 2012, manuscript in review):

- Maintain existing stock ponds: repair eroding dams and spillways, remove excessive silt and vegetation, and control non-native predators (Ford et al. 2012).
- Provide refuge places that are moist year-round and offer dense vegetation or other protection from predators.
- Don't exclude grazing from large areas of habitat for more than one year.

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Table 2F. Pest Plants of Napa and Mendocino Counties: Thistles

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Italian thistle	*Carduus pycnocephalus*	Moderate B,B,A,2.9	Winter annual	Displaces native species; crowds out forage and other forbs; increases fire hazard	Mechanical injury when spines develop; lowers yield and quality of forage	Likely controlled and limited to disturbed areas at a regularly grazed property	Intensive concentrated sheep or goat grazing in early spring can remove seeds; cattle can be trained to eat it.	Manual removal is feasible only for small infestations; pull, dig, or cut after bolting and before flowering with minimal soil disturbance; mowing is not reliable. Chemical treatment before flowering can be effective. Burning is likely to *increase* the infestations unless repeated.
Woolly distaff thistle	*Carthamus lanatus*	Alert; Moderate A,B,C,2.8	Winter annual	Displaces natives	Mechanical injury when spines develop; lowers quality of forage	Likely controlled at a regularly grazed property	Intense grazing can *increase* dominance of this pest plant; goats likely will eat this, and cattle can be trained to eat it.	Mowing just before and not after flowers develop can be effective.
Purple starthistle	*Centaurea calcitrapa*	Moderate B,B,B,2.7	Annual to perennial	Forms dense stands and displaces desirable species	Mechanical injury when spines develop; not palatable to wildlife or livestock and prevents access to forage	Not likely to be controlled by conventional grazing.	Has not been scientifically tested; goats likely will eat this, and cattle can be trained to eat it.	Manual removal (grubbing) with minimal soil disturbance early in growing season can be effective. Mowing and burning are not effective. Chemical treatment in winter or spring can be effective.
Meadow knapweed	*Centaurea debeauxii*	Alert: Moderate B,B,C,2.7	Perennial	Spreads rapidly; displaces natives	Mechanical injury when spines develop; lowers quality of forage	Not likely to be controlled by conventional grazing.	Has not been scientifically; goats likely will eat this, and cattle can be trained to eat it.	Manual removal (grubbing) with minimal soil disturbance early in growing season can be effective. Mowing and burning are not effective. Chemical treatment in winter or spring can be effective.

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Table 2F. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Spotted knapweed	*Centaurea maculosa*	High A,B,B,3.4	Biennial to perennial	Displaces natives	Mechanical injury when spines develop; lowers quality of forage	Not likely to be controlled by conventional grazing.	Has not been scientifically; goats likely will eat this, and cattle can be trained to eat it.	Manual removal (grubbing) with minimal soil disturbance early in growing season can be effective; Mowing and burning are not effective. Chemical treatment in winter or spring can be effective.
Malta starthistle (tocalote)	*Centaurea melitensis*	Moderate B,B,B,2.6	Winter annual	Spreads rapidly; displaces natives	Mechanical injury when spines develop; lowers quality of forage	Not likely to be controlled by conventional grazing.	Same as C. solstitialis	Same as C. solstitialis
Yellow starthistle	*Centaurea solstitialis*	High A,B,A,3.0	Winter annual	Displaces native species; crowds out forage and other forbs; depletes soil moisture; increases fire hazard	Mechanical injury when spines develop; long-term ingestion causes a lethal brain lesion in horses; lowers yield and quality of forage	Not likely to be controlled by conventional grazing.	Repeated intensive concentrated grazing after bolting and before development of spiny flowers can be effective followed by mowing/herbicide treatments can be effective but not eradication; goats are preferable to cattle because they will browse on spiny flower heads later in the year; cattle can be trained to eat it.	Repeated intensive concentrated mowing after bolting and before development of spiny flowers can be effective; most effective for small infestations. Prescribed burning has proven effective only after repetitions for 2 or more consecutive years; otherwise, fire is counter-productive and will increase germination and spread of YST due to increased light penetration and soil warming resulting from the removal of thatch and other competing plant species; prescribed burning in a single year may be effective as part of an integrated pest management strategy including mowing and herbicides.
Squarrose knapweed	*Centaurea virgata var. squarrosa*	Moderate B,B,B,2.8	Perennial	Displaces natives	Mechanical injury when spines develop;	Not likely to be controlled by conventional grazing.	Has not been scientifically tested	Manual removal (grubbing) with minimal soil disturbance early in growing season can be effective; mowing and burning are not

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Table 2F. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
					lowers quality of forage			effective. Chemical treatment in winter or spring can be effective.
Canada thistle	*Cirsium arvense*	Moderate B,B,B,2.8	Perennial	Displaces natives in disturbed and undisturbed soils, and in wet or dry habitats	Mechanical injury when spines develop; possibly toxic to animals; lowers quality of forage	Likely to be controlled by conventional grazing during the winter and spring	Goats, cattle, and sheep will eat it when young.	Dominance maintained by allelopathy. Repeated mowing and grazing can be effective, and should be timed to avoid impacts to desirable plants. Burning is generally not effective. Chemical control can be effective if combined with planting of competing natives.
Bull thistle	*Cirsium vulgare*	Moderate B,B,B,3.3	Biennial	Displaces native plants	Mechanical injury when spines develop; no nutritive value; lowers quality of forage	Likely controlled and limited to disturbed areas at a regularly grazed property, with light to moderate grazing intensity	Goats and sheep will eat this when young, and cattle can be trained to eat it.	Repeated mowing and grazing can be effective, and should be timed to avoid impacts to desirable plants. Burning is generally not effective. Chemical control can be effective if combined with planting of competing natives.
Scotch thistle	*Onopordum acanthium*	High B,B,B,2.9	Biennial	Displaces native plants	Mechanical injury when spines develop; lowers quality of forage	Likely controlled and limited to disturbed areas at a regularly grazed property, with light to moderate grazing intensity	Goats and sheep will eat this when young, and cattle can be trained to eat it.	Repeated mowing and grazing can be effective, and should be timed to avoid impacts to desirable plants. Burning is generally not effective. Chemical control can be effective if combined with planting of competing natives.

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Table 2G. Pest Plants of Napa and Mendocino Counties: Other Forbs

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Russian knapweed	*Acroptilon repens*	Moderate B,B,B,3.2	Perennial	Displaces natives	Toxic, not palatable; lowers quality of forage	Not likely to be controlled by conventional grazing.	Has not been scientifically tested	Difficult to control. Repeated mechanical and chemical treatment combined with inter-planting of shading species such as perennial grasses might be effective. Prescribed fire effectiveness is uncertain, but reported to be ineffective due to resistance and re-seeding.
Mayweed	*Anthemis cotula*	Watchlist D,B,B,2.4	Winter or summer annual	Displaces natives	Toxic	Has not been scientifically studied	Has not been scientifically tested	Mowing before seeds develop can be effective.
Capeweed (fertile and sterile)	*Arctotheca calendula*	Alert: Moderate B,B,C,3.6 (fertile) Moderate B,B,B,2.8 (sterile)	Annual or perennial	Rapidly forms mono-specific mats, displacing natives in coastal grasslands and riparian zones	Tolerated	Intense grazing can *increase* this pest plant	Intense grazing can *increase* this pest plant	Manual removal (including stolons), heavy mechanical scraping, or solarization can be effective. No bio-control agents known. Repeated chemical control can reduce density but not sufficient to eradicate.
Australian saltbush	*Atriplex semibaccata*	Moderate B,B,B,2.9	Perennial	Displaces natives, especially of saline or alkaline soils	Toxic; lowers quality of forage	Has not been scientifically studied	Has not been scientifically tested	Manual removal before seeds develop can be effective. Chemical and prescribed burning controls have not been tested.
Black mustard	*Brassica nigra*	Moderate B,B,A,2.0	Winter annual	Displaces natives	Toxic; palatability poor; lowers quality of forage	Likely controlled at a regularly grazed property; but likely to increase in the absence of	Intensive concentrated grazing likely to *increase* dominance of this pest plant; goats likely will eat this, and cattle can be	Disturbance promotes dominance and spread, especially nutrient-rich soils used by livestock. Dominance maintained by allelopathy. Repeated manual removal (pulling, cutting, or close

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Table 2G. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
						grazing	trained to eat it.	mowing before seeds develop can be effective for small infestations. Disturbance and burning usually *increase* mustard species. Herbicides applied to rosettes after mowing can be effective. Dense stands can increase the fire frequency as plants are extremely flammable upon desiccation. The increased nitrification of soil and lack of viable competitors after burning can increase the infestation.
Sea-fig	*Carpobrotus chilensis*	Moderate B,B,A,1.8	Perennial	Forms mono-specific mats, displacing natives	Palatability poor; lowers quality of forage	Not likely to be controlled by conventional grazing.	Has not been scientifically tested.	Manual removal (of all plant parts) without soil disturbance can be effective. Burning not effective.
Rush skeletonweed	*Chondrilla juncea*	Moderate B,B,B,3.1	Biennial to perennial	Displaces natives	Has not been scientifically studied.	Has not been scientifically studied.	Has not been scientifically tested	Has not been scientifically tested.
Poison hemlock	*Conium maculatum*	Moderate B,B,B,2.8	Biennial	Quickly occupies disturbed soils; displaces natives	Toxic to vertebrates; lowers quality of forage	Likely controlled at a regularly grazed property; but likely to increase in the absence of grazing	Has not been scientifically tested	Repeated manual removal (pulling, cutting, or close mowing before seeds develop can be effective for small infestations. Burning has not been scientifically tested, but is considered unlikely to be effective. Herbicides applied to rosettes can be effective.
Common teasel &	*Dipsacus fullonum &*	Moderate B,B,B,3.8	Biennial to	Forms mono-specific stands,	Spines discourage	Not likely to be controlled by	Has not been scientifically	Difficult to control. Manual cutting and mowing

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Table 2G. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Fuller's teasel	*Dipsacus sativus*		perennial	displacing natives in moist soils and riparian zones	livestock grazing; lowers quality of forage	conventional grazing.	tested	can control small populations, but have shown mixed results due to regrowth and opening of space for germination of new plants. Chemical treatments have also shown mixed results.
Stinkwort	*Dittrichia graveolens*	Alert: Moderate B,A,C,3.0	Annual	Rapidly expanding; displaces natives	Might be toxic; avoided by livestock; lowers quality of forage	Has not been scientifically studied.	Has not been scientifically tested.	Hoeing and pulling with flower tops bagged has been effective. Chemical treatments have been effective.
Patterson's curse	*Echium plantagineum*	Alert	Annual to biennial	Displaces natives	highly toxic; lowers quality of forage	Has not been scientifically studied.	Has not been scientifically tested.	Has not been scientifically tested.
Broadleaf filaree & shortfruited filaree	*Erodium botrys & Erodium brachycarpum*	Watchlist	Winter annual	Not usually a conservation concern	Forage value is good	Likely controlled at a property grazed regularly and moderately	Seasonal light to moderate grazing could be prescribed to minimize *Erodium* by allowing increased competition from grasses.	More abundant where grazing has reduced competing grasses; less abundant when grazing is light or during high precipitation years. More abundant after fire and where rodent herbivory is reduced.
Fennel	*Foeniculum vulgare*	High A,B,A,3.0	Perennial	Develops dense uniform stands; displaces natives, alters composition and structure of grasslands, coastal scrub, riparian, and wetlands.	Young shoots tolerated when other forage is less palatable	Likely controlled at a regularly grazed property; but likely to increase in the absence of grazing	Grazing of larger stands not expected to be effective, and could spread seeds.	Difficult to control. Manual removal by mattock, with minimal soil disturbance has been effective on small infestations; cutting, mowing, and chopping are ineffective. Burning alone is not effective; however, fall burns followed by repeated chemical treatments have been effective.

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Table 2G. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
								Continued grazing near infested grasslands has been effective in preventing infestation. Chemical treatments have been effective.
Shortpod mustard	*Hirshfeldia incana*	Moderate B,B,A,1.9	Biennial to perennial	Displaces natives	Has not been scientifically studied.	Has not been scientifically studied.	Goats likely will eat this, and cattle can be trained to eat it.	Has not been scientifically tested.
Common St. Johnswort	*Hypericum perforatum*	Moderate B,B,B,3.7	Annual	Forms mono-specific stands, displacing natives	Nutritive value unknown, but cattle, sheep, and goats will eat it. Photo-sensitizing to light colored livestock	Likely controlled with regular grazing at moderate or less intensity; but likely to increase in the absence of grazing	Seasonal light to moderate grazing could be prescribed to control existing plants and new infestations, allowing competition from grasses.	Difficult to control. Biological control by natural arthropod enemies has been effective. Combined program of biological control, moderate grazing, minimizing soil disturbance, and planting competitors has been effective. Continued grazing near infested grasslands has been effective in preventing infestation.
Common catsear	*Hypochaeris radicata*	Moderate C,B,A,2.2	Winter annual	Rapidly invades areas of disturbed soil; usually not a dense stand	Palatable	Grazing usually facilitates survival	Removal of grazing can be effective in short-term control	Has not been scientifically tested.
Dyer's woad	*Isatis tinctoria*	Moderate B,B,A,3.0	Annual to biennial	Rapidly spreads and can form dense mono-specific stands, displacing natives	Palatable, but usually avoided; nutritional value fair	Grazing is not effective.	Grazing is not effective.	Hand-pulling, hoeing, and digging can be effective for small and large stands; repeated clipping can also be effective. Burning is not effective because the plants are only

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Table 2G. (cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
								top-killed, and will re-sprout. Chemical treatments can be effective on small new infestations.
Perennial pepperweed	*Lepidium latifolium*	High A,A,A,3.1	Perennial	Rapidly spreads and can form dense mono-specific stands in wet areas, riparian zones, disturbed sites, and grasslands; displaces natives	Nutritional value is poor	Grazing is not generally effective.	Goats likely will eat this, and cattle can be trained to eat it.	Difficult to control. Non-chemical control treatments have been ineffective. Chemical controls alone are effective in the short-term if timed correctly, and followed by planting of a desirable replacement.
Ox-eye daisy	*Leucanthemum vulgare*	Moderate B,B,B,2.5	Perennial	Can form dense mono-specific stands, displacing natives	Not palatable; imparts disagreeable taste to milk	Has not been scientifically studied.	High density cattle grazing has been effective; goats likely will eat this, and cattle can be trained to eat it.	Difficult to control. Hand-removal is difficult due to abundance of viable rhizomes; heavy mulching can be effective. Chemical treatment has been effective.
Dalmation toadflax	*Linaria genistifolia ssp. dalmatica*	Moderate B,B,B,2.8	Perennial	Can form dense mono-specific stands, displacing natives	Generally avoided by cattle, but eaten by goats and sheep; lowers quality of forage	Moderate to intensive grazing by sheep and goats has been effective.	Sheep and goats will eat it, and cattle can be trained to eat it; intensive grazing can be effective	Repeated hand-pulling can be effective; mowing and cutting is less effective. Biocontrol insects have been effective. Chemical treatments have had inconsistent effectiveness due to genetic variability in resistance. Burning is not usually effective because root buds and buried seeds are unaffected by fire; and burning can remove

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Table 2G. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
								competing plants.
Yellow toadflax	*Linaria vulgaris*	Moderate B,B,B,2.3	Perennial	Can form dense mono-specific stands, displacing natives	Generally avoided by cattle, but eaten by goats and sheep; lowers quality of forage	Moderate to intensive grazing by sheep and goats has been effective.	Sheep and goats will eat it, and cattle can be trained to eat it; intensive grazing can be effective	Repeated hand-pulling can be effective; mowing and cutting is less effective. Biocontrol insects have been effective. Chemical treatments have had inconsistent effectiveness due to genetic variability in resistance. Burning is not usually effective because root buds and buried seeds are unaffected by fire; and burning can remove competing plants.
Crystalline iceplant	*Mesembryanthemum crystallinum*	Alert; Moderate B,B,C,3.7	Annual to biennial	Invades disturbed soil areas, and displaces natives by creating a mat of dead matter and depositing salts	Palatability poor; lowers quality of forage	Not likely to be controlled by conventional grazing.	Has not been scientifically tested.	Manual removal (of all plant parts) without soil disturbance can be effective. Burning not effective.
Pennyroyal	*Mentha pulegium*	Moderate C,A,A,2.7	Perennial	Displaces native in disturbed wetlands	Unpalatable; toxic to livestock	Not likely to be controlled by conventional grazing.	Has not been scientifically tested.	Manual controls are not effective. Research is needed on biocontrols, grazing, and burning treatments. Focused chemical treatments can be effective.
Rose clover	*Trifolium hirtum*	Moderate C,B,B,2.8	Winter annual	Outcompetes natives due to wider tolerance of dry and cold conditions	Valuable; planted as forage	Likely controlled at a regularly grazed property	Has not been scientifically tested.	Has not been scientifically tested.

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Table 2H Pest Plants of Napa and Mendocino Counties: Grasses

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Barb goatgrass	*Aegilops triuncialis*	High A,A,B,3.6	Winter annual	Forms mono-specific stands that diminish native species diversity and wildlife habitat	Mechanical injury, not palatable, especially at maturity; lowers quality of forage	Not likely to control; but likely to increase in the absence of grazing.	Intensive concentrated grazing just before and up to seed head emergence, continued through growing season can reduce seed production.	Early detection and control of new infestations is critical; seeds readily distributed by attachment to livestock and wildlife; large infestations difficult to control. Repeated mowing can substitute for grazing before seed head emergence. Repeated chemical treatment risks damage to other grasses, but can be effective. Repeated and thorough prescribed burn in spring can be effective, especially for large populations.
Silver hairgrass	*Aira caryophyllea*	Watchlist D,C,A,2.5	Winter annual		Valuable	Likely controlled at a regularly grazed property	Not likely to improve effectiveness	Has not been scientifically tested.
Sweet vernalgrass	*Anthoxanthum odoratum*	Moderate B,B,B,2.7	Perennial		Toxic; lowers quality of forage	Likely controlled at a regularly grazed property	Has not been scientifically tested.	Manual removal or repeated mowing before seeds develop can be effective.
Ripgut brome	*Bromus diandrus*	Moderate B,B,A,3.3	Winter annual	Fire hazard along with other annual grasses and forbs	Valuable at early growth stages; mechanical injury after awns develop; otherwise adequate	Likely controlled at a regularly grazed property; but likely to increase in the absence of grazing	Not likely to improve effectiveness; grazing that removes competing more palatable grasses can *favor* brome grasses	Caused by spring rest Repeated manual removal (pulling, cutting, or close mowing) before seeds mature can be effective.
Red brome	*Bromus madritensis ssp. rubens*	High A,B,A,3.0	Winter annual	Fire hazard along with other	Valuable at early growth stages;	Likely controlled at a regularly	Not likely to improve effectiveness;	Repeated manual removal (pulling, cutting, or close mowing) before seeds mature can be effective.

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Table 2H. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
				annual grasses and forbs	mechanical injury after awns develop; palatability poor to fair	grazed property; but likely to increase in the absence of grazing	grazing that removes competing more palatable grasses can *favor* brome grasses	
Pampass grass	*Cortaderia selloana*	High A,A,B,3.2	Perennial	Quickly colonizes coastal areas, especially disturbed soils, with very large plants; displaces natives and increases fire hazard	Has not been scientifically tested.	Not likely to be controlled by conventional grazing.	Has not been scientifically tested.	Difficult to control with few options. Manual methods include hand-pulling or digging of seedlings and adult plants. Chemical treatments can be effective in combination with cutting and seed removal.
Hedgehog dogtailgrass	*Cynosurus echinatus*	Moderate B,B,A,2.5	Winter annual	Has not been scientifically studied	Has not been scientifically studied	Likely controlled at a regularly grazed property ; but has not been scientifically tested.	Has not been scientifically tested.	Manual removal can be effective if without soil disturbance.
Tall fescue	*Festuca arundinacea*	Moderate B,B,A,2.9	Perennial	Forms dense mats of thatch; displaces natives	Planted for forage	Likely controlled at a regularly grazed property	Has not been scientifically tested.	Has not been scientifically tested.
Common velvet grass	*Holcus lanatus*	Moderate B,B,A,2.9	Perennial	Forms dense mats of thatch; inhibits and displaces	Palatable in early growth stages, but low in nutritive	Not likely to be controlled by conventional grazing; but	Has not been scientifically tested.	Dominance maintained by allelopathy. Hand-pulling, cutting, scraping, and repeated mowing treatments have been effective if before seed set,

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Table 2H. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
				natives	value; unpalatable at later stages, possibly due to toxins including cyanide	likely to increase in the absence of grazing.		and in combination with planting of a desirable alternative.
Mediterranean barley & Hare, smooth and wall barley	*Hordeum marinum & Hordeum murinum*	Moderate B,B,A,2.8	Winter annual	Has not been scientifically studied	Mechanical injury when spines develop; otherwise palatable	Likely controlled at a regularly grazed property; but likely to increase in the absence of grazing	Has not been scientifically tested.	Heavy grazing or repeated mowing can be effective. Otherwise, has not been scientifically tested.
Italian ryegrass	*Lolium multiflorum*	Moderate A,B,A,2.6	Winter annual or biennial	Forms dense mats of thatch; inhibits and displaces natives; increases fire hazard	Valuable	Likely controlled at a regularly grazed property	Not likely to improve effectiveness	Dominance maintained by allelopathy. Mowing or grazing by cattle or goats prior to bolting and flowering can be effective.
Harding grass	*Phalaris aquatica*	Moderate B,B,B,2.6	Perennial	Displaces natives and increases fire hazard.	Valuable, especially before mature stages	Likely controlled at a regularly grazed property; but likely to increase in the absence of grazing	High-density grazing can be effective	Manual cutting and mulching have been effective. Repeated mowing and burning treatments have been effective if timed properly. Chemical treatments have been effective, especially in combination with mowing.
Medusahead	*Taeniatherum caput-medusae*	High A,A,A,3.4	Winter annual	Forms dense mats of thatch;	Mechanical injury; low palatability in	Likely to increase in the absence	High-density grazing can be effective	Burning prior to flowering can be effective. Grazing by cattle or sheep in early

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Table 2H. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
				inhibits and displaces natives; increases fire hazard	early stages, not palatable at maturity; lowers quality of forage	of grazing. Grazing animals can aid its dispersal.		spring can be useful, but less effective than burning.
Squirreltail fescue	*Vulpia bromoides*	Watchlist D,C,B,2.9	Winter annual	Displaces natives and increases fire hazard.	Mechanical injury; low palatability in early stages, not palatable at maturity; lowers quality of forage	Likely controlled at a regularly grazed property	High-density grazing can be effective if in early spring	Has not been scientifically tested.
Rattail fescue	*Vulpia myuros*	Moderate B,B,A,3.0	Winter annual	Displaces natives and increases fire hazard.	Mechanical injury; low palatability in early stages, not palatable at maturity; lowers quality of forage	Likely controlled at a regularly grazed property	High-density grazing can be effective if in early spring	Has not been scientifically tested.

Table 2I. Pest Plants of Napa and Mendocino County: Trees and Shrubs

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
Silver wattle	*Acacia dealbata*	Moderate B,B,B,2.5	Perennial	Displaces native species	Toxic; lowers quality of forage	Not likely to be controlled by conventional grazing.	Unlikely	Manual removal of seedlings probably the most promising control
Tree-of-Heaven	*Ailanthus altissima*	Moderate B,B,B,3.0	Perennial	Creates thickets, displacing	Has not been scientificall	Continued browsing by cattle can control young	Recommend repeated concentrated	Dominance maintained by allelopathy. Manual pulling, cutting and chemical

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Table 2I. (Cont.)

Common Name	Scientific Name	CalIPC Pest Rating	Growth Habitat	Conservation Risk	Forage Quality	Control with Grazing Management		Notes and Control with Non-Grazing Management on Rangelands
						Extensive Grazing	Specialized Grazing Treatments	
				natives, especially in riparian zones	y studied	plants and sprouts	goat grazing	treatment of stumps can be effective. Prescribed fire not effective due to prolific re-sprouting.
Portuges e broom	*Cytisus striatus*	ModerateB, B,B,2.7	Perennial	Displaces native species; increases fire hazard	Toxic and unpalatable	Not likely to be controlled by conventional grazing.	Repeated high-density grazing by goats has been effective.	Combinations of hand-pulling, brush cutting, and mulching can be effective where chemical treatment, burning, and scraping with heavy equipment are not feasible. Repeated burning of uncut broom can be effective. Chemical treatments can be effective.
Blue gum	*Eucalyptus globulus*	Moderate B,B,B,2.8	Perennial	Forms dense mats of litter and branches; inhibits and displaces native species; increases fire hazard	Unpalatabl e	Not likely to be controlled by conventional grazing.	Unlikely	Dominance maintained by allelopathy. Cutting and chemical treatment of stumps has been most effective; repeated chemical treatment of foliage has been effective.
French broom	*Genista monspessu lana*	High A,A,B,3.2	Perennial	Displaces native species; lowers quality of forage; increases fire hazard	Toxic to livestock; lowers quality of forage	Not likely to be controlled by conventional grazing.	Repeated high-density grazing by goats has been effective.	Combinations of hand-pulling, brush cutting, and mulching can be effective. Repeated burning of uncut broom can be effective. Chemical treatments can be effective.
Gorse	*Ulex europaeus*	High A,B,B,2.9	Perennial	Dense stands displace native species; increases fire hazard	Spiny and mostly unpalatable when mature; lowers quality of forage	Not likely to be controlled by conventional grazing.	Repeated high-density grazing by goats has been effective, and cattle can be trained to eat it.	Difficult to control. Hand-pulling can be effective, but cutting is not. Burning has had mixed results, and is hard to control. Chemical treatments can be effective.

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FISH FRIENDLY FARMING™
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SONOMA AND MENDOCINO COUNTIES
FARM CONSERVATION PLAN TEMPLATE

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FISH FRIENDLY FARMING™ CERTIFICATION PROGRAM
FARM CONSERVATION PLAN

ELEMENT 1 - GENERAL SITE FEATURES

1. SITE NAME:_____

LOCATION: _____

VINEYARD OWNER/MANAGER: _____

PHONE NUMBER: _____

EMAIL: _____

2. TRIBUTARY WATERSHED: _____

3. GENERAL SITE DESCRIPTION:

Acres of existing vineyard: _____

Acres of new vineyard: _____

Acres of proposed replanting of vineyard: _____

Acres of other agricultural land/forestry land: _____

Acres of wildland: _____

Acres of buildings/developed areas (includes reservoirs): _____

TOTAL acres: _____

4. SITE HISTORY:

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5. THIS FARM PLAN CONTAINS THE FOLLOWING ELEMENTS:

☐ **II - NEW VINEYARD**

☐ **III - MANAGING THE VINEYARD**
Include this element both for existing vineyards and new vineyards

☐ **IV – MAJOR REPLANTS OF AN EXISTING VINEYARD**

☐ **V - ROADS**

☐ **VI - CREEK/RIVER CORRIDOR**

☐ **VII – PHOTO-MONITORING**

6. ADDITIONAL INFORMATION

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ELEMENT 2 - NEW VINEYARD*:
FARM CONSERVATION PLAN

INVENTORY OF PROPERTY TO DETERMINE VINEYARD* AREAS

1. PRELIMINARY SITE EVALUATION

The preliminary site evaluation involves a broad look at the overall property and incorporates environmental constraints and mitigations into the vineyard design.

2. COLLECTING RESOURCES FOR THE INVENTORY

- ❑ Order a high-resolution aerial photograph of the entire property.
- ❑ At a minimum purchase a 7.5-minute topographic map of the entire property or have a detailed topographic survey completed.
- ❑ Make copies of the aerials and maps at the same size as the originals to use for the evaluation.
- ❑ Additional specialized maps and resources may be needed to complete the preliminary evaluation. Some of these are noted in various sections. The Fish Friendly Farming workshops will assist in collecting resources.
- ❑ Define and outline each of the areas of the property under consideration for vineyard development for use in the preliminary evaluation. Give each area a name or number.

[1] "Vineyard is used in text, but also applies to orchards

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3. SLOPES: AREAS UNDER CONSIDERATION FOR VINEYARD DEVELOPMENT

For each defined area or section where a vineyard may be developed, numerous slope measurements should be made. Record your measurements of percent slope and slope length for each segment of the property.

Site Area	Slope Measurements (from topo map)	For 5-30% Slope Areas - are there small areas of steeper slopes?	Slope Field Check	Slope Lengths

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If you have a detailed site topographic survey include it in the farm plan.

Create an overlay on the map or aerial of slope classifications for the entire property. Slope classes to be used are <5%, 5-30%, 30-50%, and >50%.

For slope class 5-30% areas delineate all knolls, hills and small steep areas over 30% on your map.

4. SOIL TYPES AND EROSION RATINGS:

Fill out the table using the USDA Soil Survey and BMP workbook and site-specific information, if available.

Site Area (list number or name)	Soil Type	Slope Classification	Permeability	Erosion Hazard Rating	Hydrologic Soil Group	K Value	T Value

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5. SLOPE STABILITY/EXISTING EROSION SITES/SEDIMENT SOURCES

Outline on the aerial obvious areas of unstable soils such as landslides, melted ice cream looking hillsides, gullies and slips

Outline on the aerial the entire road system currently on the property including jeep trails, old logging and skid roads

Site Area	**List Type of Erosion Problem** (example: gully**)**	**List Cause if Known** (example: old culvert**)**

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6. NATURAL DRAINAGE FEATURES

Delineate the blue line and dashed blue line streams on the topo map and aerial. Give each a name or number. The FFF program staff can assist with this section.

Delineate all the ephemeral creeks on the map and aerial. Give each a name or number. Take photos of each creek and label each with the name/number and year.

Creek (list by name or number)	**Describe Condition:** (natural and vegetated, partially vegetated, partially vegetated with road crossing, all vegetation removed, lined with riprap or other material, highly eroded or other – describe)	**List Level of Erosion along Creek** (high, medium, low)

Indicate any springs on the map/photo and describe their features if known:

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Indicate on map and check drainage conditions you observe:

- ☐ Additional runoff from upstream areas entering property including road culverts, drainage system or urban stormdrain
- ☐ Backwater area occurs downstream
- ☐ Upstream development occurring or planned
- ☐ Upstream reservoirs
- ☐ Downstream channel incision (leave blank if not sure)
- ☐ Creeks on the site are highly eroded and unstable
- ☐ Additional observations:

7. VEGETATION/HABITAT/SPECIAL STATUS SPECIES

List the features of the vegetation for each area

Site Area	List Vegetation Types For Each Site Area (see BMP workbook for list)	Density of Primary Vegetation Type (High, Medium, or Low)	Density of Understory (High, Medium, or Low)

Complete a review of the California Natural Diversity Database for potential special status species of the property.

List species (and site area if possible):

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List past uses of each site area and approximately when land use ended and if confined to a specific area.

LAND USE	LIST SITE AREA(S) WHERE LAND USE HAS OCCURRED AND DATES (IF KNOWN)
Grazing	
Feedlot	
Dairy	
Timber harvesting	
Recreation	
Orchard	
Row crops	
Residential	
Other – explain	

8. CULTURAL AND HISTORICAL SITES

Complete preliminary review for archaeological and historic sites.

9. OTHER SITE FEATURES

List other site features:

FEATURE	SITE AREA
Buildings	
Water Resources	
Utility Corridors	
Access Routes	
Landfills (indicate of it could have old pesticide disposal or diesel or gasoline.)	
Mines and Quarries	
Recreational Sites	
Other	

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10. DETERMINING THE NEW VINEYARD DEVELOPMENT AREAS

On copies of the aerial and topographic maps outline the areas of less than 30% slope and soils suitable for grape growing. These are the potential vineyard development areas. Within these potential vineyard development areas of less than 30% slope, areas of higher slope should be outlined. Give each potential vineyard development area a number.

Summary of Site Conditions. Use the preliminary site evaluation to fill out the table for each proposed vineyard development area

Potential Vineyard Development Area (give each a number)	Slopes	Acreage >30% Slope in Vineyard Area	Natural Creek Channels (type and name or number)	Condition of Creeks (from #6)	Vegetation Type and Condition (from #7)	Special Status Species or Habitats	Cultural or Historic Resources	Existing Erosion Sites Including Roads and Unstable Slopes

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Summary of potential impacts and enhancement needs:

List proposed vineyard development areas and acreages and areas on the site for potential enhancement (see BMP workbook)

Feature	Areas & Acreages	Potential Mitigations & Mitigation Areas
Creek Channels **For Non-ephemeral Creeks: Use Element VI**		
Vegetation Types and Clearing		
Special Status Species or Habitats		
Cultural or Historic		
Existing Erosion Sites **For Roads: Use Element V**		
Other		

Delineate footprint of proposed new vineyard area after reviewing slope, creek corridor, and other restrictions. Outline proposed areas for vegetation enhancement and other site conditions. Have a 1''=200' topographic map with 5-foot contours created for each proposed new vineyard area for use in the erosion control plan.

SITE DESIGN: PROPOSED NEW VINEYARD AREAS

Description of Proposed New Vineyard Areas

Area Name or Number	Acreage	Layout

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11. SOIL CONSERVATION AND EROSION CONTROL PLAN

Landslide Hazards

Do any of the proposed new vineyard areas have slides, slips or large gullies?

☐ yes
☐ no

If yes, has an engineering geologist reviewed the areas?

☐ yes
☐ no

The Sonoma County Hillside Vineyard Ordinance requires an Erosion and Sediment Control Plan for many new vineyards. The ordinance requires that a civil engineer, approved by the County, prepare the erosion control plan and that the erosion control plan should include:

- ❑ Narrative and graphic information describing the project
- ❑ The name of the preparer or civil engineer
- ❑ A description of the site including topography, soil types, vegetation, streams, lakes, reservoirs, roads, homes and existing drainage improvements. Identification of areas on the vineyard site that may have significantly more or less potential for erosion
- ❑ A summary of temporary and permanent measures to protect disturbed areas and manage stormwater runoff on the vineyard site and minimize the discharge of sediment from the vineyard site. A schedule for implementation, maintenance and upkeep of the temporary and permanent measures and provisions for responsibility of maintenance
- ❑ A location map of the vineyard site
- ❑ A topographic map of the site at a scale of 1''=200' showing all the details of the project including vineyard layout and boundaries, existing and finished contours, soil types, stormwater flow lines, creeks and setbacks, vegetation, buildings, wells and utilities, proposed soil protection measures, proposed stormwater management and sediment control measures and calculations for each measure, construction details, drainage area of the stormwater management system

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In addition the following should be included:

- ❑ Detailed engineering drawings of project features
- ❑ USLE based evaluation of sheet erosion should be completed as part of a new vineyard plan
- ❑ Vineyard designs also need to include limitations on increases in peak discharges and other BMPs from the following sections.
- ❑ The Fish Friendly Farming program recommends that an Erosion Control Plan be prepared for all new vineyards or parts of vineyards with slopes in excess of 10% and that the plan include all of the above elements.
- ❑ Attach erosion control plan to farm plan

12. DRAINAGE IMPROVEMENTS

Indicate the proposed drainage improvements on the detailed erosion control plan map as well as the aerial photo. Indicate the inlets and the vineyard area that drains to each inlet or other improvement, all outlets and any improvements to address offsite runoff entering the site.

Indicate the type of drainage system used for each vineyard area. Check all that apply and indicate the vineyard area number or name:

DRAINAGE SYSTEM	**VINEYARD AREAS**						
Underground pipe with drop inlets							
Terrace benches with drop inlets and underground pipes							
Grassed/vegetated waterway							
Rock-lined waterway							
Flexible pipe drop							
Diversion ditch							
Perforated pipes							
Other – Specify							
None needed							

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Does the drainage plan retain natural waterways including ephemeral stream/swales, year round and seasonal creeks?

☐ yes
☐ no

Does the drainage improvement plan use the 100-year frequency, 24-hour duration rainfall or greater event (National Weather Service Data)? Attach calculations for each system to farm plan.

☐ yes
☐ no

Does the drainage system have energy dissipaters or stilling basins at every outlet?

☐ yes
☐ no

Are the dissipaters at the outlet sized to withstand maximum storm volumes?

☐ yes
☐ no

Does the proposed drainage system spread water release points over the site to avoid concentrating flow to a few release points and increasing erosion potential?

☐ yes
☐ no

Have the stormwater volumes for various storm events at each outlet and for the total number of outlets in a creek been evaluated for their potential to cause erosion to the creek?

☐ yes
☐ no

Does each inlet have a screen, grate or other measure to reduce clogging?

☐ yes
☐ no

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Does the drainage system increase the peak stormwater discharge from the vineyard areas more than 15% for the 2-, 5- and 10-year frequency, 24-hour duration rainfall event from the existing pre-vineyard condition for each sub-watershed on the property? Attach model results for each sub-watershed (see Appendix 2).

☐ yes
☐ no

If yes, describe the features such as stilling/detention basins or water spreaders at the release points that have been included in the system to offset the flow increases and attach calculations.

If no, complete this evaluation and revise the system either by increasing the number of outlets if a problem occurs at one outlet location, or by installing detention basins or other measures to reduce the overall volume and discharge into a creek and avoid localized erosion.

13. LAND TREATMENT PROPOSED IN VINEYARD AREAS

Indicate the types of land treatment proposed and indicate the name/number of the vineyard area:

METHOD	**VINEYARD AREAS**						
Re-contouring							
Deep ripping							
Ripping/soil conditioning							
Construction of terraces							
Minimal grading							
Other – Specify							

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What size (in acres) are the areas to be graded?

Vineyard Area	Acreage

Will finished grading create cross slope furrows to avoid gully formation?

☐ yes
☐ no

Are the areas to be graded sized so that all work including erosion control can be completed by October 15?

☐ yes
☐ no

If no, break the project into phases.

14. VINEYARD FIELD ROAD LOCATIONS AND CROSSINGS

Indicate the vineyard field roads on the site plan including all creek crossings. Give each crossing a number.

Are road crossings of creeks – ephemeral, seasonal and year round minimized in the site design?

☐ yes
☐ no

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For each creek crossing indicate the type:

Type of Crossing	Vineyard Road and Crossing Number	Type of Creek – Ephemeral or Year-round
At-grade Seasonal Ford		
Permanent Ford		
Bridge		
Seasonal Culverted Crossing		
Permanent Culverted Crossing		
Other - Specify		

Are all roads located away from creek corridors?

☐ yes
☐ no

Other roads on the site should be included in Element V – Roads.

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15. VEGETATION REMOVAL

List the type of vegetation removal used for each vineyard area.

Check all that apply and indicate the vineyard area number or name:

VEGETATION REMOVAL TYPE	VINEYARD AREAS				
Natural vegetation retained in swales and ephemeral streams next to vineyard area					
Vegetation removal minimized affecting vineyard footprint only					
Some vegetation removal in swales and streams					
Natural vegetation enhanced or replanted on other portion of site					
Heritage trees retained in vineyard					
No clearing of riparian vegetation along stream corridors					
Clearing of vegetation from stream corridors					

For vineyards that affect coniferous forest, oak woodland, wetlands or other sensitive habitats and require revegetation and replanting projects, attach a map indicating areas of projects, a project description including a plant species list, planting techniques and times, and maintenance measures. Implementation timeline (see page 21) should include vegetation enhancement and replanting program.

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Does the fencing plan, vineyard layout, and creek corridors allow for wildlife movement through or around the site?

☐ yes
☐ no

16. EROSION SITES

Are there existing erosion sites in or near the vineyard areas?

☐ yes
☐ no

If yes, describe the type of erosion problem:

Attach plans for repairs or indicate timing of design of repairs as part of implementation timeline.

17. WATER SUPPLY AND CONSERVATION

Indicate on the aerial photo, site plan, or detailed map the proposed water sources and features of the irrigation system. Check all that apply:

☐ Off-channel reservoir with year-round diversion (not recommended or likely to be permitted)

☐ Off-channel reservoir with winter only diversion (Dec. 15 — March 31)

☐ Riparian diversion used year-round (not recommended and not likely to be permitted)

☐ Riparian diversion with seasonal restrictions/regulatory pond

☐ Well – indicate distance from creek corridor

☐ On-channel reservoir (not recommended and not likely to be permitted)

☐ Wastewater use indicate source and amount

☐ Cisterns to collect vineyard drainage and frost control water

☐ Other:

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☐ Review Appendix 4 and complete or have completed the analyses for the water rights permit. This review will demonstrate if there is adequate water for the vineyard development. It is recommend that a hydrologist or civil engineer be retained to complete this analysis and that you contact the Division of Water Rights of the State Water Resources Control Board in Sacramento regarding your application prior to starting the analysis or the vineyard project.

Will there be a need for frost control water supply and is this need included in the water rights application/permit?

☐ yes
☐ no

Describe water conservation features in the irrigation and frost control system:

INSTALLATION OF THE NEW VINEYARD AND APPLICATION OF BMPs

18. TIMING

Indicate the year for each of the following activities as part of the new vineyard development.

ACTIVITY	YEAR
Evaluation of site and preparation of plan	
Completion of CEQA, local permits and other requirements	
Clearing the land - retaining natural vegetation in drainage areas as much as possible	
Grading, terracing or other major soil conditioning and contouring on the vineyard site only	
Vineyard field road construction	
Installation of underground drainage system, grassed waterways, diversion ditches or other drainage improvements in the vineyard as needed	
Installation/development of primary elements of water supply system	
Planting of cover crops during vineyard development	
Installation of temporary erosion control	

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ACTIVITY	YEAR
Installation of additional erosion control	
Observation of site drainage system performance, erosion problems and use of temporary erosion control measures	
Repair of any drainage problems, erosion sites and problems	
Fine grading of terraces	
Installation of drip lines	
Planting of vines/installation of trellis	
Planting of cover crops	
Installation of additional permanent erosion control	

19. LAND TREATMENT

If land preparation involves extensive grading will area be graded, drainage improvements installed and erosion control in place prior to October 15 of each year?

☐ yes
☐ no

20. COVER CROPS AFTER DEVELOPMENT

Is temporary cover crop seed available and at hand, irrigation or other water system available by September 30 for each year of grading and for each vineyard area?

☐ yes
☐ no

In addition to the seeding of cover crops are roads, terrace benches and faces and all areas of graded land protected with mulch, erosion blanket or other materials to assure all soil surfaces have either an established dense cover crops or other material by October 15?

☐ yes
☐ no

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Are vineyard roads fully mulched and have water bars installed prior to October 15?

☐ yes
☐ no

21. DRAINAGE SYSTEM INSTALLATION

Review the BMPs and description of each type of drainage system in the BMP workbook and make sure the plans and specifications of the vineyard design are detailed and include all necessary information.

- ❑ Supervise or have an engineer supervise the installation of the drainage system to assure proper trenching pipe and inlet installation, ditch slopes, backfill compaction, and other features are correctly constructed.
- ❑ Actively seed all areas with cover crop following construction. Use mulch and erosion blanket if needed in steep areas to protect soil and encourage cover crop growth.
- ❑ Observe the system in action frequently during the first winter to assure any problems are corrected immediately.

22. TERRACE OR BENCH INSTALLATION

Review the BMPs and recommended design features for benches in the BMP workbook to assure your vineyard design complies with BMPs.

- ❑ Supervise or have an engineer supervise installation of the benches and slopes of the terrace, inlets and underground pipe installation and any other features to assure they are correctly installed.
- ❑ Actively seed all areas with cover crop following construction including terrace face. Use mulch and erosion blanket on face to protect soil and encourage cover crop growth.
- ❑ Observe terrace system in action frequently during the first winter to assure any problems are corrected immediately.

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23. ADDITINAL EROSION CONTROL MEASURES

Is a winterization and emergency erosion control program written out and ready to be implemented? Does it include frequent inspections of drainage facilities and outlets, graded areas and permanent roads?

☐ yes
☐ no

If no, revise your program.

Are emergency erosion control materials – strawbales or wattles, sand bags, or silt fencing stockpiled on site and site employees trained in their use?

☐ yes
☐ no

Are temporary strawbale sediment basins around inlets installed prior to October 15?

☐ yes
☐ no

24. PERMANENT EROSION CONTROL

Does the vineyard include vegetated filter strips between the vineyard and all waterways?

☐ yes
☐ no

If no, incorporate filter strips into the project or winterize field roads or turnarounds adequately for this purpose.

Does the site include a sediment basin(s)?

☐ yes
☐ no

Where will soil removed from the basin be placed?

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Once the new vineyard is established, management measures should continue to conserve soil and water and protect all aspects of the natural and installed drainage system. The intended management practices for the vineyard should be outlined in Element III Managing the Vineyard.

SUMMARY: NEW VINEYARD ELEMENT

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Preliminary Site Evaluation Includes:		
☐	☐	Evaluation of slopes over areas of the property under consideration for vineyard development
☐	☐	Inventory of soil types and their characteristics
☐	☐	Inventory of any unstable slopes or erosion sites and delineation of road system
☐	☐	Delineation of entire stream network and all drainage features including assessment of the general condition of creeks
☐	☐	Inventory of vegetation types and conditions, unique habitats, prior land uses and records of special status species occurrence
☐	☐	Inventory of cultural and historical sites

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Preliminary Site Evaluation Includes:		
☐	☐	Inventory of other features
☐	☐	Use of preliminary site evaluation to determine vineyard area footprint and any mitigation or revegetation/enhancement areas
Site Design Includes:		
Slopes/Erosion:		
☐	☐	Vineyard areas are less than 30% slope. Areas of higher slope within the 30% or less slope areas should not exceed two acres. For areas with slopes in the 30-50% classification an evaluation of the cost and revenues from the vineyard over a 10-year period should be done prior to any consideration of vineyard development or site work.
☐	☐	Erosion control plan completed which addresses sheet erosion and slope lengths to avoid concentrated flows and has incorporated other measures to control erosion.
☐	☐	Vineyard areas do not include unstable slopes without engineered repairs.
☐	☐	Land preparation involves a minimum of vegetation removal.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Slopes/Erosion:		
☐	☐	Land preparation involves little to no clearing or alteration of swales/ephemeral creeks, intermittent or year round stream corridors.
☐	☐	Areas of the site that will be graded or ripped are limited in size so that all land preparation can be completed and seeded with cover crops and erosion control measures installed before October 15.
☐	☐	Existing erosion problems such as gullies are repaired as part of the plan.
☐	☐	Filter strips are incorporated into the vineyard design and are adequately sized for the slope adjacent to waterways. Filter strips can be winterized vineyard roads and turnarounds.
Drainage System:		
☐	☐	Natural waterways including ephemeral stream/swales, seasonal and year round creeks are retained and/or revegetated.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Drainage System:		
☐	☐	Drainage improvements in each new vineyard area are sized for the 50 to 100-year frequency, 24-hour duration rainfall event as based upon National Weather Service data.
☐	☐	Drainage system plans and calculations are included in this plan.
☐	☐	Drainage system addresses offsite stormwater entering the site.
☐	☐	Stormwater discharge from the new vineyards does not exceed (by greater than 15%) the pre-project stormwater discharge from the site for a 2-, 5-, and 10-year frequency, 24-hour duration rainfall event. If such an increase occurs then detention facilities or other attenuation measures are included in the plan. Calculations of stormwater discharge for the site are attached.
☐	☐	Drainage improvements do not concentrate flows into limited outlets but use numerous outlets to spread flows and avoid erosion.
☐	☐	All drainage outlets have adequately sized energy dissipaters or stilling/detention basins.
☐	☐	Outlets have been evaluated for their potential for causing localized erosion or cumulatively causing erosion in creeks.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Drainage System:		
☐	☐	Inlets will have screens, grates or other measures to reduce clogging.
Vineyard Field Roads - Location and Crossings:		
☐	☐	Vineyard roads limit crossings of ephemeral, intermittent and year round streams and use most fish friendly crossing design for the site.
☐	☐	Vineyard roads are located away from the creek corridor to avoid washout and erosion during flood events.
Site Design Includes:		
Vineyard Field Roads - Location and Crossings:		
☐	☐	A separate Element V for all roads includes design, drainage and installation is completed as part of the farm plan. This section is just for location and crossings.
Vegetation Removal:		
☐	☐	Revegetation or enhancement project plans included for vineyards that involve significant clearing of oaks, wetlands, coniferous forest or other sensitive habitats.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Vegetation Removal:		
☐	☐	Fencing plan includes evaluation of wildlife migration corridors on the site or in the overall area of the project.
Water Sources:		
☐	☐	Analysis is completed for new water appropriation or diversion showing adequate water is available for the new vineyard project and permit is applied for with the State Water Resources Control Board.
☐	☐	Water sources proposed include off-channel reservoirs with winter diversions, or wells that are not next to creek.
☐	☐	Irrigation system and if applicable, frost control system uses best technology for water conservation.
Site Installation Includes:		
☐	☐	Timeline for installation allows for reasonable acreages such that grading, installation of drainage improvements are done and cover crops and erosion control are installed between April 15 and October 15.
☐	☐	All vineyard areas: benches – flat and face, roads and other cleared areas will have soil protection, dense cover crops, mulch, erosion blanket and other measures in place by October 15.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Installation Includes:		
☐	☐	Cover crops are seeded and irrigated as needed to densely cover graded areas by October 15.
☐	☐	Emergency erosion control preparedness plan and materials are in place by October 15. Temporary cover crops are seeded and irrigated as needed to densely cover graded areas by October 15.
☐	☐	Drainage system installed using BMPs for type of system with adequately sized energy dissipaters or detention basin installed at all outlets.
☐	☐	Winter site inspection and erosion control program prepared and ready to implement.
☐	☐	Additional erosion control is installed if appropriate.
☐	☐	Vineyard management – Element III completed and attached.

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IMPLEMENTATION TIMELINE: NEW VINEYARD ELEMENT

Timeline should demonstrate how BMPs will be implemented over the first ten years of the new vineyard development.

ACTION/BMP	TIME FRAME

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ELEMENT 3 - MANAGING THE VINEYARD:
FARM CONSERVATION PLAN

SITE INVENTORY

1. FEATURES OF PROPERTY AND THE VINEYARDS

Mark each area of vineyard on the map or aerial photograph and give each a number or name:

Vineyard Acreage:

Area 1:
Area 2:
Area 3:
Add more areas as needed:

Vineyard Layout (cross slope grid, up and down hill grid, contour terraced):

Area 1:
Area 2:
Area 3:
Add more areas as needed:

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2. SOIL TYPES AND EROSION RATINGS: (from USDA Soil Survey and BMP workbook)

Vineyard Area (list number or name)	Soil Type	Slope Classification	Runoff Permeability	Erosion Hazard Rating

3. CHECKING SLOPES (compare USDA soil survey slope classification to field measurement)

Area 1: _____ Field checked %slopes: _____
Area 2: _____ Field checked %slopes: _____
Area 3: _____ Field checked %slopes: _____

Add more areas as needed:

Approximate acreage of slopes over 30% in vineyard area, list by name or number:

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4. NATURAL DRAINAGE FEATURES

Delineate ephemeral creeks, seasonal creeks, and year round creeks on the topo map. Give each creek a number or name.

Delineate any springs, seeps, or wetlands on the property and give each a number or name.

Creek Name or Number	**Type of Creek- Ephemeral, Seasonal or Year round**	**Describe condition:** • **Natural vegetation – no alteration** • **Partially vegetated** • **Completely altered** • **Other conditions - road crossings, slips, slides, etc.**

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VINEYARD MANAGEMENT PRACTICES

Describe your practices below; see Element 3 Instructions and BMPs for specific questions to answer and information to include.

5. COVER CROPS

Photograph each vineyard area and its roads during the rainy season to show winterization and soil conservation practices.

Describe general cover crop management in each vineyard area, including what cover crop mix is seeded, if natural vegetation is allowed to grow, if different mixes are used in various areas of each vineyard, if cover crop mixes have been changed. The table on the next page can also be used.

6. SEASONAL TILLING PRACTICES

Describe tillage practices, including the frequency of tillage for each vineyard area and when in the season in the vine row tillage and avenue tillage is carried out. Explain why you till, if you changed tillage practices, and why:

7. WINTERIZATION OF SEASONAL FIELD ROADS INCLUDING TURNAROUNDS (HEADLANDS)

Describe winterization practices for the seasonal roads and turnarounds in each vineyard area.

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COVER CROP MANAGEMENT

Cover Crop Mix Used	Cost/ Acre	Year	Vineyard Area	Management Regime: Mow, Till, Strip Spray Vine Row, Till Vine Row, Disk Every Other Row, Etc.	IPM Plants & Benefits	Irrigation Amounts	Weed Problems	Erosion Problems	Vine Competition Problems	Tonnage and Quality

Additional Comments:

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8. VINEYARD DRAINAGE SYSTEM

This description should only focus on the in-vineyard drainage system.

Features of the Vineyard Drainage System

In the following table describe the drainage system for each vineyard area.

Vineyard Area	**Type Of Drainage System/ List all that occur in each vineyard area:** • **Underground Pipes with Drop Inlet** • **Perforated Pipe** • **Terrace Benches with Drop Inlet and Underground Pipes** • **Grassed/Vegetated Waterway** • **Rock-Lined Waterway** • **Flexible Pipe Drop** • **Diversion Ditch** • **Other**	**Design Criteria (size storm event; attach plans and designs, if available)**	**Comments**

Describe regular maintenance actions for drainage system including: timing of debris removal for inlets, repair and replacement of outlet dissipaters, repair of ruts on terraces, reseeding of grassed waterways.

Describe winter inspection and management actions.

Describe problem areas where failures or erosion of inlets, outlets, pipes, terraces, ditches, or lines waterways has occurred. Indicate how often each problem occurs. Outline repairs done or upgrades needed.

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9. NATURAL DRAINAGE FEATURES MANAGEMENT AND MAINTENANCE

Fill in the following table describing the condition of each ephemeral stream/swale. See inventory in Section 4. The FFF program staff will assist you if needed.

Ephemeral Creek/Swale Name or Number	Erosion Problems Location and Description	Needs Dissipater (List Location)	Needs Revegetation (List Location)	List management and maintenance practices	Other Comments

10. EMERGENCY EROSION CONTROL READINESS

Describe methods:

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11. EROSION SITE REPAIRS

Describe current erosion problems in vineyards or vineyard roads including gullies, rilling, and hillside slippage.

Describe any erosion problems (gullies, rilling, hillside slippage or failures) on other areas of the property.

Describe repairs made and success of repairs to any erosion problem.

12. SUMMER DUST CONTROL METHODS

Describe methods:

13. PEST AND DISEASE CONTROL PRACTICES

Chemical Storage and Mixing
Work with the FFF staff to mark the location of the chemical storage site and mix and load site on the aerial

Is the storage area outside of regularly flooded areas?

☐ yes
☐ no

Is there an impermeable floor in the storage area?

☐ yes
☐ no

Are all containers labeled properly?

☐ yes
☐ no

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Is the chemical storage site posted and locked?

☐ yes
☐ no

Are containers of dry formulation stored off the floor on palettes or shelves?

☐ yes
☐ no

Is there a containment berm around the chemical mixing areas to limit movement of chemicals into surface water?

☐ yes
☐ no

Do the storage and mixing areas have a separate drainage system from the storm water system?

☐ yes
☐ no

If you have vineyard/orchard heaters, do you move them out of the creek side/riverside areas prior to the rainy season?

☐ yes
☐ no

Integrated Pest Management

Do you monitor insects before applying chemicals?

☐ yes
☐ no

Do you have Pest Control Advisor (PCA) who provides pest and disease control recommendations?

☐ yes
☐ no

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Do you understand the lifecycles of the pest insects that can affect your crop?

☐ yes
☐ no

Do you employ Integrated Pest Management (IPM) methods?

☐ yes
☐ no

Do you plant cover crops or perennials to support beneficial insects?

☐ yes
☐ no

Please describe location of plantings.

Have you established economic thresholds for crop damage from each pest/disease and only spray once this threshold is exceeded?

☐ yes
☐ no

Describe established economic thresholds for each pest/disease:

Are you a certified or registered organic grower?

☐ yes
☐ no

Are you a certified biodynamic grower?

☐ yes
☐ no

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Describe your monitoring and treatment methods for each disease or pest. Mark N/A if you do not have the listed pest or diseases. Be detailed and accurate and list all the chemicals currently used and those previously applied.

Disease/ Pest	Monitoring methods for pre and post application	List cultural and chemical control method usually used	List fish toxicity from Table IIID in BMP workbook	List the chemical formulation used	List any other methods used occasionally	List changes in applications near to riparian corridor, river, creeks or other areas
Powdery mildew						
Eutypa						
Young Esca (measles, black goo, young vine decline)						
Botrytis bunchrot						
Oak root fungus						
Pierce's disease/ sharp-shooters						
Grape phylloxera						
Fanleaf virus						
Spider mites						
Grape leafhopper						
Vine mealybug						
Nematodes						
European grapevine moth						
Other						

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Application Methods

Do you have residences near to the vineyard/orchard?

☐ yes
☐ no

Do you discuss chemical practices with neighbors, especially if residences are within 50 ft of the vineyard/orchard edge?

☐ yes
☐ no

How often do you calibrate your spray equipment and maintain it to avoid leaks?

Are you using older equipment that limits the choice of materials or control of spray area or volumes?

☐ yes
☐ no

Do you monitor wind speed while you spray?

☐ yes
☐ no

What do you use to measure wind speed?

WEED CONTROL

Year	Vineyard Area	Types of Weeds	Describe Control Strategy (including chemical and mechanical controls)	Number of times control weeds per year	Timing	Effectiveness

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FERTILIZER USE

Describe your use of fertilizer; list the type of fertilizer and manner of application:

If you use drip irrigation systems for chemical or fertilizer applications, do you have backflow protection in the system to prevent chemicals or fertilizers from entering wells or tanks?

☐ yes
☐ no

WELLHEAD PROTECTION

Is there a containment berm around each wellhead?

☐ yes
☐ no

Are wellheads located uphill from chemical storage and mixing/cleaning areas?

☐ yes
☐ no

RESERVOIR ALGAE CONTROL

Do you use algaecides in your reservoir, and if so, what chemicals do you use?

☐ yes
☐ no

When do you apply the algaecide and how much?

14. WATER SUPPLY AND CONSERVATION

Water Conservation

<u>Irrigation Methods</u>

Irrigation is done by:

☐ Drip system
☐ Sprinklers
☐ Other

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Describe methods used to determine when to irrigate:

Do you have a shortage of irrigation water?

☐ yes
☐ no

If yes, only in dry years or regularly?

What is the average annual amount of water used for irrigation per acre?

Frost Control Methods

Passive Measures

Indicate which passive management measures you use:

☐ **Double pruning**
☐ **Mow cover crops**
☐ **Disk and roll vineyard floor**
☐ **Apply copper**
☐ **Change in border vegetation to block or drain cold air**
☐ **Apply Frost Gard or Frost Shield**

Features of the Frost Control System

What are the total acres of vineyards and orchards including fallow areas?

How many acres have frost control?

Work with the FFF staff to delineate each area of vineyard with frost control on the map or aerial photograph

Work with the FFF staff to delineate areas of the vineyard as early, mid and late-season budding varieties on the map or aerial photograph and list the acreages of each

Is your system set up to shut off the frost protection water to mid-season and late budding varieties while the early budding varieties are receiving frost control?

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Work with the FFF staff to delineate on the map or aerial photograph the locations of the main water lines used in frost control operations and valves in the pipe system used to shut off the frost protection water.

What is the diversion rate of the pump in gallons per minute (gpm) and in cubic feet per second (cfs) if known? Indicate if pump has variable speeds?

Indicate the severity of frost in the area:

- ☐ **Severe** (down to 27°F or -3.9°C wet bulb temperature)
- ☐ **Moderate** (28-30°F or -2.2°C wet bulb temperature)
- ☐ **Mild** (31-32°F or -0.5 - 0°C wet bulb temperature) frost zone?

Do you have climatic conditions (mild frost zone) that would allow for the use of wind machines for frost control?

What is the source of weather data used for frost forecasts?

Describe the number of locations in the vineyard regularly monitored and the frequency of monitoring during frost events

Do you have remote access via computer or cell phone to weather data from the vineyard?

Do you monitor:

- ☐ Air temperature
- ☐ Humidity
- ☐ Dew point temperature
- ☐ Wet bulb temperature

How many hours in an average year is frost control necessary?

What type of sprinklers do you have?

What is the approximate gallon/hour/acre of water used for frost control? If this volume varies for different vineyards please list

Is your system set up to shut off the frost protection water to mid-season and late budding varieties while the early budding varieties are receiving frost control?

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If you are in a moderate or mild frost zone would you change to a micro-sprinklers system?

Do you machine harvest?

Work with FFF staff to complete the frost water savings calculator, please check the BMPs you are/will be implementing.

☐ No use of water for frost in portions of vineyard
☐ Passive measures used – cover-crop mowing, application of copper or Frost Gard, double pruning
☐ Increased on-site temperature monitoring
☐ Installation of valves in water system to restrict early season water applications to mid and late budding grape varieties
☐ Older overhead sprinklers will be retrofitted
☐ Overhead sprinklers will be replaced with low-flow sprinklers
☐ Overhead Sprinklers will be replaced with wind machines
☐ On-site recollection of water with subsurface drains and sump

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Features of System

Fill out the appropriate table for reach type of water supply you have. Use your water right permit or license to find the needed information.

Features of Reservoirs and Water Supply

Type of reservoir	List water source: surface or sub-surface for each reservoir	Total storage size of each reservoir in acre-feet	Stream name if surface water source	Number of times fill reservoir and sources	Appropriate water right application number	Appro-priative right license number	Appro-priative right permit number	Riparian right State-ment of use	Rate of diversion and period of diversion for surface water sources	List bypass flow/ diversion conditions if applicable	How is flow measured to determine bypass flow for creek	How is diversion volume monitored by meter or reservoir filling records	Acreage of irrigated land for each water source	Acreage of frost control for each water source
On-stream reservoir														
Off stream reservoir														
Regulatory pond for riparian water right														
Pond above headwaters of stream														

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Use this table if you have a well, even if you store ground water in a reservoir.

Features of Wells and Water Supply

Well number or location	Production (gallons per minute)	Depth (in feet)	Depth of first opening, screen or pumping water level	Used for irrigation, frost or both?	If used to fill reservoir, indicate number or name	Distance from creek or river channel (in feet)	If you have an appropriative water right for the well, list the number	Do you file a riparian statement of use for well?	Acreage of irrigated land for this water source	Acreage of frost control for this water source

Indicate if you use any of the following and list the approximate amount of water used from this source and the season of use:

- ☐ Purchase water from irrigation district
- ☐ Use municipal recycled water
- ☐ Use winery wastewater
- ☐ Riparian diversion list creek

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Potential For Changes In System

Is there an on-channel reservoir that may be blocking fish passage?

☐ yes
☐ no

Could the reservoir be retrofitted to allow for bypass flows or a fish ladder to allow passage?

☐ yes
☐ no
☐ maybe
☐ not sure

If funds were available, could the on-channel reservoir be replaced with an off-channel reservoir on the site and the creek channel restored?

☐ yes
☐ no
☐ maybe
☐ not sure

If using a direct diversion could the timing of the diversion be altered to winter only use (Dec. 15- March 31) with a regulatory pond?

☐ yes
☐ no
☐ maybe
☐ not sure

If using a direct pump in the river or creek channel, is it fitted with a fish screen?
☐ yes
☐ no
☐ use pump in gravel

Is the fish screen designed according to NOAA standards?
☐ yes
☐ no

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15. REPLANTING

Only use this replanting section if the replanting involves no grading, is smaller than 20 acres and does not involve expansion of the vineyard. For the other replanting programs use Element 4.

Only use this replanting section if the replanting involves no grading, no vegetation removal no change in footprint and does not involve expansion of the vineyard. For the other replanting programs use Element 4.

List the timing (month, year) for each vineyard area in the replanting program.

List soil conservation/erosion control for each replant area including incorporation of filter strips and relocation of vineyard roads away from creek.

Describe the drainage improvements for each area including revegetation of ephemeral creeks.

Is it possible to increase filtration or detention of storm water on the site. Can T-spreaders be installed to reduce concentrated flows.

Attach the Erosion Control Plan and calculations for any improvements that have been designed.

Describe changes to fencing to allow increased wildlife migration.

Describe changes to each replant area to better control and conserve irrigation and frost control water.

Describe source of any increase in water supply for the replant areas including water rights licenses or application numbers.

Include any other features of the replanting program that address soil, water conservation, drainage or other features.

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16. ADDITIONAL ACTIVITIES

Outline other practices you implement that benefit the environment. Include tree planting, wildlife watering troughs, native grass plantings, wildlife-friendly fencing and other upland practices. Outline creek improvements in Element 6.

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SUMMARY: MANAGING THE VINEYARD ELEMENT

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Soil Conservation		
☐	☐	Winter cover crop use over entire vineyard floor and terraces by Oct. 15, use of a perennial cover crop, or if harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.
☐	☐	No tilling in the vineyard until after end of rainy season and no sooner than April 1. Mowing to reduce frost damage is okay.
☐	☐	Winterization of turnarounds, roads and other areas in vineyard and adjacent areas by Oct. 15, or if harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.
☐	☐	Installation of vegetated filter strips by Oct. 15, or if harvest is later than Oct. 15, install erosion control practices by Oct. 15, then seed cover crop post harvest.
☐	☐	Emergency erosion control preparedness by Oct. 15.
Drainage System		
☐	☐	Drainage improvements in vineyard are designed at a minimum for the 50- to 100-year frequency.
☐	☐	Farmer completes annual inspection and maintenance of drainage system including inlets.
☐	☐	Farmer completes winter inspections and repairs as needed.
☐	☐	Farmer completes repairs to system (resizing to increase capacity) as needed.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Drainage System		
☐	☐	Revegetation of swales and ephemeral streams (if applicable).
☐	☐	All outlets have adequate energy dissipaters or basins.
Pest and Disease Control		
☐	☐	Monitor insects prior to use of chemical control.
☐	☐	An integrated pest management system is used.
☐	☐	Limit use of pre-emergent, persistent herbicides and/or persistent pesticides (organophosphates).
☐	☐	Limit use or revise application methods for pesticides and herbicides within 50 ft. of waterways.
☐	☐	Manage riparian corridor to remove non-native and host plants to reduce Pierce's disease. Details are in Element 6.
☐	☐	Storage of chemicals follows county guidelines.
☐	☐	Mixing and loading sites and rinse/wash practices are protected of surface and groundwater quality.
☐	☐	Spray applications follow a methodology that takes into account weather, drift, state of equipment, neighbors, and other conditions.
☐	☐	Spray applications follow a methodology that takes into account weather, drift, state of equipment, neighbors, and other conditions.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Pest and Disease Control		
☐	☐	Well head protection is in place and farmer is aware of GWPA zones and regulations.
☐	☐	A backflow protection system is in place and farmer has a spill prevention plan.
☐	☐	Reservoirs are managed with environmentally friendly algacides (if applicable)
☐	☐	For all Orchards: Dormant insecticide sprays are only applied when weather reports indicate no rain for 48 hours following the application.
Water Supply and Conservation		
☐	☐	Water conserving irrigation practices are used.
☐	☐	Irrigation system is regularly checked for leaks.
☐	☐	Soil moisture/plant condition is monitored to determine irrigation needs.
☐	☐	Frost water conservation measures are installed
☐	☐	Use non-water or waste/recycled water for frost control
☐	☐	If direct diversion from creek channel is used for water supply, an off-stream reservoir is used for storage and re-charge of reservoir involves less than 1 cfs instantaneous rate.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Water Supply and Conservation		
☐	☐	Fish screens are installed (if applicable).
☐	☐	French drain type pump used in gravel (If applicable).
☐	☐	Wastewater is used in summer (If applicable).
☐	☐	Water right permit/license (If applicable).
☐	☐	Season of diversion/impoundment is Dec 15-March 31.
☐	☐	Winter diversion (December 15-March 31) into off-channel reservoir.
☐	☐	Evaluation of change from on-channel to off-channel reservoirs.
☐	☐	Evaluation of change from summer riparian diversion to winter diversion and off-channel storage.
Replanting		
☐	☐	Replanting program includes soil conservation practices during installation.
☐	☐	Replanting program incorporates filter strips and relocation of vineyard roads away from creeks.
☐	☐	Replanting program includes upgrades to drainage and revegetation of ephemeral creeks if appropriate.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Replanting		
☐	☐	Replanting program incorporates water conservation features.
☐	☐	Replanting program reviews fencing for wildlife migration.

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IMPLEMENTATION TIMELINE: MANAGING THE VINEYARD ELEMENT

Timeline should demonstrate how BMPs will be implemented over the next ten years.

ACTION/BMP	TIME FRAME

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ELEMENT 4 - REPLANTING/EXPANSION OF EXISTING VINEYARD: FARM CONSERVATION PLAN

This element is for existing vineyards that are undergoing a replanting program that includes:

- ❑ Major grading or re-contouring
- ❑ Removal of vegetation other than vines
- ❑ If none of the above conditions apply, use Element III that includes a simpler replanting section.
- ❑ If expanding the vineyard, complete Element II.
- ❑ All vineyards whether new or undergoing replanting need to complete Element III - Managing the Vineyard.

SITE INVENTORY

1. FEATURES OF THE REPLANT SITES

- ❑ Make copies of your aerial photograph and topo map and outline different features on each copy
- ❑ Indicate and label the following features on an aerial map to create a complete and accurate picture of the replant/expansion program:
  - ❑ All existing vineyards which will not be replanted
  - ❑ All areas of existing vineyard to be replanted: give each a name or number
  - ❑ All ephemeral streams/swales/even if highly altered, year-round and seasonal creeks and their riparian corridors (see Section 5)
  - ❑ Existing water sources and all proposed new water developments
  - ❑ Farm buildings
  - ❑ Main year-round access roads and vineyard roads

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- ❑ Vineyard fencing
- ❑ Adjacent land uses
- ❑ Areas of other land uses on the property
- ❑ The year proposed for each replant/expansion area

❑ Take photographs of each replant area

2. LIST THE ACREAGE OF EACH REPLANTING/EXPANSION AREA

Replant Area	Acreage
Area 1:	
Area 2:	
Area 3:	
Area 4:	
Area 5:	
Area 6:	
Area 7:	
Area 8:	

Add more areas if needed:

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3. SOIL TYPES AND EROSION RATINGS
(from USDA Soil Survey and BMP workbook)

List the soil type, slope classification, permeability and erosion hazard rating from the description of the soil type

Replant Area (list number or name)	Soil Type	Slope Classification	Runoff Permeability	Erosion Hazard Rating	Highly Erodible?	Hydrologic Soil Group	K Value	T Value

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4. SLOPES OF EACH REPLANT/EXPANSION AREA

For each replant or expansion area slope measurements should be made. Record your measurements of percent slope and slope length.

Replant Area	Slope Measurements (from topo map)	For Slopes >30%: Are There Small Areas of Steeper Slopes?	Slope Field Check	Slope Lengths (list from topo map)

5. NATURAL DRAINAGE FEATURES

Using a copy of the topo map and aerial photo delineate the blue line and dashed blue line streams. Give each a name or number.

Delineate all the ephemeral creeks on the map and aerial (see page 212 in the workbook for directions). Give each a name or number.

Take photos of each creek and label each with the name/number and year.

Creek Name or Number	Type of Creek- Ephemeral, Seasonal or Year round	Describe condition: • Natural vegetation – no alteration • Partially vegetated • Completely altered • Other conditions - road crossings, slips, slides, etc.	List Level of Erosion along Creek - High, Medium, Low	Distance from Edge of Ephemeral Creek Corridor to First Row of Vines

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Indicate any springs on the map/photo and describe their features if known:

Indicate on map any drainage conditions you observe:

☐ Additional runoff from upstream area entering property including road culverts, vineyard drainage system or urban storm drain.

☐ Backwater area occurs downstream.

☐ Upstream development occurring or planned.

☐ Upstream reservoirs.

☐ Downstream channel incision.

☐ Creeks on the site are highly eroded and unstable.

☐ Additional observations.

6. EROSION SITES

Are there erosion problems such as gullies, slope slippage, lumpy looking ground, old landslides or road failures within 200 feet of the replant areas?

☐ yes
☐ no

If yes indicate each on the map or aerial photo and give each a number.
Do any of the proposed expansion areas have slides, slips, lumpy looking ground or large gullies?

☐ yes
☐ no

If yes, has an engineering geologist or civil engineer reviewed the site?

☐ yes
☐ no

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7. FEATURES OF THE VINEYARD DRAINAGE SYSTEM IN EACH REPLANT AREA

In the following table describe the existing drainage system for each replant area. On the map/topo the drainage system should be delineated.

Replant Area						
Indicate Types of Drainage System by Area: • **Underground pipes with drop inlet** • **Perforated pipe** • **Terrace benches with drop inlet and underground pipes** • **Grassed/vegetated waterway** • **Rock lined waterway** • **Flexible pipe drop** • **Diversion ditch** • **Other type**						
Design criteria: size storm event, attach plans and designs if applicable.						
List location and degree of erosion in the vineyard.						
List location and degree of erosion at outlets, along ditches, in waterways, etc.						
Indicate where major problems such as slips, gullies and blowouts have occurred.						
Indicate locations of major repairs.						

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8. SUMMARY OF CONDITIONS

Use the information from Sections 1-8 to fill out the summary table for each replanting area or each expansion area.

Replant Area	Average Slope	Acreage of Areas >30% slope	Natural Creeks: Type, Name/ Number	Condition of Each Ephemeral Creek: Level of Vegetation/ Erosion	Proximity of Replant Area to Ephemeral Creek Corridor	Type of Existing Drainage System in Vineyard Area	Erosion Problems in Vineyard and at Drainage System Outlets	Year to be Replanted

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9. EVALUATION OF THE REPLANTING AREAS AND EXPANSION AREAS

- Review the summary of conditions from Section 8 and apply the following BMPs to the footprint of each replant and expansion area

- Each site acreage allows for all grading to be completed in the dry season and be fully winterized by October 15.

- It is highly recommended that for sites over 30% slope a detailed review of costs and revenues be completed. Costs include installation and management with full BMPs and revenues for a 10-year period with estimates for both high and low market conditions for grapes. Analysis should determine that the site is economically feasible to replant or expand and manage over the long term with required BMPs (Element III).

- Setback of 25 feet from ephemeral creeks included. Filter strips, seasonal vineyard roads and turnarounds (winterized as filter strips) can be in the setback.

- Erosion and lack of vegetation in creeks addressed in replant design

- Erosion problems in vineyard, at drainage system outlets, diversion ditches, reservoirs and other facilities addressed in replant design

- Vegetation removal evaluated for expansions to determine if permits needed

- The fencing plan and creek corridors allow for wildlife movement through or around the site

- Filter strips are included between vineyards and all creek corridors.

10. SOIL CONSERVATION AND EROSION CONTROL

Landslide Hazards

Do any of the proposed replant/expansion areas have slides, slips or large gullies?

☐ yes
☐ no

If yes, has an engineering geologist reviewed these areas?

☐ yes
☐ no

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- Complete an erosion and sediment control plan only for those replant/expansion areas covered by the Sonoma County Ordinance and those with recurring erosion problems or past major failures or erosion problems as identified in the inventory to prescribe the best set of drainage improvements and management measures to control soil erosion on the replant site.

- Many replant/expansion sites will not require this section.

- Narrative and graphic information describing the project

- The name of the preparer or civil engineer.

- A description of the site including topography, soil types, vegetation, streams, lakes, reservoirs, roads, homes and existing drainage improvements. Identification of areas on the vineyard site that may have significantly more or less potential for erosion.

- A summary of temporary and permanent measures to protect disturbed areas and manage stormwater runoff on the vineyard site and minimize the discharge of sediment from the vineyard site. A schedule for implementation, maintenance and upkeep of the temporary and permanent measures and provisions for responsibility of maintenance.

- A location map of the vineyard site.

- A topographic map of the site at a scale of 1''=200' showing all the details of the project including vineyard layout and boundaries, existing and finished contours, soil types, stormwater flow lines, creeks and setbacks, vegetation, buildings, wells and utilities, proposed soil protection measures, proposed stormwater management and sediment control measures and calculations for each measure, construction details, drainage area of the stormwater management system.

In addition the following should be included:

- Detailed engineering drawings of project features

- USLE based evaluation of sheet erosion should be completed as part of a new vineyard plan

- Vineyard designs also need to include limitations on increases in peak discharges and other BMPs from the following sections.

- Attach erosion control plan to farm plan

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11. DRAINAGE IMPROVEMENTS

Replant sites with recurring erosion problems, large blowouts or insufficient drainage systems will need to complete this section. Many replant sites will not need to complete this section.

Indicate the proposed drainage improvements on the detailed erosion control plan map as well as the aerial photo. Indicate the inlets and the vineyard area that drains to each inlet or other improvement, all outlets and any improvements to address offsite runoff entering the site.

DRAINAGE SYSTEM	**REPLANT AREAS**						
Underground pipe with drop inlet							
Terrace benches with drop inlet and underground pipes							
Grassed/vegetated waterway							
Rock-lined waterway							
Flexible pipe drop							
Diversion ditch							
Perforated pipes							
Other – Specify							
None needed							

Does the drainage plan retain natural waterways including ephemeral stream/swales, year round and seasonal creeks?

☐ yes
☐ no

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Does the drainage improvement plan use the 50 to 100-year frequency, 24-hour duration rainfall or greater event (National Weather Service Data)? Attach calculations for each system to farm plan.

☐ yes
☐ no

Does the drainage system have energy dissipaters or stilling basins at every outlet?

☐ yes
☐ no

Are the dissipaters at the outlet sized to withstand maximum storm volumes?

☐ yes
☐ no

Does the proposed drainage system spread water release points over the site to avoid concentrating flow to a few release points and increasing erosion potential?

☐ yes
☐ no

Have the stormwater volumes for various storm events at each outlet and for the total number of outlets in a creek been evaluated for their potential to cause erosion to the creek?

☐ yes
☐ no

Does each inlet have a screen, grate or other measure to reduce clogging?

☐ yes
☐ no

Does the drainage system increase peak stormwater discharge from the vineyard area by more than 10-15% for the 2, 5, and 10-year frequency 24-hour duration events? (see Appendix 2)

☐ yes
☐ no

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If yes, describe the features such as stilling/detention basins or water spreaders at the release points that have been included in the system to offset the flow increases and attach calculations (see Appendix 2).

If no, complete this evaluation and revise the system either by increasing the number of outlets if a problem occurs at one outlet location, or by installing detention basins or other measures to reduce the overall volume and discharge into a creek and avoid localized erosion.

12. LAND TREATMENT PROPOSED IN VINEYARD AREAS

This section is only used if the replant/expansion will be graded and ripped. Many replant sites will not require this section.

Indicate the types of land treatment proposed and indicate the name/number of the replant/expansion area:

METHOD	**REPLANT AREAS**						
Re-contouring							
Deep ripping							
Ripping/soil conditioning							
Construction of terraces							
Minimal grading							
Other – Specify							

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What size (in acres) are the areas to be graded?

Replant Area	**Acreage**

Will finished grading create cross slope furrows to avoid gully formation?

☐ yes
☐ no

Are the areas to be graded sized so that all work including erosion control can be completed by October 15?

☐ yes
☐ no

If no, break the project into phases.

13. VINEYARD FIELD ROAD LOCATIONS AND CROSSINGS

Most replant/expansion sites will need to complete this section.

Indicate the vineyard field roads on the site plan including all creek crossings. Give each crossing a number.

Are road crossings of creeks – ephemeral, intermittent and year round minimized in the site design?

☐ yes
☐ no

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For each creek crossing indicate the type:

Type of Crossing	Vineyard Road and Crossing Number	Type of Creek – Ephemeral, Seasonal or Year-round
At-grade seasonal ford		
Permanent ford		
Bridge		
Culverted crossing installed seasonally		
Culverted crossing permanent		
Other - Specify		

Are all roads located away from creek corridors?

☐ yes
☐ no

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14. VEGETATION REMOVAL

Only expansion sites or, in a few instances, replant sites with vegetation removal need to include this section. Most replant sites will not need to fill out this section.

List the type of vegetation removal used for each replant area.

Check all that apply and indicate the vineyard area number or name:

	Replant Areas				
Natural vegetation retained in swales and ephemeral streams next to or within vineyard area					
Vegetation removal within vineyard footprint only					
Some vegetation removal in swales and streams next to or within vineyard area					
Natural vegetation enhanced or replanted on other portion of property					
No clearing of riparian vegetation along stream corridors					
Clearing of vegetation from stream corridors					

Will permits be required for removal of coniferous forest, wetland fill in or disturbance sensitive habitat?

☐ yes
☐ no

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Fencing

Does the fencing plan, vineyard layout, and creek corridors allow for wildlife movement through or around the site?

☐ yes
☐ no

If no, review current fencing to reduce blocking wildlife corridors and work with the Fish Friendly Farming program to implement changes.

15. EROSION SITES

Are there existing erosion sites in or near the replant areas?

☐ yes
☐ no

List areas:

Attach plans for repairs or indicate timing of design of repairs as part of implementation timeline.

16. WATER SUPPLY AND CONSERVATION

Your water rights should be described in Element III.

Describe any differences in the water supply, irrigation or frost control system that will be made as part of the replanting.

Are these changes consistent with your current water right permit/ license?

Please describe any differences and if you are seeking to amend your permit or license.

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INSTALLATION OF THE REPLANT AND APPLICATION OF BMPs

17. TIMING

Indicate the year for each of the following activities as part of the new vineyard development.

ACTIVITY	YEAR
Evaluation of site and preparation of plan	
Completion local permits and other requirements such as water rights license (if applicable)	
Clearing the land - retaining natural vegetation in drainage areas as much as possible (if applicable)	
Grading, soil chiseling, terracing or other major soil conditioning and contouring on the vineyard site only (if applicable)	
Vineyard road relocation or construction (if applicable)	
Repair of any drainage problems, erosion sites and problems in the replant/expansion area if applicable	
Installation of underground drainage system, grassed waterways, diversion ditches or other drainage improvements in the replant/expansion area as needed	
Installation, relocation or development of primary elements of water supply system (if applicable)	
Planting of temporary cover crops	
Installation of temporary erosion control	
Installation of permanent erosion control (if appropriate)	
Observation of site drainage system performance, erosion problems and use of temporary erosion control measures	
Fine grading of terraces	
Installation of drip lines	
Planting of vines/installation of trellis	
Planting of cover crops	
Installation of additional permanent erosion control	

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18. LAND TREATMENT

If replanting or expansion project involves extensive grading will area be graded, drainage improvements installed and erosion control in place prior to October 15 of each year?

☐ yes
☐ no

19. COVER CROPS AFTER INSTALLATION

Is cover crop seed available and at hand, irrigation or other water system available by September 30 for each year of grading and for each vineyard area?

☐ yes
☐ no

In addition to the seeding of cover crops are roads, terrace benches and faces and all areas of graded land protected with mulch, erosion blanket or other materials to assure all soil surfaces have either an established dense cover crops or other material by October 15?

☐ yes
☐ no

Are vineyard roads fully mulched and have waterbars installed prior to October 15?

☐ yes
☐ no

20. DRAINAGE SYSTEM INSTALLATION

Review the BMPs and description of each type of drainage system in the BMP workbook and make sure the plans and specifications of the vineyard design are detailed and include all necessary information. If the drainage system is not being altered for the replant/expansion project leave this section blank.

- ❑ Supervise or have an engineer supervise the installation of the drainage system to assure proper trenching pipe and inlet installation, ditch slopes, backfill compaction, and other features are correctly constructed.

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- ❑ Actively seed all areas with cover crop following construction. Use mulch and erosion blanket if needed in steep areas to protect soil and encourage cover crop growth.
- ❑ Observe the system in action frequently during the first winter to assure any problems are corrected immediately.

21. TERRACE OR BENCH INSTALLATION

Review the BMPs and recommended design features for benches and make sure the plans and specifications of the vineyard design are detailed and include all necessary information. If the drainage system is not being altered for the replant project leave this section blank.

- ❑ Supervise or have an engineer supervise installation of the benches and slopes of the terrace, inlets and underground pipe installation and any other features to assure they are correctly installed.
- ❑ Actively seed all areas with cover crop following construction including terrace face. Use mulch and erosion blanket on face to protect soil and encourage cover crop growth.

- ❑ Observe terrace system in action frequently during the first winter to assure any problems are corrected immediately.

22. EMERGENCY EROSION CONTROL MEASURES

Is a winterization and emergency erosion control program written out and ready to be implemented? Does it include frequent inspections of drainage facilities and outlets, graded areas and permanent roads?

☐ yes
☐ no

If no, revise your program.

Are emergency erosion control materials – strawbales or wattles, sand bags, or silt fencing stockpiled on site and site employees trained in their use?

☐ yes
☐ no

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Are temporary strawbale sediment basins around inlets installed prior to October 15?

☐ yes
☐ no

23. ADDITIONAL EROSION CONTROL

Does the vineyard include vegetated filter strips between the vineyard and all waterways?

☐ yes
☐ no

If no, incorporate filter strips into the project or winterize field roads or turnarounds adequately for this purpose.
Does the site include a sediment basin(s)?

☐ yes
☐ no

Where will soil removed from the basin be placed?

The replant project should use temporary cover crops, inspections and emergency and permanent erosion control procedures. Once established, management measures should continue to conserve soil and water and protect all aspects of the natural and installed drainage system. The intended management practices for the vineyard should be outlined in Element III Managing the Vineyard.

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SUMMARY: REPLANTING/EXPANSION OF EXISTING VINEYARD ELEMENT

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Inventory Includes:		
☐	☐	Map/aerial with features of the site.
☐	☐	List of site acreages.
☐	☐	Inventory of soil types and their characteristics.
☐	☐	Evaluation of slopes.
☐	☐	Inventory of any unstable slopes or erosion sites.
☐	☐	Delineation of entire stream network including assessment of the general condition of creeks.
☐	☐	Inventory of vegetation types for expansion areas.
☐	☐	Inventory of features of vineyard drainage system and erosion problems in replant areas.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
☐	☐	Completion of inventory summary table.
Site Inventory Includes:		
☐	☐	Use of site inventory to determine replant/expansion area footprint.
Site Design Includes:		
Slopes/Erosion:		
☐	☐	Replant area is less than 30% slope. Areas of higher slope within the 30% or less slope areas should not exceed two acres. For replants on sites over 30% slope evaluation of the long-term economic viability is done.
☐	☐	For replant sites covered by the Sonoma County Hillside Ordinance or those with recurring erosion problems or prior large failures an erosion control plan completed which addresses sheet erosion and slope lengths to avoid concentrated flows and has incorporated other measures to control erosion. Some replant sites will not require this step.
☐	☐	Vineyard areas do not include unstable slopes without engineered repairs.
☐	☐	Filter strips are incorporated into the vineyard design and are adequately sized for the slope adjacent to waterways. Filter strips can be winterized vineyard roads and turnarounds.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Drainage System:		
☐	☐	Natural waterways including ephemeral stream/swales, intermittent and year round creeks are retained and/or revegetated.
☐	☐	If drainage improvements are made in the replant area they are sized for the 25-yr, 24 hr rainfall event as based upon National Weather Service data.
☐	☐	Drainage system plans and calculations are included in this plan (if applicable).
☐	☐	Drainage system addresses offsite stormwater entering the site if applicable).
☐	☐	The drainage system from the expanded or replanted vineyards does not increase stormwater discharge by more than 10-15% for the 2, 5, and 10-year frequency 24-hour duration events. If such increases are unavoidable, then detention or water spreader facilities should be included to mitigate the increase. Calculations of stormwater discharge for the site are attached.
☐	☐	Drainage improvements do not concentrate flows into limited outlets but use numerous outlets to spread flows and avoid erosion.
☐	☐	All drainage outlets have adequately sized energy dissipaters or stilling/detention basins.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
☐	☐	Outlets have been evaluated for their potential for causing localized erosion or cumulatively causing erosion in creeks.
☐	☐	Inlets will have screens, grates or other measures to reduce clogging.
Land Treatment:		
☐	☐	Land preparation involves a minimum of vegetation removal.
☐	☐	Land preparation involves little to no clearing or alteration of swales/ephemeral creeks, intermittent or year round stream corridors.
☐	☐	Areas of the site that will be graded or ripped are limited in size so that all land preparation can be completed and seeded with temporary cover crops and erosion control measures installed before October 15.
Vineyard Field Roads - Location and Crossings:		
☐	☐	Vineyard roads limit crossings of ephemeral, intermittent and year round streams and use most fish friendly crossing design for the site.
☐	☐	Vineyard roads are located away from the creek corridor to avoid washout and erosion during flood events.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Vineyard Field Roads - Location and Crossings:		
☐	☐	A separate Element V for all roads includes design drainage and installation issues and is completed as part of the farm plan. This section is just for location and crossings.
Vegetation Removal:		
☐	☐	For expansion sites that involve significant clearing of oaks, wetlands, coniferous forest or other sensitive habitats have applied for, or received, needed permits.
☐	☐	Fencing plan includes evaluation of wildlife migration corridors on the site or in the overall area of the project.
Erosion Sites:		
☐	☐	Existing erosion problems such as gullies are repaired as part of the plan.
Water Sources:		
☐	☐	Water conserving irrigation practices are used.
☐	☐	Soil moisture/plant condition is monitored to determine irrigation needs.
☐	☐	Change irrigation blocks to allow for lower volumes of direct diversions and spread irrigation period over longer time.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Design Includes:		
Water Sources:		
☐	☐	Fish screens are installed (if applicable).
☐	☐	Alternative frost control measures are used.
☐	☐	Additional water needs covered under existing water right.
Site Installation Includes:		
☐	☐	Timeline for installation allows for reasonable acreages such that grading, installation of drainage improvements are done and cover crops and erosion control is installed between April 15 and October 15.
☐	☐	All replant sites: benches – flat and face, roads and other cleared areas will have soil protection, dense cover crops, mulch, erosion blanket and other measures in place by October 15.
☐	☐	Cover crops are seeded and irrigated as needed to densely cover graded areas by October 15.
☐	☐	Emergency erosion control preparedness plan and materials are in place by October 15.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
Site Installation Includes:		
☐	☐	Drainage system installed using BMPs for type of system with adequately sized energy dissipaters or detention basin installed at all outlets (if applicable).
☐	☐	Winter site inspection and erosion control program prepared and ready to implement.
☐	☐	Additional erosion control is installed if appropriate.
☐	☐	Vineyard management – Element III completed and attached.

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IMPLEMENTATION TIMELINE: REPLANTING/EXPANSION OF EXISTING VINEYARD ELEMENT

Timeline should demonstrate how BMPs will be implemented over the first ten years of the vineyard replant.

ACTION/BMP	TIME FRAME

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ELEMENT 5 - ROADS:
FARM CONSERVATION PLAN

This section includes the main access roads on the property including those along the edges of creeks or river corridors. FFF program staff will complete this element working with the landowner/manager.

ROAD INVENTORY/ASSESSMENT

1. GENERAL FEATURES OF THE ROAD SYSTEM

Road Name or Number	**Road Use (Year-Round or Seasonally)** Give section or location if use varies	**Primary Surface Type (Gravel, Dirt, or Asphalt)** Give section or location if surface varies	**Estimate Length of Road on Property**

Additional Comments:

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2. FIELD REVIEW OF ROAD CONDITIONS.

List the starting and ending mileage for each road using vehicle odometer:

Road Name or Number	**Starting Location** (mileage should be 0.0)	**Ending Location and Accumulated Mileage**	**Note Mileage of Significant Intersections or Other Landmarks** (bridges, vineyards etc.)

Additional Comments:

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3. HILLSLOPE STABILITY

List the location of any of the following features by road:

Road Name or Number	Blue or other clay layer exposed along road cut	Slip – Indicate Size	Lumpy-looking Ground	Large Cracks in the Ground	Leaning or Split Trees	Concave Impression or Slips	Springs, Seeps or Perched Ponds

Additional Comments:

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4a. CONDITION OF ROAD SURFACE

Fill in the chart below based on the information gathered in your road survey.

Road Name or Number	Road Sections with Significant Rill Erosion	Presence of Water in Summer or Wetland Plants	Large Cracks in Road Bed	Outer Road Edge Eroding	Outer Road Edge Berm Causing Rill Erosion of Road	Road Locations Within 100 ft. of Any Type of Creek - Ephemeral, Seasonal or Year-round

Record areas of road with excessive rutting:

Additional Comments:

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4b. SLOPE OF EACH ROAD

Fill in the chart below for each road based on the information gathered in the road survey, noting locations of slope category.

Road Name or Number	<5%	<15%	<25%	<30%	over30%

Additional Comments:

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5a. ROAD SURFACE DRAINAGE: INSLOPED/CROWNED

Fill out table for each type of surface drainage on the road. List the location where the conditions occur .

Road Name and Number	Locations with Significant Erosion of Inboard Ditch	Locations with Significant Filling of Inboard Ditch	Locations with Erosion or Slumping of Cutbank	Inventory each ditch relief culvert and record: • location • diameter • type* of culvert • crushed, plugged or damaged conditions energy dissipater, • erosion at outlet • other conditions	Record Locations and Number of Waterbars and if Installed Correctly	Locations Where Ditch Relief Culverts Overflow Eroding Road Surface	Record the Number of Ditch Relief Culverts per Length of Road and List % Slope from Table 4b	Locations Where Ditch Relief Culvert Discharges Directly into Creek

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Road Name and Number	Locations with Significant Erosion of Inboard Ditch	Locations with Significant Filling of Inboard Ditch	Locations with Erosion or Slumping of Cutbank	Inventory each ditch relief culvert and record: • location • diameter • type* of culvert • crushed, plugged or damaged conditions energy dissipater, • erosion at outlet • other conditions	Record Locations and Number of Waterbars and if Installed Correctly	Locations Where Ditch Relief Culverts Overflow Eroding Road Surface	Record the Number of Ditch Relief Culverts per Length of Road and List % Slope from Table 4b	Locations Where Ditch Relief Culvert Discharges Directly into Creek

* CMP = corrugated metal pipe, PVC pipe, concrete pipe, PCP = plastic corrugated pipe

Additional Comments:

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5b. ROAD SURFACE DRAINAGE: OUTSLOPED/CROWNED

Fill out the table for each type of surface drainage on the road. List the location where the conditions occur.

Road Name and Number	Number of Rolling Dips/Water Bars per Length of Road	Record locations of rolling dips: • if dissipater is adequate or not, • if there is erosion at the outlet or not, • if dip is broken down, • if dip extend from cutbank to road edge	Locations Where Road Surface is Eroding Significantly	Locations Where the Cutbank is Slumping onto Road

Additional Comments:

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5c. VINEYARD ROADS – DRAINAGE

List locations of the following road features:

Vineyard Area*	Surface: Gravel, Asphalt or Cover Crop	Water Bars (Y / N)	Rolling Dips (Y / N)	Drains into Vineyard Drainage System	Identify Locations with Rill Erosion	Discharge into Creek	Filter Strip Between Road and Creek Corridor

*Use this table to document features of perimeter vineyard roads and other primary vineyard roads. Vineyard roads over 10% slope should have water bars, dissipaters or other drainage features. Primary year-round access roads that may pass around or through the vineyard should be evaluated in Tables 5a and 5b. The winterization measures you use for seasonal vineyard roads should also be outlined in Element 3.

Additional Comments:

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6a. STREAM CROSSINGS – ROAD FILL WITH CULVERTS

Fill in the chart below based on the information gathered in your road survey and the notes on your aerial photos and maps. Describe locations in mileage from the starting point on each road.

Road Name or Number	Creek Name or Number	Creek Type: (Year-round, Seasonal, Ephemeral)	Crossing Number*	Crossing Location	Type** of Culvert	Culvert Diameter	Plugged, Rusty or Crushed Culvert (Y/N)	Energy Dissipat-er (Y/N)	Trash Rack (Y/N)	Critical Dip for Overflow (Y/N)	Indicate if Upstream Deposition/ Downstream Erosion	Significant Erosion or Blowout has Occurred

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Road Name or Number	Creek Name or Number	Creek Type: (Year-round, Seasonal, Ephemeral)	Crossing Number*	Crossing Location	Type** of Culvert	Culvert Diameter	Plugged, Rusty or Crushed Culvert (Y/N)	Energy Dissipat-er (Y/N)	Trash Rack (Y/N)	Critical Dip for Overflow (Y/N)	Indicate if Upstream Deposition/ Downstream Erosion	Significant Erosion or Blowout has Occurred

* All crossings (culverts, bridges and fords) are numbered sequentially on each road beginning at the starting location
**Corrugated metal pipe, PVC pipe, concrete pipe, flex pipe, bottomless arch culvert, concrete box culvert or other type.

Additional Comments:

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6b. STREAM CROSSINGS – BRIDGES AND FORDS

Fill in the chart below based on the information gathered in your road survey and the notes on your aerial photos and maps. Describe locations in mileage from the starting point on each road.

Road Name or Number	Creek Name or Number	Creek Type: (Year-round, Seasonal, or Ephemeral)	Crossing Number*	Crossing Location	BRIDGES			FORDS		
					Bridge Deck Collects Flood Debris	Piers Stable	Piers Squeeze Stream Width	Seasonal or Year-round Ford	Type of Ford: (At-grade Gravel, Seasonally Installed Gravel Berm, Concrete)	Erosion at Downstream End or Sides of Concrete Ford

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Road Name or Number	Creek Name or Number	Creek Type: (Year-round, Seasonal, or Ephemeral)	Crossing Number*	Crossing Location	BRIDGES			FORDS		
					Bridge Deck Collects Flood Debris	Piers Stable	Piers Squeeze Stream Width	Seasonal or Year-round Ford	Type of Ford: (At-grade Gravel, Seasonally Installed Gravel Berm, Concrete)	Erosion at Downstream End or Sides of Concrete Ford

* All crossings (culverts, bridges and fords) are numbered sequentially on each road beginning at the starting location

Additional Comments:

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7. SUMMARY OF SURVEY AND ROAD REPAIR AND IMPROVEMENT PROGRAM

For each identified problem condition in the road system list the BMP or repair and improvement to be used and the time frame for implementation.

Condition	Locations (List Road Number and Mileage Location)	Repair or Improvement	Implementation Timeline
1. Road sections with signs of unstable hill slope conditions			
2. Road section with significant surface rilling			
3. Road section with road surface cracks			
4. Road section with outer road berm causing erosion			
5. Road section with wetland plants			
6. Road section with significant ditch erosion			
7. Road section with significant ditch filling			
8. Road section with cutbank slumping			
9. Road section with inadequate numbers of ditch relief culverts or numerous damaged or undersized culverts			

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Condition	Locations (List Road Number and Mileage Location)	Repair or Improvement	Implementation Timeline
10. Road section where ditch relief culverts overflow road surface			
11. Road sections with ditch relief culverts without energy dissipaters			
12. Road sections where ditch relief culverts discharge directly into creek			
13. Outsloped or crowned road sections with inadequate numbers of rolling dips			
14. Outsloped or crowned road sections with water bars/rolling dips where energy dissipaters are missing			
15. Vineyard roads with rilling and a lack of water bars or other drainage features			
16. Road sections adjacent to creeks including ephemeral, seasonal, and year-round streams			
17. Stream crossings with undersized culverts			

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Condition	Locations (List Road Number and Mileage Location)	Repair or Improvement	Implementation Timeline
18. Stream crossings without energy dissipaters			
19. Stream crossings where overflows onto the road have occurred			
20. Stream crossings with erosion at the culvert outlet			
21. Stream crossings with deposition at upstream inlet			
22. Stream crossings with sedminent deposition at outlet			
23. Stream crossings with plugged, rusty or crushed culverts			
24. All stream crossings that have failed or been significantly damaged			
25. Culverted crossings /permanent fords on year-round streams			
26. Bridges with unstable piers, inadequate width or debris on deck			
27. Ford with erosion on downstream end or sides			

Additional Comments:

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8. ROAD MAINTENANCE AND WINTER INSPECTION

OUTLINE YOUR CURRENT WINTER INSPECTION AND YEARLY ROAD MAINTENANCE PROGRAM

Describe the winter inspection program you use and how frequently you review the conditions of the roads, crossings, and culverts.

List the time of the year you inspect the conditions of roads, crossings, culverts, and other features and when repair/maintenance is done.

List the dates you install and remove any seasonal crossings or bridges.

List the areas of the property you regularly inspect and those which are inspected on a less regular basis.

List the locations you use to stockpile dirt removed from roads, ditches or other road maintenance.

List methods employed for emergency repairs and locations of repairs.

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Indicate the location and frequency of regular maintenance activities you've completed for each road in the past 5-10 years:

Road Name or Number	Regrade Road Surface	Regravel or Repair Road Surface	Ditch Maintenance or Clearing	Ditch Relief Culvert Replacement	Energy Dissipater Maintenance and Replacement	Installation of Water Bars	Replacement of Stream Crossing Culverts	Maintenance and Replacement of Energy Dissipater at Stream Crossings	Maintenance of Ford or Bridge	Revegetation as Part of Road Repair

Additional Comments:

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9. ROAD CLOSURE AND RESTORATION

List roads identified as too close to creeks, on unstable slopes or no longer needed.

List the abandoned roads including skid roads.

Indicate closed or abandoned roads, roads identified as too close to creeks, on unstable slopes or no longer needed on map/aerial and when the road was closed (if known).

Attach the plans for restoration of the closed road.

10. NEW ROAD DESIGN

Only complete this section if you intend to construct new roads.

Attach plans with specifications.

List the BMPs used to make the new road fish friendly.

Review Appendix 5 for stream crossing designs for fish passage.

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11. NEW ROAD CONSTRUCTION

Attach the new road design and specifications to the farm plan.

Outline the timeline for the project.

Outline the erosion control measures and their locations to be used during the construction process.

12. ROAD RECONSTRUCTION

Only complete this section if you intend to reconstruct roads.

Attach plans with the specifications.

List the BMPs used to make the road reconstruction fish friendly.

Outline the timeline for the project.

Outline the erosion control measures and their locations to be used during the reconstruction project.

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SUMMARY: ROADS ELEMENT

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
☐	☐	Completion of road survey and identification of road problems.
Road repair and improvement program including:		
☐	☐	• Changes in road drainage and surface design (for example, inslope to outslope).
☐	☐	• Replacement and repair of ditches, ditch relief culverts, energy dissipaters.
☐	☐	• Increase in frequency of water bars, rolling dips, or ditch relief culverts.
☐	☐	• Closure or relocation of roads with continual erosion problems, those built on unstable ground, or too close to creeks. Plan should include road restoration and closure actions.
☐	☐	• Repair/replacement of stream crossings with a minimum of seasonal crossings and use of bridges for year-round creeks.
Road maintenance and inspection program including:		
☐	☐	• All culverts, energy dissipaters, road surfaces, stream crossings, and ditches.
☐	☐	• Winterization of all seasonal roads.
☐	☐	• Winter inspection of all stream crossings and removal of wood and debris to avoid failures.
☐	☐	• Periodic maintenance of road system with regular inspection program.

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ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
New road design/construction program, reconstruction program, or road restoration program (if applicable) including:		
☐	☐	• Use of fish friendly guidelines in road location, design elements, and construction plans and specifications.
☐	☐	• Seasonal construction restrictions.
☐	☐	• Use of erosion control in all construction activities.
☐	☐	• Use of NMFS/Fish and Game guidelines for stream crossings on fish bearing creeks (Appendix 5).
☐	☐	• Fish and Game approvals of all stream crossings.

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IMPLEMENTATION TIMELINE: ROADS ELEMENT

For each BMP to be applied outline timeline for implementation over next 10 years.

ACTION/BMP	TIME FRAME

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ELEMENT 6 - CREEK/RIVER CORRIDORS: FARM CONSERVATION PLAN

This section focuses on year-round and seasonal creeks on the property. The maps and aerials from Elements II, III or IV with the ephemeral creeks and vineyard drainage system will also be used in this section. The FFF program staff will complete this section following a field visit with the landowner/manager.

INVENTORY OF CREEK/RIVER CORRIDOR SYSTEM

1. INDICATE ALL STREAMS ON SITE

The FFF program staff will work with the landowner/manager to outline the stream system

2. DEFINE THE CREEK TYPE

For each year-round and seasonal (blue-line) creek determine the general type of creek and fill in the appropriate inventory for each creek.

☐ **UNCONFINED, ALLUVIAL CHANNEL – Fill out Section A**

☐ **PARTLY CONFINED, ALLUVIAL CHANNEL – Fill out Section A**

☐ **CONFINED, BEDROCK CHANNEL – Fill out Section B**

If you have unconfined and confined channels fill out both sections A and B.

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SECTION A. ALLUVIAL, UNCONFINED AND ALLUVIAL, PARTIALLY CONFINED CHANNEL

ASSESS CONDITION OF CREEK/RIVER CORRIDOR

A3. MEASUREMENT OF THE WIDTH OF THE SCOUR CHANNEL

List all measurements in feet. Complete for all creeks. This table is for measurement of the width of the scour channel. List creek name or number next to measurement on the table.

Creek Name or Number	Measurement	Measurement	Measurement	Measurement	Average of Measurements

Additional comments:

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Have you noticed a rapid widening of the creek scour channel indicating it may be aggrading?

☐ yes
☐ no

If yes, estimate how many feet it has widened and in what area of the corridor?

A4. CORRIDOR WIDTH

This table is for measurement of the width of the riparian corridor from edge to edge. Complete for all creeks. Measurements are taken at the same locations for Sections 3-6. List name or number next to the measurement on the table.

Creek Name or Number	Measurement	Measurement	Measurement	Measurement	Average of Measurements

Additional comments:

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A5. CORRIDOR AND VINEYARD

This table is for measurements made from the top of the bank of the scour channel to the first row of vines on each side of the corridor. Complete for all creeks next to vineyards. Measurements are taken at the same locations for Sections 3-6.

Creek Name or Number	Measurement	Measurement	Measurement	Measurement	Average of Measurements

Additional comments:

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This table is for measurements made from the outside edge of the riparian corridor to the first row of vines on each side of the corridor. Complete for all creeks next to vineyards. Measurements are taken at the same locations for Sections 3-6. List creek name or number next to the measurement.

Creek Name or Number	Measurement	Measurement	Measurement	Measurement	Average of Measurements

Additional comments:

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A6. BANK HEIGHTS

This table is for measurements of the banks made from the lowest point in the creek to the top of the bank. Complete for all creeks. Measurements will be taken as close to the locations used for Sections 3-5 as possible where you can still measure the deepest point in the channel to top of bank.

Creek Name or Number	Measurement	Measurement	Measurement	Measurement	Average of Measurements

Additional comments:

How steep are the banks? Indicate name or number of creek.

- ☐ Really steep (1:1)
- ☐ Moderate (2:1)
- ☐ Gentle (3:1 or less)

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What are the banks made up of?

- ☐ Loose gravel and sand
- ☐ Silt/loam
- ☐ Compacted clay
- ☐ Large cobble with gravel, sand, and silt
- ☐ Riprap

Have you noticed a large change in the depth of the creek or height of the banks indicating that the bed may be dropping or incising?

- ☐ yes
- ☐ no

Estimate how many feet the bed has dropped in how many years. If there is one area where this is occurring, indicate its location on the aerial photo.

Is there is a bridge to measure change in the creek bed? If yes, indicate it on the aerial photo.

- ☐ yes
- ☐ no

Is there a large amount of bank erosion in any area of the stream or river corridor?

- ☐ yes
- ☐ no

Did this erosion occur in a wet winter or regularly nearly every winter?

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A7. VEGETATION

Indicate the vegetation types along the outer edge of the corridor: List name or number of creek next to vegetation type.

☐ Large and over 20 feet tall:
☐ Medium and less than 15 feet tall:
☐ Dense undergrowth of vines and other plants under the trees:
☐ Small and bushy trees:
☐ Little or no vegetation:
☐ There is riprap or other material along the creek edge:
☐ Large areas of non-native vegetation (see BMP workbook):
☐ Other – describe:

Indicate the vegetation types along the inner edge of the corridor: List name or number of creek next to vegetation type.

☐ Large and over 20 feet tall:
☐ Medium and less than 15 feet tall:
☐ Small and bushy:
☐ Little or no vegetation:
☐ There is riprap or other material along the creek edge:
☐ Large areas of non-native vegetation (see BMP workbook):
☐ Other – describe:

A8. CREEK CHANNEL FEATURES

List the features on the creek channel. List creek name or number next to measurement.

☐ Deep pools >5 ft deep:
☐ Small pools <2 ft deep:
☐ Gravel bars in a meandering channel:
☐ Riffles (a ridge of small gravel which extends across the channel):
☐ Bends and a meandering course:
☐ Occasional bank erosion along the outside of bends:
☐ Bank erosion almost every year:
☐ Logs and stumps along the channel edges and in the scour channel:
☐ No large wood in the scour channel:
☐ Other – describe:

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Indicate summer water flows in the creek. List creek name or number next to measurement.

☐ Always dries up:
☐ Always runs year-round:
☐ Has deep pools but no surface flow:
☐ Only dries up in dry years:
☐ Started to dry up a few years ago, but used to run year-round:
☐ Started to dry up a few years ago, but used to have deep pools:
☐ Other – describe:

Describe the material on the stream bottom. List creek name or number next to measurement.

☐ Silt:
☐ Silt with some sand and gravel:
☐ Gravel with a lot of silt:
☐ Gravel with little silt:
☐ Cobbles with sand and gravel:
☐ Big rocks with little areas of sand, silt or gravel:
☐ Other – describe:

Notes:

A9. FISH AND WILDLIFE

Do you see large adult (>12 inches) salmon/trout in the creek between October and April? Complete for all creeks. List creek names.

☐ yes
☐ no

Do you see small fish (<1 inches) in the stream?

☐ yes
☐ no

If yes, do the small fish:

☐ dart quickly away?
☐ continue to swim slowly in the pool or riffle?

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List other wildlife you see near or in the creek and the riparian corridor:

A10. FLOODING

- Where does the creek regularly flow over its banks and flood? Mark these areas on the aerial.

- Where does the creek occasionally flow over its banks and flood? Mark these areas on the aerial.

- If your site is affected by floodwater releases from the large reservoirs record your observations on the effects of these releases.

A11. ROAD AND VEHICLE CROSSINGS

- Mark all your creek crossings on the map/aerial.

- List the type of crossing and season of use:

- List any public road crossings within one-half mile of the creek:

A12. CHANGES OVER TIME

Indicate the changes you have noticed in the stream/river corridor over the past ten years or more. List the creek name or number next to the condition.

☐ Large amounts of bank erosion:
☐ Large amounts of filling in of the channel:
☐ Channel bed has dropped over five feet:
☐ Summer water flows have decreased substantially:
☐ Flood levels have increased for about the same size of rainstorm:
☐ Large invasion of invasive plants:

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☐ There is almost no gravel in the channel anymore, it is down to hardpan:
☐ Large amounts of fine silt cover gravel or fill pools:
☐ Pools are shallow that used to be deep:
☐ Other changes – be specific:

A13. CHECK YOUR PRACTICES

Indicate which of the following practices you perform on the creek/river and its corridor. List the name or number of the creek next to the practice.

☐ Tree/brush removal over entire creek channel every year:
☐ Herbicide channel to keep plants from growing:
☐ Riprap creek channel:
☐ Straighten creek channel, remove gravel bars and remove trees:
☐ Gravel extraction over part or all of channel:
☐ Rearrange gravel bars with heavy equipment:
☐ Remove large trees when across current:
☐ Rearrange large trees from across the current to bank edge:
☐ No direct management of creek corridor:
☐ Clear non-native plants in corridor:
☐ Clear native plants in corridor for Pierce's Disease:
☐ List how you determine what plants to remove:
☐ Other – be specific:

Bank stabilization done when necessary includes:

☐ Replant with willows or other native plants:

☐ Stabilize banks with woody materials and rock at toe of slope but not predominantly rock:

☐ Stabilize banks with structures – riprap, gabions, cribwalls, or other plantings are secondary in repairs to structural materials:

A14. EVALUATE UPSTREAM AND DOWNSTREAM CONDITIONS

On the aerial or map indicate all stream crossings and bridges upstream or downstream of site.

Are there reservoirs upstream of the creek corridor?

☐ yes
☐ no

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If yes, for each creek count the number of reservoirs, how far upstream the reservoirs are.

Are there urban areas upstream of the corridor?

☐ yes
☐ no

If yes, indicate which creek:

Are there any large slides upstream of the corridors?

☐ yes
☐ no

If yes, indicate which creek:

Does the inventory in Elements 2, 3 or 4 of ephemeral creeks indicate large areas of erosion?

☐ yes
☐ no

If yes, indicate which creek and if repair of these areas is included in the element:

Is the main river channel within one mile of the site?

☐ yes
☐ no

If yes, indicate which creek:

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A15. INVENTORY SUMMARY

This table summarizes the measurements and condition for each of the year-round and seasonal creek/river corridors.

FARM CONSERVATION PLAN ELEMENT VI - CREEK/RIVER CORRIDOR SUMMARY TABLE FOR CORRIDOR INVENTORY

Creek Name or Number	Length on property (feet)	Creek flow regime (year-round or seasonal)	Creek type (unconfined /alluvial or partly confined/alluvial)

Additional comments:

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SUMMARY OF MEASUREMENTS FROM INVENTORY

List averages of measurements unless otherwise specified.

Creek Name or Number						
Scour Channel Width						
Corridor Width						
Distance to Vineyard From Scour Channel Edge						
Distance to Vineyard From Corridor Edge						
Bank Heights						
Vegetation Type for Outside Edge of Corridor						
Vegetation Type for Edge of Scour Channel						
Summer Water Features						
Stream Bottom Features						
Flooding Areas and Frequency						
Changes Over Time						
Upstream/Downstream Conditions						
Primary Management Practices						
Corridor Condition (From #16)						

Additional comments:

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A16. DETERMINING CORRIDOR CONDITION

Based on the summary table and the detailed descriptions in the BMP workbook, the FFF staff will determine the corridor condition for each creek. Creek condition types include:

- Highly altered
- Moderately altered
- Occasionally problematic
- Rarely a problem
- Suddenly a problem
- Alluvial fan
- Main Stem Russian River

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A17. NECESSARY CORRIDOR WIDTH

For each year-round/seasonal creek, the necessary corridor width will be calculated and recorded below along with information from the inventory (see method and instructions in BMPs workbook). The Fish Friendly Farming staff will complete many of these measurements with the farmer. Fill out table for the Russian River, if you have main channel frontage.

Creek Name						
Watershed Area in Square Miles						
Estimated Scour Channel Width in Feet						
Current Average Scour Channel Width in Feet						
Estimated Corridor Width in Feet						
Current Average Corridor Width in Feet						
Indicate if Bank Heights Are in Excess of 12 Feet						

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Do you own both sides of the creek?

☐ yes
☐ no

MAIN STEM RUSSIAN RIVER

Location	
Proximity of Vineyard to Edge of Scour Channel	
Proximity of Vineyard to Edge of Riparian Corridor	
Overall Width of Riparian Corridor	
Bank Heights	
Major Bank Erosion Problems Occurring – List How Often	
Do You Own Both Sides Of The Channel?	

A18. DETERMINING CORRIDOR RESTORATION STRATEGY

Work with the Fish Friendly Farming program staff to determine the revegetation project for the site.

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A19. DETERMINING IMPLEMENTATION TIMELINE

CORRIDOR CONDITIONS: **SUDDENLY A PROBLEM**
RARELY A PROBLEM
OCCASIONALLY PROBLEMATIC

For the above listed corridor conditions the farm plan should indicate one of the following restoration strategies:

☐ **Increase the width of the corridor over time (10 years) as bank erosion occurs** and revegetation is done. An adaptive management plan will be done. There are areas without vegetation but the corridor needs to be widened. Vineyard and roads are moved back over time to increase corridor width. BMPs used are:
- ☐ Revegetation of the corridor
- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Removal and management of invasive species
- ☐ Incised channels, aggraded channels and summer dry channels conditions are addressed.

☐ **Increase the width through several seasons (3-5 years of active revegetation).** Vineyards and roads are moved back to increase the corridor width.
BMPs used are:
- ☐ Revegetation of the corridor
- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Removal of and management of invasive species
- ☐ Incised channels, aggraded channels and summer dry channel conditions are addressed
- ☐ Corridor restoration under this option should be scaled to allow for phases of vineyard setback and revegetation to occur in seasonal periods between April 15 and October 15.
- ☐ Indicate the phases on a site map or aerial photo. This is not a good option for the corridor if it is currently well vegetated with native species.

☐ **Corridor width is adequate** on your site as defined in the necessary corridor width calculation. A management only option is needed consisting of the following BMPs:
- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Removal and management of invasive species

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☐ **Main Russian River sites** – Revegetation and management will involve setback of vineyard over time and bank revegetation as feasible using the following BMPs:
- ☐ Vegetated bank repairs
- ☐ Removal and management of invasive species
- ☐ It is highly likely that any revegetation effort on the banks of the river will require rock at the toe of the bank and set back to a 3:1 slope. However it is noted that the owner has little control over such factors as reservoir releases, channel management and gravel mining effects and cannot repair the problems these factors may produce. Bank blowouts may require major financial assistance.

☐ **For the lower mile of tributary streams in the Russian River watershed, the stream may be highly affected by river conditions**.
- ☐ Owner will revegetate and manage using the BMPs indicated for the corridor condition on the site.

☐ **Alluvial fan sites**
- ☐ Review of overall morphology of fan
- ☐ Revegetation across fan surface
- ☐ Set banks of active channel back if needed

CORRIDOR CONDITIONS: HIGHLY ALTERED
MODERATELY ALTERED

For these corridors a phased restoration program is needed.

☐ **For highly altered corridors, complete phased revegetation/restoration plan over a 10-year time frame**. Plan to set back vineyard roads with each phase through an adaptive management process. If the site includes only one side of the channel, half the required width is used. The plan should use the following BMPs:
- ☐ Changes to channel form appropriate to the site
- ☐ Revegetation with native species at appropriate distance and elevation to active channel
- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Incised channels, aggraded channels and summer dry channel conditions are addressed. Since many highly altered corridors are also incised channels, address this issue by incorporating a floodplain bench into the revegetation plan.
- ☐ Invasive plant removal should be addressed both prior to revegetation efforts and over the course of the restoration program as a maintenance activity. Make sure your workers are trained in the differences between the newly planted native species and the invasive ones.

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☐ **For moderately altered corridors there are areas with some vegetation or just several problem areas where the corridor needs additional width. Increase the width through several seasons (3-5 years of active revegetation).** Vineyards and roads are moved back to increase the corridor width. BMPs used are:

- ☐ Revegetation of the corridor
- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Removal and management of invasive species
- ☐ Incised channels, aggraded channels and summer dry channel conditions are addressed.
- ☐ Corridor restoration under this option should be scaled to allow for phases of vineyard setback and revegetation to occur in seasonal periods between April 15 and October 15. Indicate the phases on a site map or aerial photo. This is not a good option for the corridor if it is currently well vegetated with native species.

☐ **Main Russian River sites** – Highly and moderately altered corridors of the main Russian River are likely to be unstable and capable of eroding banks and vineyards easily. Setting the vineyard back from the scour channel is likely to save money over the long-term particularly if implementation funds are available. The river can erode 20-30 feet of bank and floodplain vineyard in one large storm making these vineyards very vulnerable. Revegetation and management will involve setback of the vineyard and bank revegetation as feasible using the following BMPs:

- ☐ Revegetation of banks, revegetation of floodplain
- ☐ Removal and management of invasive species
- ☐ It is highly likely that any revegetation effort on the banks of the river will require rock at the toe of the bank and set back to a 3:1 slope. However it is noted that owner has little control over such factors as reservoir releases, channel management and gravel mining effects and cannot repair the problems these factors may produce. Bank blowouts may require major financial assistance.

☐ **For the lower mile of tributary streams in the Mendocino and Middle Reach areas of the Russian River, the stream may be highly affected by river conditions**.

- ☐ Owner will revegetate and manage using the BMPs indicated for the corridor condition on the site.

☐ **Alluvial fan sites**

- ☐ Review of overall morphology of fan
- ☐ Revegetation across fan surface
- ☐ Set banks of active channel back if needed

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SUMMARY: CREEK/RIVER CORRIDORS ELEMENT — UNCONFINED, ALLUVIAL AND PARTLY CONFINED, ALLUVIAL CHANNELS

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
☐	☐	Completed inventory of corridor condition and other factors with maps, aerial photos, site photos and required information included.
☐	☐	Current management practices are reviewed and revisions recognized.
☐	☐	Assessment of necessary width for sustainable corridor is completed.
☐	☐	If upslope problems such as on-channel reservoirs and roads are on the property, they are addressed in the other required elements of the farm plan.
☐	☐	If upslope or river channel problems are affecting the stream corridor, problem is identified and owner will work with the Fish Friendly Farming program instructor to address problem.
☐	☐	For highly altered corridors and moderately altered corridors, restoration and management strategy and timeline are attached.
☐	☐	For all other types of corridors - revegetation and management strategy with timeline is completed.

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IMPLEMENTATION TIMELINE: CREEK/RIVER CORRIDORS ELEMENT — UNCONFINED, ALLUVIAL AND PARTLY CONFINED, ALLUVIAL CHANNELS

Timeline should demonstrate how BMPs will be implemented over the next 10 years.

ACTION/BMP	TIME FRAME

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ELEMENT 6 - CREEK/RIVER CORRIDORS:
FARM CONSERVATION PLAN
Section B Confined Channels

This section focuses on year-round and seasonal creeks on the property. The maps and aerials from Elements 2, 3 or 4 with the ephemeral creeks and vineyard drainage system are used in this section.

INVENTORY OF CREEK/RIVER CORRIDOR SYSTEM

1. INDICATE ALL STREAMS ON SITE

The FFF program staff will outline the stream system and each creek on an aerial photo and list the length in feet or miles of all the year-round and seasonal streams on site.

2. DEFINE THE CREEK TYPE

For each year-round and seasonal creek determine the general type of creek and fill in the appropriate inventory for each creek.

☐ **UNCONFINED, ALLUVIAL CHANNEL – Fill out Section A**

☐ **PARTLY CONFINED, ALLUVIAL CHANNEL – Fill out Section A**

☐ **CONFINED, BEDROCK CHANNEL – Fill out Section B**

If you have unconfined and confined channels fill out both sections A and B.

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SECTION B: CONFINED/BEDROCK CHANNELS

INVENTORY OF STREAM FEATURES

B3. PHOTOGRAPH

Take photos of the channel from numerous locations as listed in the instructions. Label each photograph with the location and the date.

B4. VEGETATION

List the vegetation types on the slopes and/or the stream banks and indicate the creek name or number:

☐ Chaparral scrub:
☐ Coniferous forest (pine, Douglas fir, redwood):
☐ Oak woodland:
☐ Oak grassland:
☐ Mixed hardwoods (madrone, oak, scrub, conifers):
☐ Grassland with few trees:
☐ Grazed grassland:
☐ Riparian trees on stream banks:
☐ Rocky with few trees or vegetative cover:
☐ Recently harvested of timber or cleared of vegetation:
☐ Other – describe:

Is the channel well shaded by trees along the banks?

☐ yes
☐ no

Indicate other aspects of the canyon or banks of the stream:

☐ Large landslides along canyon or banks:
☐ Small slips along the hillsides:
☐ Hillsides look very stable:
☐ Lumpy-looking, melted ice cream look to hillside:
☐ Too much forest or vegetative cover to see condition of soil or slopes:
☐ Other – describe:

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If there are trees along the creek, indicate the size of the trees:

☐ Large and over 20 feet tall:
☐ Medium and less than 15 feet tall:
☐ Small and bushy:
☐ Little or no vegetation:
☐ There is riprap or other material along the creek edge:

B5. CHANNEL FEATURES

Bedrock or confined channels can vary greatly in regards to where pool, gravel areas and other features form. If the features of the channel can be viewed from a road or by walking along the channel, indicate the features you observe. Indicate the creek name or number next to each feature. If none of the channel features can be seen, skip this section.

☐ Deep pools (>5 ft. deep) the bottom is hard to see:
☐ Shallow pools (<2 ft deep) the bottom is easy to see:
☐ Shallow pools with a layer of fine sediment on bottom:
☐ Riffle/gravel area with mostly rocks, large air spaces dominate the gravel surface:

☐ Riffle/gravel area with silt covering over the gravel surface:
☐ Large trees, wood stumps along channel edges or across channel:
☐ Log jam (numerous trees, logs and debris) across channel:
☐ Bank blow out or failures along channel edge, may have trees and stumps in the sediment:
☐ Large landslides greater than 100 ft. in height:
☐ Other features – be specific:

B6. WATER FLOW

Indicate the amount of water in the channel. Complete for all confined creeks. List creek name next to each measurement.

☐ Always dries up:
☐ Always runs year-round:
☐ Has deep pools but no surface flow:
☐ Only dries up in dry years:
☐ Started to dry up a few years ago but used to run year-round:
☐ Started to dry up a few years ago but used to have deep pools:

Have you noticed a change in the summer water level over the past ten years or more?

☐ yes
☐ no

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If yes, is there a new land use in the watershed which may be affecting water flows such as residential or agricultural development, timber harvesting or road construction?

B7. ROADS AND CROSSINGS

Indicate if a road runs along the creek or above the creek across the canyon slope. Be sure this road and all the crossings are evaluated in Element 5.

☐ yes
☐ no

B8. HILLSLOPE STABILITY

Are there large (greater than 50 ft. in vertical distance) landslides along the channel or on the hillslopes above the channel?

☐ yes
☐ no

If yes, mark the location on a map.

B9. INVENTORY SUMMARY

This table summarizes the measurements and condition for each of the year-round and seasonal creek/river corridors.

FARM CONSERVATION PLAN ELEMENT 6 - CREEK/RIVER CORRIDOR SUMMARY TABLE FOR CORRIDOR INVENTORY

Creek Name or Number	Length on property (feet)	Creek flow regime (year-round or seasonal)	Creek type (unconfined /alluvial or partly confined/alluvial)

Additional comments:

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B9. APPLYING BMPs: CONFINED/BEDROCK CHANNELS

The most important aspect of confined channels is to reduce sources of excessive fine sediment from roads, cleared areas and other uses of watershed lands. Revise road crossings, retain canopy over the stream, and make sure that water flows are not reduced through diversions. Additional enhancement of the channel through placement of large logs and stumps, as well as some streamside vegetation, can increase fish habitat. For many of the larger watershed issues, it may not be possible for one landowner to address all of the problems. Formation of stewardship groups may be the best method for addressing the larger watershed issues of sediment and water use (see Element 7).

The following BMPs address these critical issues:

- Elements 2, 3, and 5 address many methods to control erosion. Be sure these elements are competed and all erosion control BMPs are used.

- Roads and road crossings of confined channels may need reconstruction and drainage and erosion improvements. Review Element 5 to make sure all roads along confined channels are addressed. If possible, avoid using streamside roads and restore these to avoid affecting the creek.

- Review the water conservation section of Element 2 and 3 to make sure adequate summer flow remains in the stream.

Additional BMPs that may address particular features on your creek include:

- Stabilization of landslides along channel and on canyon slopes. Consult with NRCS or an engineering geologist for assistance.

- Do not remove or relocate trees that fall into the stream unless a bridge or structure is threatened. Work with Fish and Game and the Fish Friendly Farming program staff to relocate large wood rather than removing it.

- Revegetation of channel banks identified on assessment as bare or without canopy if revegetation with riparian species is appropriate.

- Revegetation of slopes and hillsides with native species and forest to increase future supplies of large wood and increase canopy over stream as well as reduce soil erosion and stabilize slopes.

- Installation of large wood and stumps to increase habitat for fish – consult with Fish and Game on locations and project design.

- All activities on slopes near streams should avoid disturbing the channel or removing trees within 300 ft. of the channel. Forest land studies have shown that large wood and canopy are provided by this 300 ft. of streamside buffer area.

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- Work with neighbors to reduce erosion and fine sediment from getting in to the creek. Avoid increasing flood volume though avoidance of new road construction, vegetation clearing and urbanization.

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SUMMARY: CREEK/RIVER CORRIDORS ELEMENT — CONFINED/BEDROCK CHANNELS

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
☐	☐	Completed inventory of corridor condition and other factors with maps, aerial photos, site photos and required information included.
☐	☐	Completed Elements 2, 3, 4, and 6 to address road crossings, erosion, water diversions and stewardship groups.
Indicate BMPs that address particular features on your creek.		
☐	☐	Owner/manager will stabilize landslides along channel and on canyon slopes (if applicable).
☐	☐	Fallen trees are left in channel unless a bridge or structure is threatened.
☐	☐	Channel banks will be revegetated (if applicable).
☐	☐	Slopes and hillsides will be revegetated with native species and forest (if applicable).
☐	☐	Habitat surveys indicate a need for large wood and stumps to be placed in channel to increase fish habitat.
☐	☐	All activities on slopes near to the streams should avoid disturbing the channel or removing trees within 300 feet of the channel.
☐	☐	Work with neighbors to reduce erosion and fine sediment from getting into the creek. Avoid increasing flood volume through avoidance of new road construction, vegetation clearing and urbanization.

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IMPLEMENTATION TIMELINE: CREEK/RIVER CORRIDORS ELEMENT — CONFINED/BEDROCK CHANNELS

For each BMP to be applied, outline a timeline for implementation over the next 10 years.

ACTION/BMP	TIME FRAME

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ELEMENT 7 - PHOTO-MONITORING:
FARM CONSERVATION PLAN

- Indicate any site where you monitor currently.

- Monitor including:

☐ Rain Gage
☐ Stage gage for creek water flows including marks on a bridge, on marked rod etc.
☐ Photo areas

As part of this program and the certification you will need to take photos on a regular basis and retain these photos with the farm plan. To the greatest degree possible, use the same sites as you have used for this farm plan. Try to use a camera with a date setting to document the dates of the photos, otherwise write the date on the back or indicate it and the site number on the digital photo file name.

Your photo-monitoring and record keeping should be done year-round, depending on the feature, and include all of the following that apply to your site.

NEW VINEYARD

☐ Site before vineyard development.

☐ Stages of installation – clearing, land treatment, road construction

☐ Temporary cover crops

☐ All erosion control measures

☐ Installation of vineyard and winter pictures for first several years

☐ Winterization of vineyard roads, turnarounds, and filter strips

☐ All drainage facilities inlets and outlets – take photos of water leaving the system to document the quality

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EXISTING VINEYARD

☐ Vineyard floor in winter with cover crops

☐ Vineyard access road winterization

☐ Drainage outlets and inlets with energy dissipaters and showing non-turbid water discharge

☐ Any in-vineyard waterways

☐ Filter strips

☐ Emergency erosion control

☐ Reservoir during bypass flows, if applicable

REPLANTING VINEYARD

☐ All of the above as applicable

ROADS

☐ Roads and all drainage facilities in winter storm flows

☐ Road surface, bank cuts

☐ Water bars and rolling dips and other drainage features with energy dissipaters

☐ All culverts with energy dissipaters

☐ Stream crossings – summer and winter

☐ Ditches and other features

☐ All repair and maintenance actions if major

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CREEK AND RIVER CORRIDORS

Mark sites for photo stations on map or aerial and use these over the years to create a record for how the river/creek changes. Use the sites where you have done your measurements and photograph all your restoration work as well as any major changes that occur in a flood or drought or as a result of off-site changes.

- ☐ Corridor and vineyard edge
- ☐ All bank failures and the repair you do for them
- ☐ All restoration work
- ☐ All bridges and crossings
- ☐ Winter flows in channel
- ☐ Summer flows in channel
- ☐ Cross sections of channel at designated points
- ☐ All maintenance actions
- ☐ The channel after major floods at all sites and any large slides or other changes up or downstream

SUMMARY: PHOTO-MONITORING ELEMENT

ALREADY BEING APPLIED	NEEDS TO BE APPLIED	BMP
☐	☐	Provide map with sites for photo monitoring.
☐	☐	Complete monitoring once you are certified.

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FISH FRIENDLY FARMING™
ENVIRONMENTAL CERTIFICATION PROGRAM
SONOMA AND MENDOCINO COUNTIES
FARM CONSERVATION PLAN WORKBOOK AND BENEFICIAL MANAGEMENT PRACTICES

CALIFORNIA LAND STEWARDSHIP INSTITUTE

Fish Friendly Farming® Environmental Certification Program

Fish Friendly Farming® Environmental Certification Program is a project of the California Land Stewardship Institute (CLSI) a not for profit organization.
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FARM CONSERVATION PLAN WORKBOOK
INTRODUCTION

The Fish Friendly Farming® Certification Program was designed to improve water quality and to restore and sustain habitat for the federally-listed threatened Coho salmon, Chinook salmon, and steelhead trout in the Russian, Navarro, Gualala and Napa Rivers and Sonoma, Suisun, Salmon and Greenwood Creek watersheds.

The Fish Friendly Farming® (FFF) program is a voluntary certification program for farmers who implement land management practices that restore and sustain fish habitat on their property and improve water quality. The Farm Conservation Plan includes a format to allow for the farmer to use one notebook to include all of the information and maps. The FFF Program recognizes that improved land stewardship is best accomplished through a cooperative and positive working relationship with landowners and farmers. Landowners make numerous decisions regarding land management and will use improved methods, if encouraged, and if technical and financial assistance is available for projects.

The following concepts guide the Fish Friendly Farming® Environmental Certification Program:

- ❑ Cooperative efforts between landowners and interest groups in the watershed will increase the level and success of restoration and recovery efforts for salmon and steelhead.
- ❑ An incentive program that rewards farmers for practicing beneficial management practices (BMPs) will protect fish habitat over the long term.
- ❑ Restoration and recovery of threatened fish populations is an immediate concern. The certification program, by providing incentives, will encourage rapid improvements. Some phasing of improvements is built into the program to recognize the economic needs of the landowner.
- ❑ Beneficial management practices are based on a credible scientific approach to watershed restoration and focus on the needs of the fish and water quality.
- ❑ Recovery of the salmon and steelhead is a long-term endeavor. Changes to support and sustain these fish populations must be integrated into all land uses in each watershed. There are many land uses and facilities not associated with agriculture that have had significant effects on the fish. This program focuses on one land use, farming, and recognizes that changes must be made in other activities and land uses as well if the fish are to recover.
- ❑ This program is entirely voluntary. Landowners chose to participate.

The potential benefits of the Fish Friendly Farming™ program for the farmer include:

- ❑ Improved soil and water conservation

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- ❑ Better roads
- ❑ Lower maintenance creek corridors
- ❑ Advice and assurances from three regulatory agencies regarding the consistency of the actions in the farm conservation plan with regulations
- ❑ Implementation funds and technical assistance for riparian corridor restoration including invasive plant removal and erosion control projects
- ❑ Road and erosion site repair
- ❑ Public recognition as an environmentally conscious farmer
- ❑ Personal satisfaction for assisting in the recovery of the steelhead trout for your children and grandchildren

In Sonoma and Mendocino Counties the Sotoyome Resource Conservation District (RCD) sponsored the program from 1999-2005. Other agencies involved include the North Coast Regional Water Quality Control Board, the California Department of Fish and Game, the National Marine Fisheries Service and the Natural Resources Conservation Service. In 2005 the California Land Stewardship Institute, a non-profit organization was formed to operate the FFF program in four counties.

This version of the Fish Friendly Farming™ Program was partially funded by the State Water Resources Control Board and the State Coastal Conservancy. A Technical Advisory Committee (TAC) reviewed the program and provided input.

This program uses a workbook for the landowner/manager to evaluate the property, the current practices, and create a farm conservation plan for the property focusing on resource concerns including fish habitat. The participants attend a series of four workshops. The FFF program staff complete a site visit and provide technical assistance to the farmer as needed to complete all aspects of the farm plan. Other technical experts may also be involved in implementation of creek restoration, road repair and other projects. The farmer will keep the workbook and the farm conservation plan and use it and revise it as necessary. The Farm Conservation Plan includes a format to allow for the farmer to use one notebook to include all of the information and maps for the property.

Once the assessment and farm conservation plan are completed the landowner can have the farm plan certified. A certification team made up of three resource agencies, Regional Water Quality Control Board, National Marine Fisheries Service and the County Agricultural Commissioner will evaluate the farm plan and perform a site visit. The FFF program staff assists the grower in presenting the Farm Conservation Plan. The certification is based on the completeness and accuracy of the site inventory in documenting the natural resources of the site, current practices and all needed BMPs and there is a reasonable timeline for implementation of additional BMPs and projects as needed. The certification process is meant to provide assistance to the farmer and result in a collaborative effort to improve land stewardship.

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Following this review each regulatory agency issues a letter to the owner stating the Farm Conservation Plan is certified. If the Farm Conservation Plan is not certified, then the agencies provide detailed comments on the steps necessary to become certified. Continued monitoring will allow for the landowner to document their practices and land stewardship and demonstrate implementation of the plan. Re-certification will occur on a 5-7 year cycle for most sites.

The following policy outlines measures required for re-certification and maintaining a valid certification:

The Fish Friendly Farming Certification is initially awarded based on the accuracy and completeness of the Farm Conservation Plan for a given site and for the list of needed actions in the Implementation Timeline to bring the site into compliance with the FFF program BMPs. We have been asked to develop a policy for revocation of the certification and define the circumstances that will result in a site losing its certification. The Board of Directors of the California Land Stewardship Institute approved this policy at its December 2008 meeting after the certifying agencies had reviewed and provided their input.

Here are the conditions under which CLSI will revoke a certification:

1. At the first re-certification no progress, or a clearly insufficient amount of progress, has been made on items in the Implementation Timeline. Extenuating circumstances, such as problems receiving permits, will be evaluated on a case-by-case basis and an additional re-certification progress check may be scheduled.

2. At re-certification a significant reduction in BMP application has occurred changing the basic condition of the site and requiring significant improvement to be recertified.

3. There is an act by the certified owner/manager that causes a violation of a particular regulation and for this the owner is cited[1]. Examples include clearing the riparian corridor along a creek, dumping spoils or debris in the creek, spilling pesticides into the creek, or grading in the winter. The issuance of a citation or other similar documented action (e.g. notice of violation, cease and desist order) is required. Having a complaint filed or an interaction with a regulator does not affect the certification. Only citations involving the laws and regulations which the FFF program covers (Clean Water Act, Porter-Cologne Act, Federal Endangered Species Act, Ca Water Code, State pesticide regulations) will affect the certification. So for example labor, health and safety laws will not be included. Not having a 1600 permit for existing permitted or licensed water facilities will not be counted as a violation due to the unclear legal status of application of the Ca. Fish and Game code to water rights facilities.

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[1] *1. Citations affecting certification status include:*
Administrative Civil Liabilities (Clean up and Abatement order from RWQCB); Notice of Violation/Federal lawsuit from NMFS; Violation List – County Agricultural Commissioner; Warden's ticket or County District Attorney/State Attorney General lawsuit – Ca. Dept. of Fish and Game. Only lawsuits settled against the certified owner/manager will apply.

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4. All use of the FFF logo and name for marketing will be done after a license agreement has been issued and such marketing will be consistent with the license agreement and this policy. Misrepresentation of program coverage such as claiming all wines come from FFF certified vineyards when, in fact, some vineyard designated wines are sourced from vineyards not certified in the program. Wines must have a minimum of 75% certified grapes to be considered FFF certified wine. This restriction will also apply to the Napa Green program where a trade organization provides a different trademark which is entirely based on the FFF certification.

5. For each instance where a certification may be revoked due to a violation the issues will be reviewed by CLSI and the owner and a set of steps to repair or mitigate the problem will be established along with the necessary actions to re-instate the certification. These will be reviewed by the certifying agencies for approval. Whatever actions are required by the agency issuing the violation could become the steps in CLSI plan with the owner. These actions would be substantive work such as revegatation, erosion control and would not involve fines such as the agency issuing the citation may impose.

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FARM CONSERVATION PLAN WORKBOOK INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES (BMPs)

This Farm Conservation Plan workbook is designed for use by the landowner/manager to evaluate, inventory and assess site conditions, evaluate current management practices, and create a conservation plan for the farm. The assessment and conservation plan that the farmer develops is the foundation tool for a continuous and thorough assessment of the resource base and operation of the farm. The workbook directs the completion of a conservation plan that provides the basis for certification as a fish friendly farm. Once completed, the workbook also provides a centralized database for the property.

The farm plan includes the following elements:

- ❑ **Element I - General Site Features**
- ❑ **Element II - New Vineyard/Orchards**
- ❑ **Element III - Managing Agricultural Lands***
- ❑ **Element IV - Major Replants**
- ❑ **Element V - Roads**
- ❑ **Element VI - Creek/River Corridors**
- ❑ **Element VII - Photo-monitoring**

Certification of the Farm Conservation Plan requires completion of all of the elements that apply to the site. For example, if you are developing a new vineyard, the plan needs to include Elements I, II, III, and VIII and if appropriate Elements V and VI. In contrast, if you have an existing vineyard and no plans to expand or replant, the plan will need to include all the Elements III and VII and if appropriate Elements V, VI. Elements V and VI are typically completed by FFF staff in collaboration with the landowner/manager and are not done for all sites.

The Farm Conservation Plan does not have to be done in one day or even one month. Take your time. Be thorough and provide as much detail as possible. The more you give to the planning process, the more you will benefit. The more you quantify your descriptions, the easier it will be to measure improvement over time. The Farm Conservation Plan will prepare you to improve your long-term efficiency and improve the bottom line. At the same time, you will be helping to bring back salmon and steelhead trout and improve water quality.

The program is designed to provide technical assistance to the farmer. The Farm Conservation Plan workshop instructor and other technical experts will assist with all the elements, but especially the Roads and Creek/River Corridors elements.

* We can provide this element for Vineyards and Orchards

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ELEMENT I - GENERAL SITE FEATURES: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

These instructions should be used with Element I of the Farm Conservation Plan template.

1. LOCATION AND BACKGROUND INFORMATION

This section should summarize the address and contact information for the property.

2. WATERSHED LOCATION

- ❑ Where is your property in the watershed? Define the tributary watershed in which the property is located.

- ❑ You will receive aerial photographs and topographic maps of your property as part of enrolling in the FFF program. If you are completing a new vineyard or major replant, you will need to have detailed topographic maps created for the proposed development area. Complete the preliminary evaluation in Element II or IV before having these detailed maps completed.

3. GENERAL SITE DESCRIPTION

- ❑ Approximate the acreage in various land uses on the property including existing vineyard, proposed new vineyard, other agricultural lands, residential or winery areas, and open spaces or wildland areas. For wildland areas, fill in the vegetation type and general slopes, if known.

4. ELEMENTS

- ❑ Check the elements included in your plan. All the plans for certification must include: Element III-Managing the Vineyard, as well as Elements 5-Roads, Element VI-Creek/River Corridors, and Element VII-Photo-monitoring. Include the New Vineyard or Major Replant Elements, if appropriate for your site.

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5. ADDITIONAL INFORMATION

- ❑ This is an area to explain any other site feature that needs more elaboration or to describe more detail about the elements you feel are needed. For example, you might explain about the replanting schedule for the site and why this element is or is not needed. You might also explain if other crops and agricultural uses occur on the property or the site history prior to a new vineyard development to document causes of exiting erosion. This is also the place to state any goals that you are using as part of the farm plan.

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FARM PLAN WORKSHOPS

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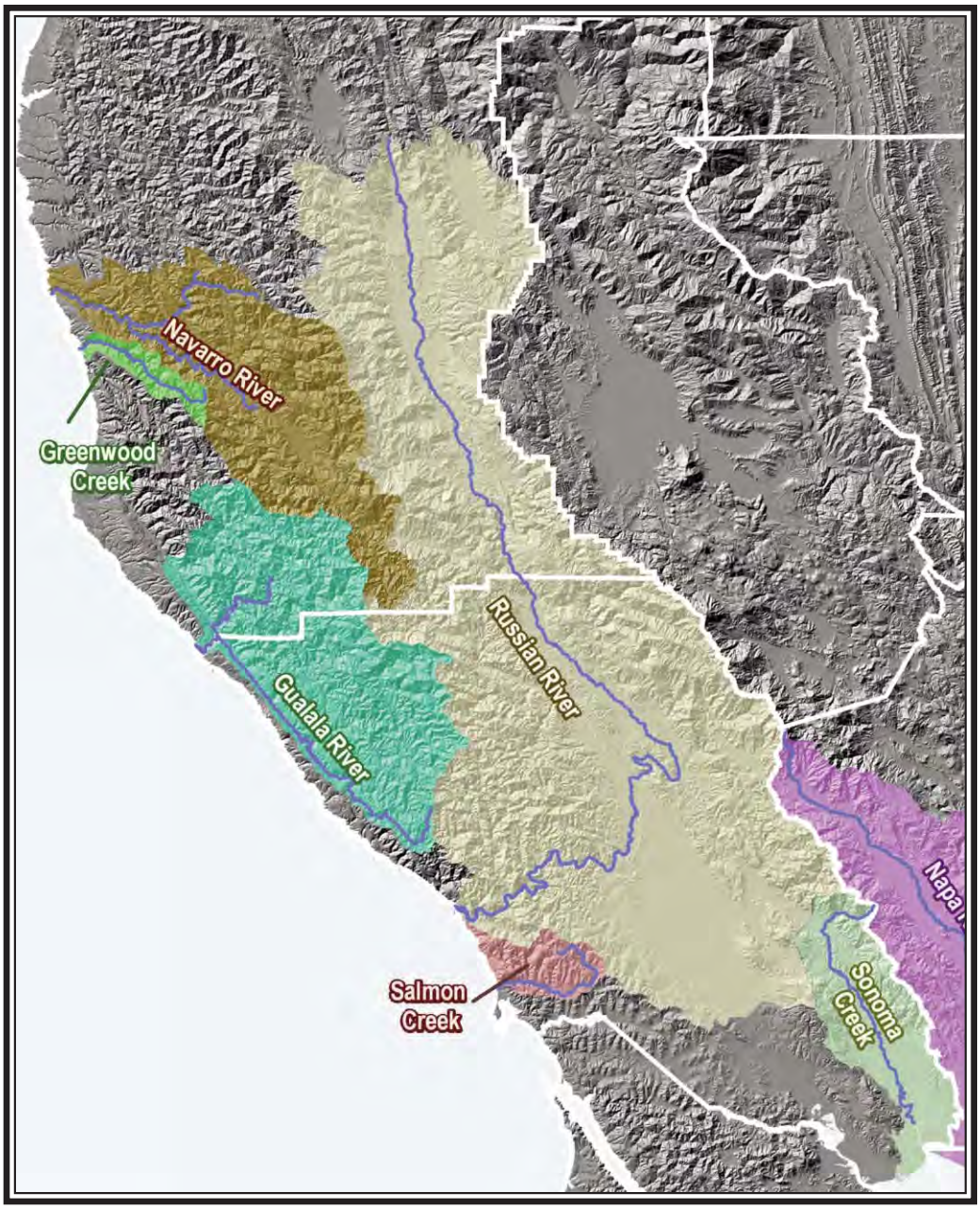

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ELEMENT II - NEW VINEYARD*: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for new proposed vineyards* and expansion of an existing vineyard and includes:

- ❑ Inventory/Assessment of the features of the property where development is being considered to integrate compliance with laws and regulations, including the California Environmental Quality Act (CEQA).
- ❑ Evaluation and application of Beneficial Management Practices (BMPs) into the site design.
- ❑ Evaluation and Beneficial Management Practices for the installation of the vineyard.

EVALUATING A SITE FOR A NEW VINEYARD*

Use Element II of the Farm Conservation Plan, your maps and aerials and take site photos as instructed in the directions. There is some overlap with other elements and you will need to refer to a few other sections of the workbook.

1. COMPLETING A PRELIMINARY SITE EVALUATION

Background: Preliminary Site Evaluation

This evaluation creates an inventory of site features including natural features, potential constraints, potential vineyard areas and potential resource protection areas. Under Sonoma County regulations an Erosion Control Plan is needed to develop a new vineyard in most locations. The Erosion Control Plan must review site slopes, soils, topography and layout in great detail. To address habitat and biological issues as well as hydrologic processes, which can affect downstream areas, a more thorough evaluation and site design process is needed. Additionally, a thorough site evaluation process can assist the property owner in avoiding significant project impacts under the California Environmental Quality Act, or CEQA. For more information on CEQA visit http://ceres.ca.gov.

This preliminary site evaluation of the property assesses the features required under local regulations and of importance to water quality protection – soils and slopes as well as vegetation, special status species, and the drainage network. The result is a set of overlays of the site used to define constraints and opportunities for location and development of new vineyards.

The preliminary evaluation will determine potential vineyard areas with the least environmental impacts. The FFF program staff can provide assistance in completing this evaluation.

**** Throughout this document we will be using the term vineyard but the information is also intended to include orchards.***

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2. RESOURCES FOR THE INVENTORY

- ❑ A relatively detailed color aerial of the entire property will be needed (scale of at least 1'' = 500'). As part of the farm plan workshops, digital color photos will be ordered at the appropriate resolution for planning on each enrolled site. Make a number of color copies of the aerial or make a digital scan. Use these copies for the next sections of the farm plan.

- ❑ A detailed topographic map will be needed for the Erosion Control Plan. However, for the first level of evaluation of the property a USGS topographic quad sheet can be used and the detailed map prepared later.

- ❑ Separate the property into areas. These can be areas where you plan to develop vineyards and areas which will not be developed, the north/south or east/west areas of the site, or you may want to separate the areas by sub-watershed for use later in evaluating site hydrology. Name or number each and delineate each area on a copy of the aerial.

3. SLOPES

Background: Slopes

Slope has an enormous effect on soil erosion, drainage and land use. Slope magnifies the effects of rainwater runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage and mass movement. Steep slopes (greater than 30%) have high to extreme erosion hazards for most soil types.

U.S. Geologic Survey (USGS) topographic maps can be used to determine the general percentage slope on a site for preliminary review purposes. The contours on a topo map indicate elevations and by adding up the number of contours one can generally determine the change in elevation on a hillside. The percent slope of a hillside is measured as rise over run multiplied by 100. The first step is to measure the elevational increase along a hillside (shown by the contours on the map) and divide by the linear distance or length over the same area measured to the scale of the map (1"=2000'). This number is then multiplied by 100 to get the percent slope. For example, a hillside which measured a 200 ft. elevation increase in a 2000 ft linear distance would have a 10% slope (200/2000 x 100). Another hillside with a 200 ft elevation gain in a 1000 ft linear distance would have a 20% slope (200/1000 x 100). A short steep slope such as a 200 ft elevation rise in a 500 ft linear distance would have a 40% slope (200/500 x 100).

For each area defined on the site, make numerous slope measurements. There are several inexpensive computer software programs such as Maptech Terrain Navigator and TOPO, as well as sophisticated Geographic Information Systems (GIS) which can be

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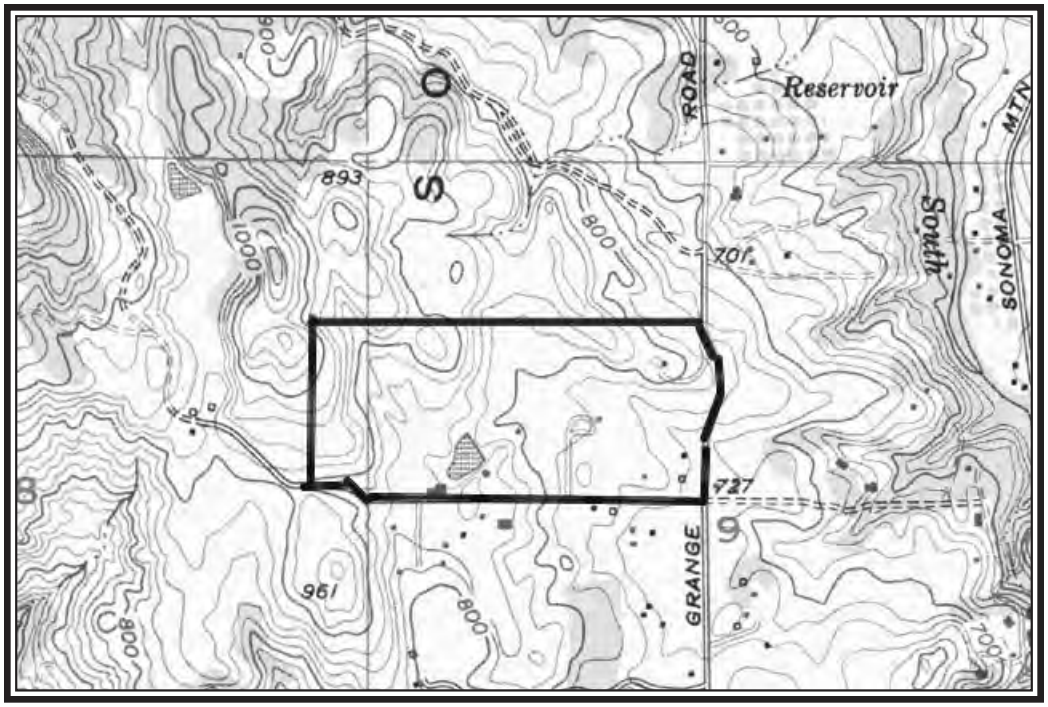
AERIAL AND MAP PROPERTY BOUNDARY



Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: PROPERTY BOUNDARY

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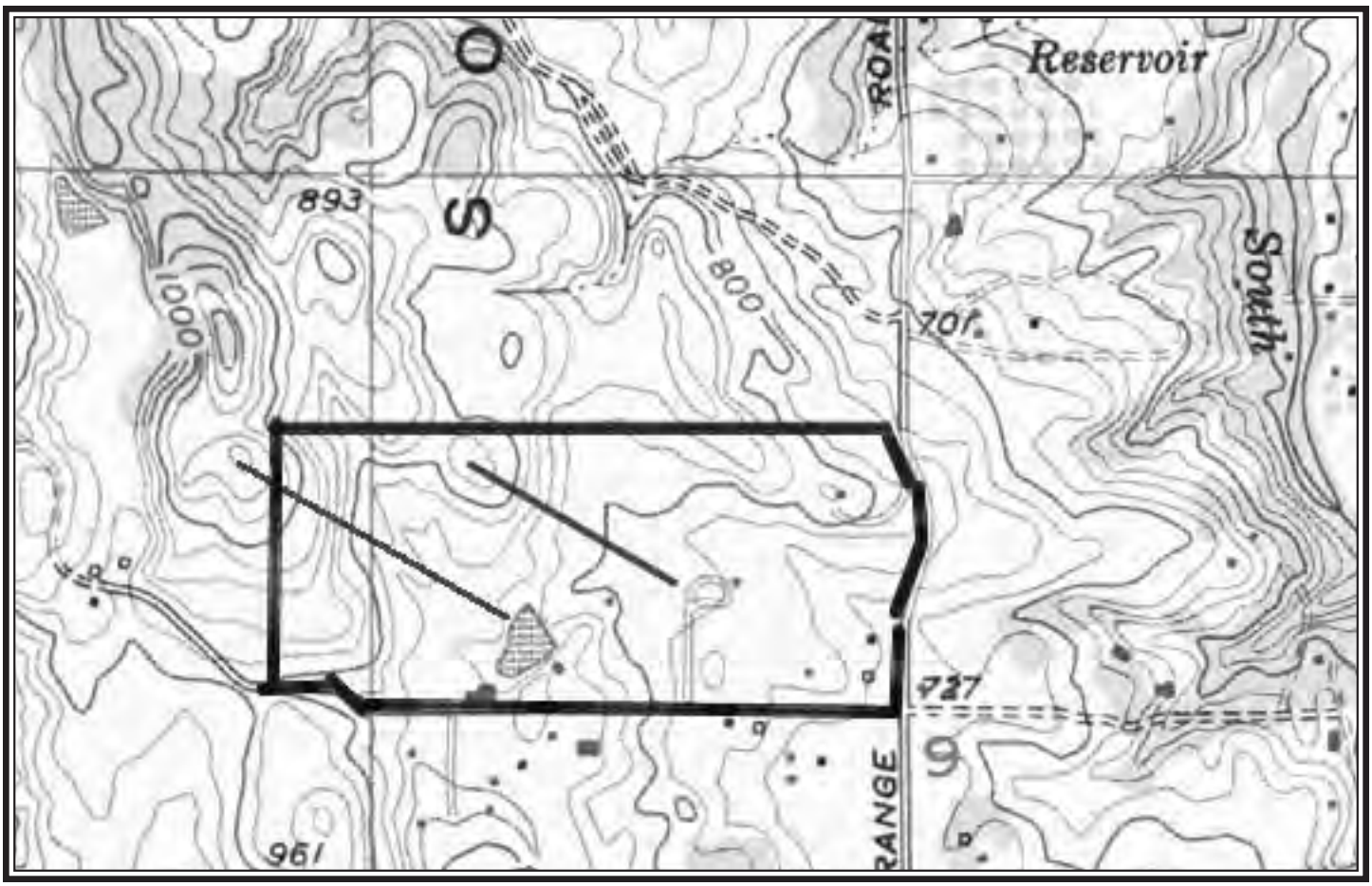

LINES SHOW EXAMPLE OF SLOPE AND SLOPE LENGTHS

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: SLOPE AND SLOPE LENGTH

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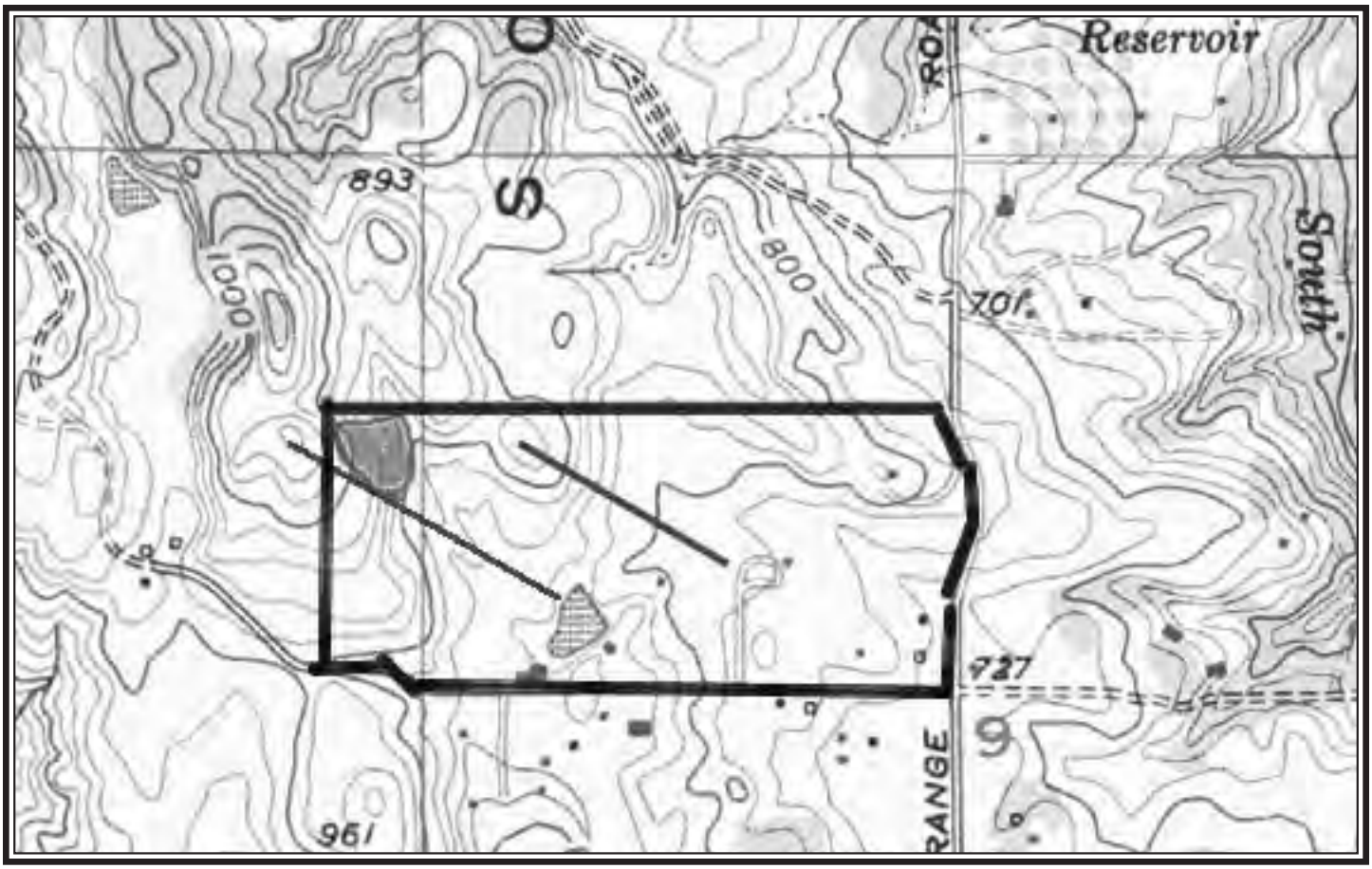

SMALL AREA OF STEEPER LAND IS OUTLINED WITHIN A GENERALLY LOW SLOPE SITE

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: DELINEATING AREAS OF STEEPER SLOPE

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used to generate a slope map of the property based on USGS topographical maps. However a much more detailed survey with two foot contours at a 1'' = 200' scale should be completed for the Sonoma County permit. Preparation of the detailed topographic map will require a site-specific survey.

SITE INVENTORY: SLOPES

- ❑ Make several measurements of slopes in each area from a topographic map or have a detailed site survey completed. In the 5-30% slope areas also measure knolls, hills and small steep areas and delineate all of these small areas over 30% slope. Keep your map and record your measurements in the Farm Conservation Plan.

- ❑ Measure and record the length of the slopes in the area of 5-30% slope class.

- ❑ With assistance from the farm plan workshops, field check the 5-30% slope areas, maps and aerials and record the measurements in the Farm Conservation Plan.

- ❑ Create an overlay either in a digital format or on paper of slope classifications of <5%, 5-15%, 15-30%, 30-50%, and >50% for the areas of the property.

4. SOIL TYPES AND HYDROLOGIC RATINGS

Background: Soil Types

Soil is the fundamental resource for all types of agriculture and will determine both the suitability of a site for various crops as well as the potential for erosion. The easiest place to find out the soil type for a site is to look in the Sonoma or Mendocino County Soil Survey available from the Natural Resource Conservation Service (NRCS). Participants in the FFF workshops receive a soil map and description for their property.

Soils are grouped into series according to their thickness and physical makeup. Within each series of soils are various soil types, which are given numbers and mapped onto aerials. For example, the Forward series has several soil types: Forward gravelly loam, 2 to 9 percent slopes (138), Forward gravelly loam, 9 to 30 percent slopes (139), Forward gravelly loam, 30 to 75 percent slopes (140), and Forward-Kidd complex, 50 to 75 percent slopes (141). These soil types are also called mapping units. Each soil series and type is described in the Soil Survey. For example:

"Forward series (Map units: 138, 139, 140, 141)

The Forward series consists of well-drained soils on uplands. Slope is 2 to 75 percent. Elevation is 400 to 3,500 feet. These soils formed in material weathered from rhyolite. The plant cover is Douglas fir, madrone, scrub oak, pepper, and bay trees. The mean annual precipitation is 30 to 50 inches, and the mean annual temperature is 54° to 56° F. Summers are warm and dry, and winters are cool and moist. The frost-free season is 200 to 230 days.

In a representative profile the surface layer is light gray, slightly acid gravelly loam 4 inches thick. The subsoil is light gray, medium acid and strongly acid loam 22 inches thick. The

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substratum is light gray, strongly acid gravelly loam that overlies weathered rhyolitic tuff at a depth of 35 inches.

Permeability is moderately rapid. The effective rooting depth is 20 to 40 inches. Available water capacity is 2 to 4.5 inches.

Forward soils are used for watershed, wildlife habitat, and limited timber production."

The description of each soil type within the soil series includes descriptions of erosion and runoff characteristics:

138- Forward gravelly loam, 2 to 9 percent slopes. *This gently sloping to moderately sloping soil is on side slopes on uplands.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and that are less than 20 inches deep to bedrock.

Runoff is medium. The hazard of erosion is slight.

This soil is used for limited timber production, vineyards and orchards, wildlife habitat, and watershed.

139- Forward gravelly loam, 9 to 30 percent slopes. *This strongly sloping to moderately steep soil is on side slopes on uplands.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and that are less than 20 inches deep to bedrock.

Runoff is medium. The hazard of erosion is slight to moderate.

This soil is used for limited timber production, wildlife habitat, and watershed.

140- Forward gravelly loam, 30 to 75 percent slopes. *This steep and very steep soil is on uplands. It has the profile described as representative of the series.*

Included with this soil in mapping were small areas of Aiken, Boomer, Kidd, and Sobrante soils. Also included were areas of soils that are similar to this Forward soil but that have a clay loam subsoil and areas of clayey, less sloping soils.

Runoff is very rapid. The hazard of erosion is high to very high.

This soil is used for timber, recreation, wildlife habitat, and watershed.

141- Forward-Kidd complex, 50 to 75 percent slopes. *This complex consists of very steep soils on uplands. These soils are so intermingled that it was not practical to separate them at the scale used in mapping. Commonly, the Forward soils are on toe slopes and the Kidd soils on side slopes.*

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This complex is about 60 percent Forward soils, about 20 percent Kidd soils, and about 20 percent Aiken, Boomer, and Sobrante soils and areas of rock outcrop.

Runoff is rapid and the hazard of erosion is high in the less sloping areas. Runoff is very rapid and the hazard of erosion is very high in the more sloping areas. The soils in this complex are used for limited timber production, wildlife habitat, and watershed."

The change in slope for a similar soil type changes the erosion rating. Soil types are defined based on slope classification. The slope classes typically used in soil surveys are:

0 - 5 % or 0 - 9%
2 – 9%
5 - 15 % or 9 - 15%
15 - 30 %
30 - 50 %
50 - 75%

Another feature of soils that the NRCS has identified is the hydrologic soil group. Soils are grouped as A, B, C or D according to the minimum rate of infiltration occurring in bare soil after prolonged wetting. Infiltration is the movement of rainfall into and through the soil and is largely affected by the surface condition of the soil and the composition and depth of the soil profile. One property may have several soil types and slope classes. The erosion hazard of each soil type/slope class is different and should be evaluated separately. Table IIA lists the hydrologic soil group for each Sonoma County soil type and is available at the soil survey website. Table IIB lists the Mendocino County soil types.

SITE INVENTORY: SOIL TYPES

- ❑ Look up your site in the Sonoma or Mendocino County Soil Survey. Use the map and soil descriptions provided in the FFF workshops

- ❑ Print out copies of the Soil Survey map and descriptions of the soil types for your site for inclusion in your Farm Conservation Plan. Use the soil survey, Appendix 1 and Table IIA to fill in the table in the Farm Conservation Plan for soil type, slope classification, erosion rating, K and T values, and hydrologic soil group for the entire property. If more detailed site information is available also include it.

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TABLE IIA
Sonoma County Soil Survey
Soil and Water Features

Soil Name and Map Symbol	**Hydrologic Group**
Arbuckle: AgB, AgD, AgE, AkB, AkC	B
Atwell: AtF, AtG	C
Baywood: BaC, BaE	A
Blucher: BcA, BhA, BhB, BlA, BlB	C
Boomer: BoE, BoF, BoG	B
Caspar: CaE, CaF	B
Cibo: CbF	D
Clear Lake: CcA, CcB, CeA, CeB, Cfa	D
Clough: CgC, CgD, CgE	D
Cohasset: CmE, CmF, CmG	B
Cole: can, CnB, CoA, CoB	C
Comptche: CpG	B
Cortina: CrA, CsA	A
Cotati: CtC, CtD, CtE	C
Diablo: DbC, DbD, DbE, DbE2, DbF, DbF2	D
Dibble: DcC, DcD, DcE, DcE2, DcF, DcF2	C
Empire: EmE, EmF, EpF	B
Felta: FaD, FaE, FaF	B
Forward: FoE, FoG, FrG	C
Goldridge: GdC, GdD, GdD2, GdE, GdE2, GdF, GdF2	B
Goulding: GgD, GgE, GgF, GgF2, GgG, GlD, GlE, GlF, GlF2, GlG, GoF	D
Guenoc: GrE, GrG	C
Haire: HaB, HbC, HbD, HbD2, HbE, HbC, HcC, HcD, HcD2, HcE, HcE2	C
Hely: HeF, HeG	C
Henneke: Hge, HgG2	D
Hugo: HhG, HkF, HkG, HkG2, HlF, HlG, HmF, HmG, HnE, HnG, HnG2, HoG, HrG, HsF, HsG	B
Huichica: HtA, HtC, HtD, HvC, HuB, HwB	D
Huse: HyG	C
Josephine: JoE, JoF, JoF2, JoG, JsG	B
Kidd: KdF, KeE, KkG	D
Kinman: KlD, KlE, KlF, KmF	C
Kneeland: KnC, KnD, KnE, KnF, KoG	C
Kneeland, sandy variant: KsD, KsE, KvE	C
Laniger: LaC, LaD, LaE, LAE2, LaF	C
Laughlin: LgE, LgF, LgG, LgG2, LhG	C
Los Gatos: LkG, LmG, LnG	C
Los Osos: LoD, LoE, LoF, LoF2, LsD, LsE, LsE2, LsF2	C
Los Robles: LuA, LvB	B

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TABLE IIA (cont.) Sonoma County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	**Hydrologic Group**
Manzanita: MbC	B
Maymen: McF, MlG	D
Mendocino: MmE, MmF, MnF	B
Montara: MoE, MoG	D
Noyo: NoD	C
Pajaro: PeA, PaB, PbB, PcA, PcB	C
Pleasanton: PeA, PeC, PgB, PhB, PkC, PlC, PlD	B
Positas: PsC, PsD	D
Raynor: RaC, RaD, RaE, RcD, ReE	D
Red Hill: RhD, RhE, RhF, RlG	B
Rayes: RmA	D
Rohnerville: RrC, RrD	B
Sebastopol: SbC, SbD, SbD2, SbE	B
Sheridan: SeE	B
Sites: SfE, SfF	B
Sobrante: ShE, ShF, ShG	C
Spreckels: SkC, SkD, SkE, SkE2, SkF	C
Steinbeck: SnC, SnD, SnD2, SnE, SnE2, SnF, SnF2	B
Stonyford: SoF, SoG, SrG	D
Supan: SsG	D
Suther: StE, StE2, StF, SuF, SuG	C
Toomes: ToE, ToG	D
Tuscan: TuC, TuE	D
Wright: WgC, WhA, WmB, WoA	C
Yolo: YlA, YmB, YnA, YoB, YrB, YsA, YtA	B
Yorkville: YuE, YuF, YvF, YwF, YwG	D
Zamora: ZaA, ZaB	B

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TABLE IIB Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	**Hydrologic Group**
101: Asabean Sanhedrin	B B
102: Asabean Sanhedrin Speaker	B B C
103: Asabean Speaker Neuns	B C C
104: Bearwallow Hellman	C C
105: Bearwallow Hellman Witherell	C C D
106, 107, 108: Bluenose Neuns Gudgrey	 B D B
109, 110: Casabonne Wohly	 B B
111: Casabonne Wohly Pardaloe	B B B
112: Clear Lake	D
113, 114: Cole	C
115: Cole	C
116: Cummiskey	B
117: Dingman Beaughton	 D
118, 119, 120: Dunsmuir Maymen Varient	 C D
121: Etsel Neuns	D C
122: Etsel Woodin	D C
123, 124, 125, 126: Feliz	B

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
127: Fluvaquents	
128: Gielow	C
129: Gshwend Frenchman	B B
130, 131, 132: Grudgey Bluenose Neuns	 B B C
133: Haplaquepts	
134, 135: Haploxeralfs Argixerolls	
136, 137: Henneke Montara	 D D
138, 139: Holohan Hollowtree Casabonne	 B C B
140: Holohan Hollowtree	B C
141, 142: Hopland	 B
143, 144: Hopland Maymen Etsel	 B D D
145, 146, 147: Hopland Sanhedrin Kekawaka	 B B B
148, 149: Hopland Witherell Squawrock	 B D C
150, 151: Hopland Wohly	 B B

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
152, 153:	
Hopland	B
Woodin	D
154, 155:	
Kekawaka	B
Casabonne	B
Wohly	B
156: Maxwell	D
157: Mayacama	C
Hopland	B
Etsel	D
158: Maymen	D
Etsel	D
Hopland	B
159: Maymen	D
Etsel	D
Mayacama	C
160: Maymen	D
Etsel	D
Snook	D
161, 162:	
Maymen	D
Woodin	C
Etsel	D
163, 164:	
Nashmead	B
Updegraff	B
Woodin	C
165, 166:	
Nashmead	B
Woodin	C
167, 168:	
Neuns	C
Bluenose	B
Tyson	B
169, 170, 171:	
Ornbaun	B
Zeni	C

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
172: Pardaloe Kekawaka Casabonne	B B B
173: Pardaloe Woodin Casabonne	B C B
174: Pardaloe Woodin	B C
175, 176: Pinnobie	 B
177, 178, 179, 180, 181, 182: Pinole	 B
183: Pits and Dumps	
184, 185, 186: Redvine	C
187: Rock Outcrop	
188: Russian	B
189: Russian	B
190: Russian	B
191, 192: Sanhedrin Asabean Speaker	 B B C
193, 194, 195: Sanhedrin Kekawaka Speaker	 B B C
196: Shortoyork Tyson Witherell	C B D
197: Shortyork Witherell Updegraff	C D B
198, 199, 200: Shortyork Yorkville Witherell	 C D D

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
201, 202: Squawrock Witherell	 C D
203, 204: Talmage	 B
205, 206: Tyson Updegraff	 B B
207: Updegraff Sanhedrin	B B
208, 209: Updegraff Speaker Neuns	 B C C
210: Urban land	
211: Witherell Hopland Squawrock	D B C
212: Wohly Casabonne	B B
213: Wohly Casabonne Pardaloe	B B B
214: Xerochrepts	
215, 216: Xerochrepts Haploxeralfs Argixerolls	
217: Xerochrepts	
218: Xerochrepts Riverwash	
219: Yellowhound Kibesillah Ornbaun	B C B
220: Yellowhound Kibesillah	B C
221, 222, 223: Yokayo	 D

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TABLE IIB (cont.) Mendocino County Soil Survey Soil and Water Features	
Soil Name and Map Symbol	Hydrologic Group
224: Yokayo Pinole Pinnobie	D B B
225, 226: Yorktree Hopland Woodin	 C B C
227, 228: Yorktree Yorkville	 C D
229, 230: Yorkville	 D
231: Yorkville Hopland	 D B
232, 233: Yorkville Squawrock Witherell	 D C D
234, 235: Yorktree Yorkville Squawrock	 C D C

TABLE IIC Sonoma County Soils Defined as Highly Erodible by the Natural Resource Conservation Service	
Soil Name	**Slope Class**
Diablo	>5%
Los Osos	>5%
Goldridge	>5%
Dibble	>5%
Suther	>5%
Steinbeck	>5%
Laughlin	>5%

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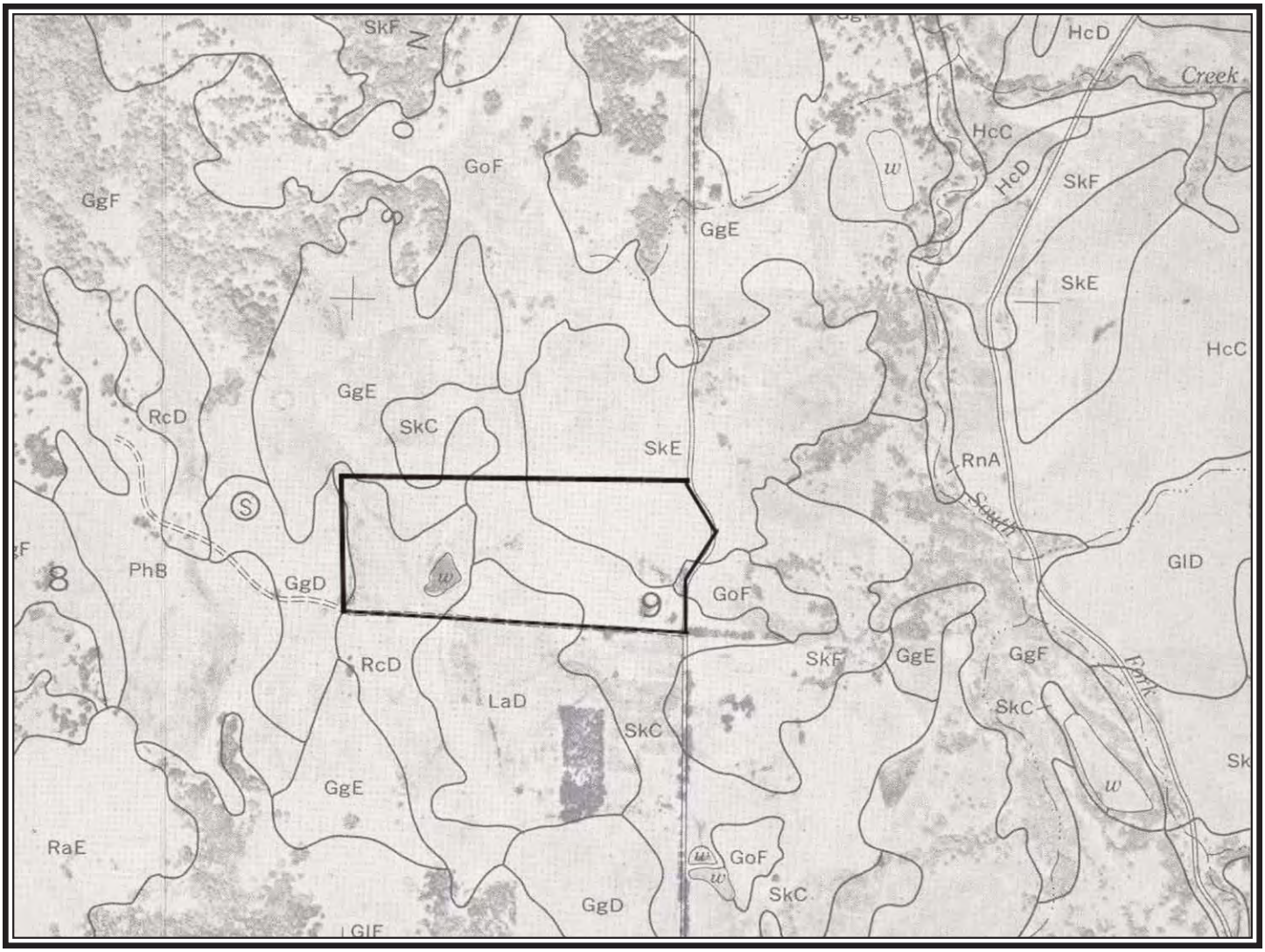

THE SOIL SURVEY INCLUDES INFORMATION ON EROSION HAZARD RATINGS AND OTHER FEATURES OF EACH SOIL TYPE

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: SOIL TYPES

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5. SLOPE STABILITY, EXISTING EROSION SITES AND SEDIMENT SOURCES

Background: Slope Stability, Existing Erosion Sites and Sediment Sources

Some landscapes have a high level of natural instability due to their geologic make-up. Depending upon the vegetative cover, unstable hillside areas can sometimes be outlined from aerial photographs. Landslides and lumpy looking hillsides pose a problem for any type of development and should receive special attention.

Erosion sites include gullies that are relatively large and often located in ephemeral creeks. Gullies are often the result of prior land uses, roads, vegetation clearing and changes in drainage by various developments. Stabilization and repair of existing erosion sites improves the condition of the property by reducing siltation and improving water quality.

Dirt roads and old skid trails may represent a major source of sediment into waterways. Roads are specifically assessed in Element V but are also included in the preliminary site evaluation as a sediment source.

SITE INVENTORY: SLOPE STABILITY / EXISTING EROSION SITES / SEDIMENT SOURCES

- ❑ Look over the site aerial for indications of old landslides and slope movements. Are there hillside slips or lumpy looking, unstable ground? Older aerial photos are often available through the NRCS, or the county, and can show the site at different time periods. Vegetation can mask the scars of old slides and slips. Long time residents may also have information. Landslide hazard maps are available from the California Department of Mines and Geology and the California Department of Forestry. Sonoma and Mendocino Counties also have landslide maps. These will indicate large landslide and landslide prone sites. Smaller slips and gullies may sometimes be repaired and integrated into a vineyard or road. However major unstable slopes should not be developed without a structural repair. If your site has unstable areas you will need to consult with an engineering geologist or civil engineer. The FFF program staff will assist with identifying these problems.

- ❑ Create an overlay on the site map and aerial photo and outline unstable slopes and any landslides for each area.

- ❑ On the copies of the aerial photo, delineate all gullies or small slips. On the farm plan, list observed and potential causes of the erosion such as road drainage, past overgrazing and soil compaction, past agricultural lands, prior timber harvesting, past grading activities, vegetation removal, or other causes.

- ❑ Delineate on the copies of the aerial photo, roads, skid roads, trails or other dirt or paved roads. Give each a name or number.

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6. NATURAL DRAINAGE FEATURES

Background: Natural Drainage Features

The entire network of creeks on the property from upstream to downstream are included in the farm plan. Perennial and seasonal creeks are evaluated in great detail in Element VI and a restoration/management program is developed for each. Ephemeral creeks are addressed in Elements II and III as well as in Element V under road crossings. The overall drainage network is delineated here for defining constraints on the property.

Blue and dashed lines on the topo map indicate perennial and seasonal creeks. Ephemeral streams occur in swales, on hillsides and only carry runoff in large storms. These are typically the first stream “channels” that can be defined below the ridgetop. Ephemeral streams are an essential part of the drainage network and, if disturbed, can quickly become gullies or landslides. The primary goals for ephemeral creeks are to repair existing erosion, revegetate to reduce the potential for erosion on the site, and retain a set of natural drainage channels that can serve as wildlife habitat corridors.

Identifying ephemeral waterways is crucial in evaluating natural drainage patterns. There are often many areas that only carry water during large storms and they may carry a great deal of water during that storm. Ephemeral streams are not indicated on topographic maps with blue lines. The topo map can be used to identify many ephemeral channels - a series of V or U shaped contour lines pointing upslope show a fold in the hillside that funnels water. On the aerial photograph identify all ephemeral creeks and outline each from the channel to the edge of vegetation or the topographic edge of the swale.

A site inspection during or just after a winter storm can be used to further delineate the ephemeral waterways on your site map. If the site is near to the headwaters of a creek, there may be numerous ephemeral streams. Carefully mark where the surface water flows on its way to the more obvious creek channel. Both the topography and surface signs of water movement, such as piles of leaves, sand deposits or scour left by surface flows, can give clues. Observations on the relative amount of flow in each creek and its condition can enhance the baseline information for the preliminary evaluation.

A review of neighboring lands can determine if there are sources of concentrated drainage that may enter your site in storms. For example, are there roads and culverts that feed into a channel? Are there plans for development such as housing or reservoirs? Are there conditions downstream that might create a backwater condition and affect the flows moving off of your site? Your site may, or may not, have any of these conditions, but a review is warranted.

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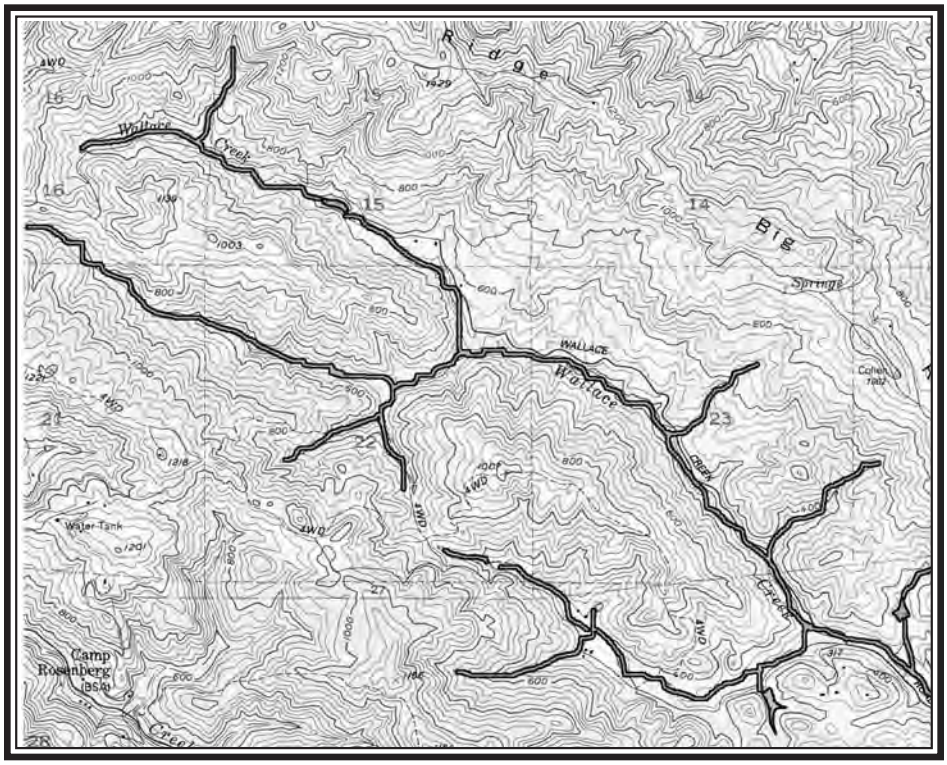
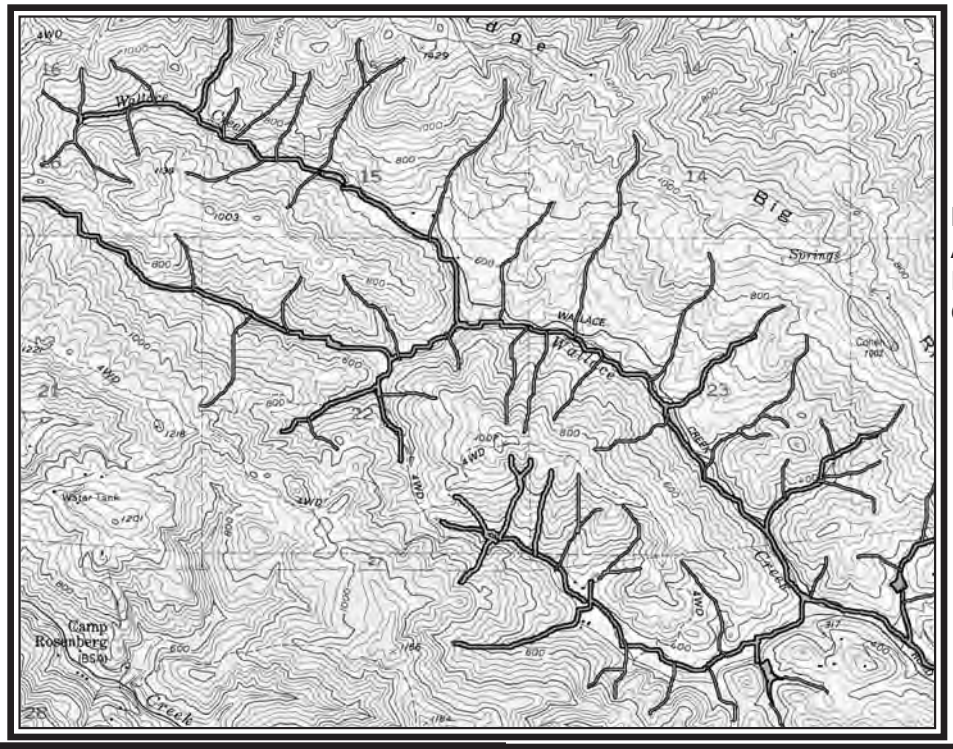


YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED



EPHEMERAL CREEKS AS WELL AS YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED

Fish Friendly Farming Environmental Certification Program	EXAMPLE OF TOPOGRAPHIC MAP WITH CREEKS OUTLINED

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Document the condition of the ephemeral creeks on the site. The condition of all the perennial and seasonal creeks is covered in Element VI. Is the ephemeral creek channel eroding? Erosion can come from the effects of upstream reservoirs, vegetative clearing, impervious surfaces or road runoff. Additionally, erosion can occur from downstream processes. For example, the main creek channel may have incised - its bed has dropped in elevation - this drop will move up into the ephemeral tributaries over time. This process will cause erosion and damage in the small channels and ephemeral streams. Look at the main channel nearest to the site. If it is alluvial (made up of sand, cobble and gravel) does it have steep high banks? Is it significantly deeper (10-15 ft) than the lands next to it? Perennial creeks also incise below on-channel reservoirs, or as a result of channel straightening or narrowing, and vegetation removal. The FFF program staff will assist with this evaluation.

The density and extent of vegetative cover in each channel should be recorded in the Farm Conservation Plan as well as erosion and other conditions.

Springs may not be obvious from an aerial photo, or map. They are often identified by the presence of water loving plants, such as willows or sedges in isolated clumps or hollows on the hillside amongst otherwise dry vegetation. In a dry year, the vegetation may be the only indication of the spring. Springs saturate soils, and if disturbed, can cause slips and slope failures.

SITE INVENTORY: NATURAL DRAINAGE FEATURES

- ❑ Indicate the blue line and dashed blue line streams on the topo map and the aerial. Give each creek a number, or a name. Take photographs of each seasonal and perennial creek.

- ❑ Indicate the ephemeral streams on the site map. Give each a number or name on the map. Take photos of each stream.

- ❑ Indicate any springs on the map/aerial photo.

- ❑ Fill out the Farm Conservation Plan on the condition of each perennial, seasonal, and ephemeral creek on the site. Indicate vegetation type and density, level of bank stabilization (riprap), level of erosion, and other features.

- ❑ List observations about site drainage from upstream conditions, downstream conditions, and other features.

7. VEGETATION / HABITAT / SPECIAL STATUS SPECIES

<u>Background: Vegetation / Habitat / Special Status Species</u>

The type, density and condition of the vegetation on the property, in combination with management practices, determine the wildlife species that may use the site and the overall habitat value of the property. The presence of a certain vegetation type does not necessarily indicate its value as wildlife habitat. The level of site disturbance, size of vegetation areas, surrounding land uses, the connection, or lack of connection, between patches of vegetation, the availability of certain food plants, nesting, roosting and burrowing areas as well as other features determine the number and diversity of wildlife in an area.

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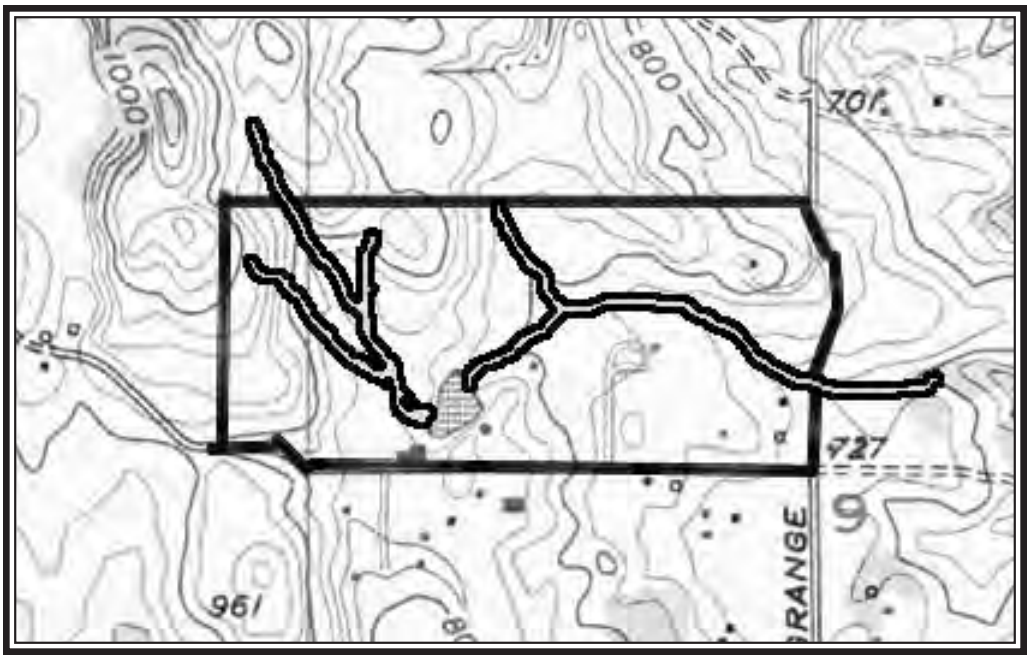

EXAMPLE OF TOPOGRAPHIC MAP AND
AERIAL PHOTO WITH STREAMS DELINEATED

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: STREAM DELINEATION

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This preliminary evaluation allows for delineation of various vegetation types. Some vegetation types such as vernal pools, wetlands, and heritage oak trees are considered rare and more sensitive to change. Additionally, vegetation of certain types such as coniferous forest that is relatively undisturbed may be considered sensitive habitat. Finally, vegetation types, in addition to other site factors, give an indication of the potential for listed, threatened, or endangered, plant or animal species.

There will be areas of the site where vegetation should not be removed and others where revegetation or other actions can compensate for vegetation changes. For removal of some plants – vernal pools, wetlands, riparian corridors, oaks and large areas of coniferous forest, special permits and mitigations are required. This preliminary delineation will assist in determining site design.

SITE INVENTORY: VEGETATION / HABITAT / SPECIAL STATUS SPECIES

- ❑ Outline the different vegetation areas on the site aerial. The CalVeg GIS layer may be useful to review but will likely not be detailed enough for site evaluations. Vegetation types are broad groupings of plants such as:
  - Coniferous forest – Douglas fir, redwoods, pine
  - Woodland forest/mixed shrub – oak, madrone, bay laurel intermixed with chaparral and other shrub species
  - Chaparral – manzanita, chemise, buckbrush and other species
  - Grassland including grazed pasture
  - Oak/grassland – grassland with scattered oaks
  - Wetlands including springs, natural seasonal pools, marshes
  - Riparian or streamside corridors – willows, cottonwoods and other deciduous species
  - Ephemeral creeks/swale corridors – riparian trees, oak woodland or chaparral lining swales and ephemeral creek corridors
  - ▪ For oaks and coniferous forest measure the trees using a dbh tape which converts circumference to diameter. The FFF program staff will assist with this task. Record these measurements in your Farm Conservation Plan.
  - ▪ Check the California Natural Diversity Database at www.dfg.ca.gov/whdab/html/cnddb.html for a map of the area with recorded occurrences of listed species, candidate species, certain plant communities, and species of concern on the property or in the vicinity. This information is recorded on a 1:24,000 mapping base, the same as a topo map. Tables II D and E list the special status species in Sonoma and Mendocino Counties. A survey for rare species may be needed, depending on the site.

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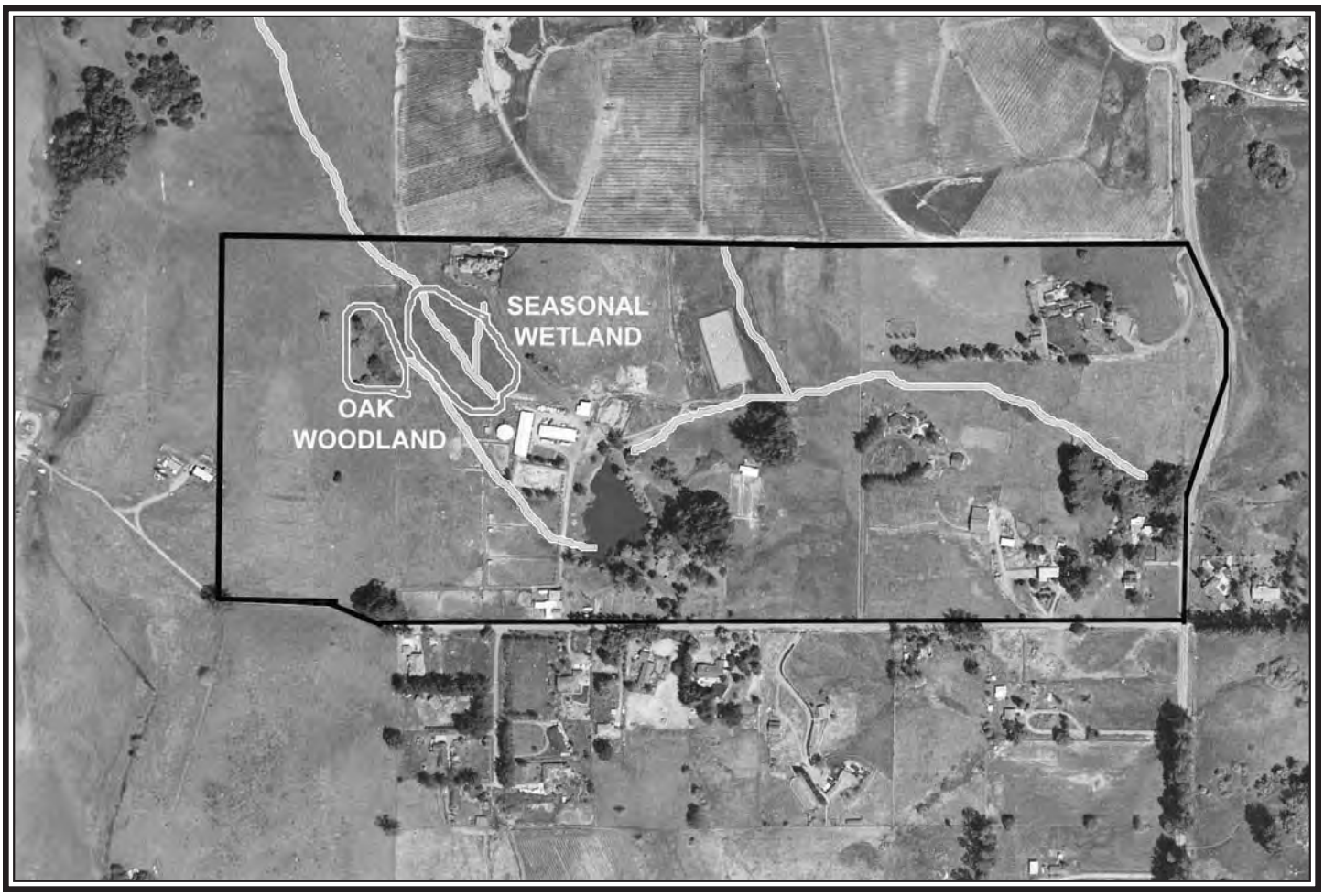

EXAMPLE OF AERIAL MAP WITH VEGETATION DELINEATED

Fish Friendly Farming Environmental Certification Program	HYPOTHETICAL NEW VINEYARD PROJECT AND PRELIMINARY SITE EVALUATION FOR FARM PLAN: VEGETATION DELINEATED

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TABLE IID California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Sonoma County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Agrostis blasdalei	Blasdale's bent grass	Species of Concern	None	--	1B
Allium peninsulare var franciscanum	Franciscan onion	Species of Concern	None	--	1B
Allopecurus aequalis var sonomensis	Sonoma alopecurus	Endangered	None	--	1B
Amorpha californica var napensis	Napa false indigo	Species of Concern	None	--	1B
Arbronia umbellate ssp breviflora	Pink sand-verbena	Species of Concern	None	--	1B
Arctostaphylos bakeri ssp bakeri	Baker's manzanita	Species of Concern	Rare	--	1B
Arctostaphylos manzanita ssp elegans	Konocti manzanita	None	None	--	1B
Arctostaphylos bakeri ssp sublaevis	The cedars manzanita	Species of Concern	Rare	--	1B
Arctostaphylos canescens ssp sonomensis	Sonoma manzanita	Species of Concern	None	--	1B
Arctostaphylos densiflora	Vine hill manzanita	Species of Concern	None	--	1B
Arctostaphylos stanfordiana ssp decumbens	Rincon manzanita	Species of Concern	None	--	1B
Astragalus clarianus	Clara hunt's milk-vetch	Endangered	Threatened	--	1B
Astragalus tener var tener	Alkali milk-vetch	None	None	--	1B

* Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

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TABLE IID (cont.)
California Department of Fish and Game
Natural Diversity Database
Special Status Plants, Animals and Natural Communities of Sonoma County

Scientific Name	Common Name	STATUS			
		Federal	California	CDFG	CNPS
Mammals					
Sorex ornatus sinuosus	Suisun shrew	Species of Concern	None	Species of Concern	--
Natural Communities					
Coastal and valley freshwater marsh	N/A	None	None	--	--
Coastal brackish marsh	N/A	None	None	--	--
Northern coastal salt marsh	N/A	None	None	--	--
Northern hardpan vernal pool	N/A	None	None	--	--
Northern vernal pool	N/A	None	None	--	--

* Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

TABLE IIE
California Department of Fish and Game
Natural Diversity Database
Special Status Plants, Animals and Natural Communities of Mendocino County

Scientific Name	Common Name	STATUS*			
		Federal	California	CDFG	CNPS
Plants					
Abronia umbellate ssp breviflora	Pink sand verbena	Species of Concern	None	--	1B
Agrostis blasdalei	Blasdale's bent grass	Species of Concern	None	--	1B
Alisma gramineum	Narrow-leaved water-plantain	None	None	--	2
Arabis macdonaldiana	McDonald's rock cress	Endangered	Endangered	--	1B
Arctostaphylos canescens ssp sonomensis	Sonoma manzanita	Species of Concern	None	--	1B
Arctostaphylos mendocinoensis	Pygmy manzanita	None	None	--	1B

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Arctostaphylos stanfordiana ssp raichei	Raiche's manzanita	Species of Concern	None	--	1B
Astragalus agnicidus	Humbolt milk-vetch	Species of Concern	Endangered	--	1B
Blennosperma nanum var robustum	Point reyes blennosperma	Endangered	Endangered	--	1B
Boschniakia hookeri	Small groundcone	None	None	--	2
Calamagrostis crassiglumis	Thurber's reed grass	Species of Concern	None	--	2
Calystegia atriplicifolia ssp buttensis	Butte county morning-glory	Species of Concern	None	--	1B
Campanula californica	Swamp marebell	Species of Concern	None	--	1B
Carex californica	California sedge	None	None	--	2
Carex livida	Livid sedge	Species of Concern	None	--	1A
Carex lyngbyei	Lyngbye's sedge	None	None	--	2
Carex saliniformis	Deceiving sedge	Species of Concern	None	--	1B
Carex viridula var viridula	Green sedge	None	None	--	2
Castilleja affinis ssp litoralis	Oregon coast Indian paintbrush	None	None	--	2
Castilleja mendocinensis	Mendocino coast indian paintbrush	Species of Concern	None	--	1B
Ceanothus confusus	Rincon ridge ceanothus	Species of Concern	None	--	1B
Chorizanthe howellii	Howell's spineflower	Endangered	Threatened	--	1B
Collinsia corymbosa	Round-headed Chinese houses	Species of Concern	None	--	1B
Cryptantha clevelandii var dissita	Serpentine cryptantha	None	None	--	1B
Cupressus goveniana ssp pigmaea	Pygmy cypress	Species of Concern	None	--	1B
Epilobium nivium	Snow mountain willowherb	Species of Concern	None	--	1B

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS***			
		Federal	**California**	**CDFG**	**CNPS**
Epilobium oreganum	Oregon fireweed	Species of Concern	None	--	1B
Erigeron supplex	Supple daisy	Species of Concern	None	--	1B
Eriogonum kelloggii	Kellogg's buckwheat	Candidate	Endangered	--	1B
Eryngium constancei	Loch lomond button-celery	Endangered	Endangered	--	1B
Erysimum menziesii ssp mensiesii	Menzie's wallflower	Endangered	Endangered	--	1B
Erythronium revolutum	Coast fawn lily	None	None	--	2
Gentiana setigera	Mendocino gentian	Species of Concern	Threatened	--	1B
Glyceria grandis	American manna grass	None	None	--	2
Hesperolinon adenophyllum	Glandular western flax	Species of Concern	None	--	1B
Horkelia bolanderi	Bolander's horkelia	Species of Concern	None	--	1B
Horkelia marinensis	Point reyes horkelia	Species of Concern	None	--	1B
Horkelia tenuiloba	Thin-lobed horkelia	Species of Concern	None	--	1B
Howellia aquatilis	Water howellia	Threatened	None	--	2
Lasthenia burkei	Burke's goldfields	Endangered	Endangered	--	1B
Lasthenia conjugens	Contra Costa goldfields	Endangered	None	--	1B
Lewisia stebbinsii	Stebbins's lewisia	Species of Concern	None	--	1B
Lilium martimum	Coast lily	Species of Concern	None	--	1B
Limnanthes bakeri	Baker's meadowfoam	Endangered	Endangered	--	1B
Lupinus antoninus	Anthony peak lupine	Species of Concern	None	--	1B

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Plants					
Lupinus milo-bakeri	Milo baker's lupine	Species of Concern	Threatened	--	1B
Malacothamnus mendocinensis	Mendocino bush mallow	Species of Concern	None	--	1A
Microseris borealis	Northern microseris	None	None	--	2
Mitella caulescens	Leafy-stemmed mitrewort	None	None	--	2
Monardella villosa ssp globosa	Robust monardella	Species of Concern	None	--	1B
Navarretia leucocephala ssp bakeri	Baker's navarretia	None	None	--	1B
Ophioglossum pusillum	Northern adder's-tongue	Species of Concern	None	--	2
Phacelia insularis var continentis	North coast phacelia	Species of Concern	None	--	1B
Pinus contorta sspbolanderi	Bolander's beach pine	Species of Concern	None	--	1B
Plagiobothrys lithocaryus	Mayacamas popcorn-flower	Species of Concern	None	--	1A
Pleuropogon hooverianus	North coast semaphore grass	Species of Concern	Threatened	--	1B
Puccinellia pumila	Dwarf alkali grass	None	None	--	2
Sanguisorba officinalis	Great burnet	None	None	--	2
Sedum eastwoodiae	Read mountain stonecrop	Candidate	None	--	1B
Sidalcea calycosa ssp rhizomata	Point reyes checkerbloom	Species of Concern	None	--	1B
Sidalcea malachroides	Maple-leaved checkerbloom	Species of Concern	None	--	1B
Sidalcea oregana ssp hydrophila	Marsh checkerbloom	None	None	--	1B
Tracyina rostrata	Beaked tracyina	Species of Concern	None	--	1B
Viola palustris	Marsh violet	None	None	--	2

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Butterflies					
Lycaeides argyrognomon lotis	Lotis blue butterfly	Endangered	None	--	--
Speyeria zerene behrensii	Behren's silverspot butterfly	Endangered	None	--	--
Amphibians					
Ascaphus truei	Tailed frog	Species of Concern	None	Species of Concern	--
Plethodon elongates	Del Norte salamander	Species of Concern	None	Species of Concern	--
Rana aurora draytonii	California red-legged frog	Threatened	None	Species of Concern	--
Rana boylii	Foothill yellow-legged frog	Species of Concern	None	Species of Concern	--
Rhyacotriton variegates	Southern torrent salamander	Species of Concern	None	Species of Concern	--
Fish					
Eucyclogobius newberryi	Tidewater goby	Endangered	None	Species of Concern	--
Hysterocarpus traski pomo	Russian River tule perch	Species of Concern	None	Species of Concern	--
Lavinia symmetricus navarroensis	Navarro roach	None	None	Species of Concern	--
Lavinia symmetricus parvipinnis	Gualala roach	Species of Concern	None	Species of Concern	--
Oncorhyncus kisutch	Coho salmon	Threatened	Endangered	--	--
Oncorhyncus mykiss	Steelhead trout	Threatened	Threatened	--	--
Oncorhyncus tshawytscha	Chinook salmon	--	--	--	--

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Reptiles					
Clemmys marmorata marmorata	Northwestern pond turtle	Species of Concern	None	Species of Concern	--
Birds					
Accipiter gentiles	Northern goshawk	Species of Concern	None	Species of Concern	--
Agelaius tricolor	Tricolored blackbird	Species of Concern	None	Species of Concern	--
Amphispiza belli belli	Bell's sage sparrow	Species of Concern	None	Species of Concern	--
Charadrius alexandrinus nivosus	Western snowy plover	Threatened	None	Species of Concern	--
Dendroica petechia brewsteri	Yellow warbler	None	None	Species of Concern	--
Fratercula cirrhata	Tufted puffin	None	None	Species of Concern	--
Haliaeetus leucocephalus (nesting & wintering)	Bald eagle	Threatened	Endangered	--	--
Icteria virens	Yellow-breasted sparrow	Species of Concern	None	Species of Concern	--
Pandion haliaetus	Osprey	None	None	Species of Concern	--
Phalacrocorax auritus	Double-crested cormorant	None	None	Species of Concern	--
Progne subis (nesting)	Purple martin	None	None	Species of Concern	--
Strix occidentalis caurina	Northern spotted owl	Threatened	None	Species of Concern	--
Mammals					
Aplodontia rufa nigra	Point Arena mountain beaver	Endangered	None	Species of Concern	--
Arborimus pomo	Red tree vole	Species of Concern	None	Species of Concern	--

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TABLE IIE (cont.) California Department of Fish and Game Natural Diversity Database Special Status Plants, Animals and Natural Communities of Mendocino County					
Scientific Name	**Common Name**	**STATUS**			
		Federal	**California**	**CDFG**	**CNPS**
Mammals					
Corynorhinus townsendii pallescens	Pale big-eared bat	Species of Concern	None	Species of Concern	--
Corynorhinus townsendii townsendii	Townsend's western big-eared bat	Species of Concern	None	Species of Concern	--
Martes pennanti pacifica	Pacific fisher	Species of Concern	None	Species of Concern	--
Gulo gulo luteus	California wolverine	Species of Concern	Threatened	--	--
Natural Communities					
Coastal and valley freshwater marsh	N/A	None	None	--	--
Coastal brackish marsh	N/A	None	None	--	--
Coastal terrace prairie	N/A	None	None	--	--
Fen	N/A	None	None	--	--
Grand fir forest	N/A	None	None	--	--
Northern coastal bluff scrub	N/A	None	None	--	--
Northern coastal salt marsh	N/A	None	None	--	--
Sphagnum bog	N/A	None	None	--	--
Upland Douglas fir forest	N/A	None	None	--	--
Valley oak woodland	N/A	None	None	--	--

*Federal and California indicates listing status under the state and federal Endangered Species Act; CDFG is California Department of Fish and Game species of concern designation; CNPS is the California Native Plant Society list of rare plants.

- ❑ Indicate in the Farm Conservation Plan the past use of the property including grazing history, logging, mining, residential and agricultural uses. Estimate when these uses occurred, for how long and at what intensity. For example, if the site has been clear-cut and then heavily grazed up to three years ago, include this information. Prior and recent land uses contribute to the current distribution of vegetation. Changing land uses can result in regeneration of native plants and identification of site areas for revegetation.

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8. CULTURAL AND HISTORICAL SITES

Background: Cultural and Historic Sites

There are a number of steps to document cultural and historical sites including a literature review for previously recorded sites, a field inventory and, if archaeological resources or historic sites are found, an impact mitigation plan must be prepared. Additional information on cultural and historical sites and procedures is available at: www.ohp.parks.ca.gov and http://ceres.ca.gov.

SITE INVENTORY: CULTURAL AND HISTORIC SITES

- ❑ A licensed archaeologist must complete the survey. The survey should focus on those areas of the site where disturbance is likely.

9. OTHER SITE FEATURES

There may be other features of the site that need to be evaluated both for site development. These might include:

- ❑ Locations of buildings, on-site landfills and any areas of the site where hazardous material could occur, such as pesticides or leaking diesel or gasoline tanks.
- ❑ Existing reservoirs and wells, groundwater and surface water resources
- ❑ Utility corridors
- ❑ Access routes to public roads
- ❑ Mines and quarries
- ❑ Recreational sites

10. USING THE PRELIMINARY EVALUATION: DETERMINING THE PROPOSED NEW VINEYARD AREAS

Slopes

- ❑ Using the slope measurements, delineate the areas of the site of less than 30% slope. Within these general areas there may be areas of less than one acre with higher slopes.

Creek Channels

- ❑ Once the slope areas available for vineyard development are delineated the natural drainage features need to be factored in. Changes to the drainage network as part of the vineyard development should be minimized.

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Element VI contains the detailed evaluation procedure and science-based protocols for restoration plans on perennial and seasonal creeks. This element includes the Russian, Gualala and Navarro River watersheds and ecological "sizing" requirements for stream corridors as well as vegetative restoration methods. New vineyards adjacent to perennial and seasonal creeks should complete this element and there may be a reduction in the potential vineyard footprint based on this analysis.

For ephemeral creeks the setback should extend from the topographic edge or vegetative edge of the hillside swale containing the creek or the edge of the creek channel or vegetative corridor. The FFF program staff can assist with these determinations on the site.

- ❑ The potential stream setbacks should be outlined on the potential vineyard areas to determine the most likely footprint.

Vegetation

- ❑ Some vegetation removal is required for most projects. Clearance of coniferous forest can require permits from the California Department of Forestry. Filling of wetlands, disturbance of listed species, or their habitats, will require mitigation. Review the locations of any of these features within the proposed vineyard areas and consider methods to avoid these features. If avoidance renders the project unworkable delineate on-site areas for mitigation of wetland, or listed species. A CEQA document will likely be needed for projects with major tree removal, effects to wetlands or listed species habitat. Additionally, major conversions of timber to vineyard will need to meet the BMP limiting increases in peak flow discharge (page 52).

- ❑ If there are large oaks scattered over the potential vineyard areas, retention should be considered. The oak should have a 15-foot buffer, left undeveloped, measured from the canopy drip line. If the oaks make portions of the project unworkable, compromise by removing some of the oaks and choosing an area on-site for a replanting area. A single oak surrounded by vineyard has a lower value to wildlife than contiguous oaks making up oak woodland habitat on another part of the property.

- ❑ Other types of vegetation such as grassland, chaparral shrub, and oak woodland shrub are not necessarily rare and depending upon the condition of the property, may be degraded from years of grazing. Clearing of this vegetation within the proposed vineyard areas coupled with replanting and enhancement of other areas outside the footprint can result in an overall increase in wildlife values and little to no contribution to cumulative effects in the watershed.

Cultural Resources

- ❑ The recommendations of the archaeological survey if applicable to the proposed vineyard areas should be incorporated.

Erosion Sites

- ❑ Existing erosion sites, if part of the proposed vineyard areas, should be repaired (see page 64) as part of the vineyard development or if outside the vineyard area included in the Farm Conservation Plan for repair.

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Summary

- ❑ Using the site inventory and preliminary evaluations, the vineyard areas can be determined. Complete the summary table in the Farm Conservation Plan.

  The proposed vineyard areas defined through this process should have a minimal level of environmental impact. The summary table of potential impacts and mitigation needs provides an outline of measures to reduce environmental impacts. Now the vineyards can be designed to allow for a minimum of effects and other areas of the site can be reviewed for repair and restoration actions.

11. DESIGNING FOR SOIL CONSERVATION AND EROSION CONTROL

Background: Types of Erosion and Vineyard Layout

Soil erosion is caused by the ability of raindrops, flowing water and wind to move soil particles. Although erosion is natural, human uses of land often increase the rate of soil erosion and increase the amount of sediment moving into creek and river channels.

There are several types of erosion. Sheet erosion involves the loss of a thin layer of topsoil across the overall hillslope and is also called sheetwash. This type of erosion is often not noticeable, but is the largest cause of soil loss. Rain striking bare unvegetated land causes the surface inch of soil to become mobile and particle by particle the soil flows off the land. This type of soil erosion is typical with farmland if careful soil conservation is not practiced and soil productivity will be lost over time. Slope plays a major factor in sheet erosion, particularly the length of the slope. Vegetation has a major effect in reducing sheet erosion.

Rill and gully erosion is easier to observe and represents the loss of soil in one location, not layer by layer as in sheet erosion. Rills and gullies usually occur due to concentration of water flow. Flows become concentrated through changes made to drainage patterns on a hillside such as roads, soil compaction, and vegetation removal. This type of erosion is prevalent when swales and ephemeral streams are cleared and are then subject to concentrated flows as a part of the natural drainage system but without protective vegetation. Gullies are expensive to repair and can be difficult to control once started. Careful consideration before vegetation clearing, or road construction, is the best way to avoid creating these problems. Rapid response to gully formation can repair small problems before they get huge.

Erosion is measured in the loss of tons of soil per year. One ton of soil loss per acre is a thickness of 2 to 3 sheets of paper. Sheet and rill erosion rates reach 8 to 15 tons or more of soil loss per acre per year.

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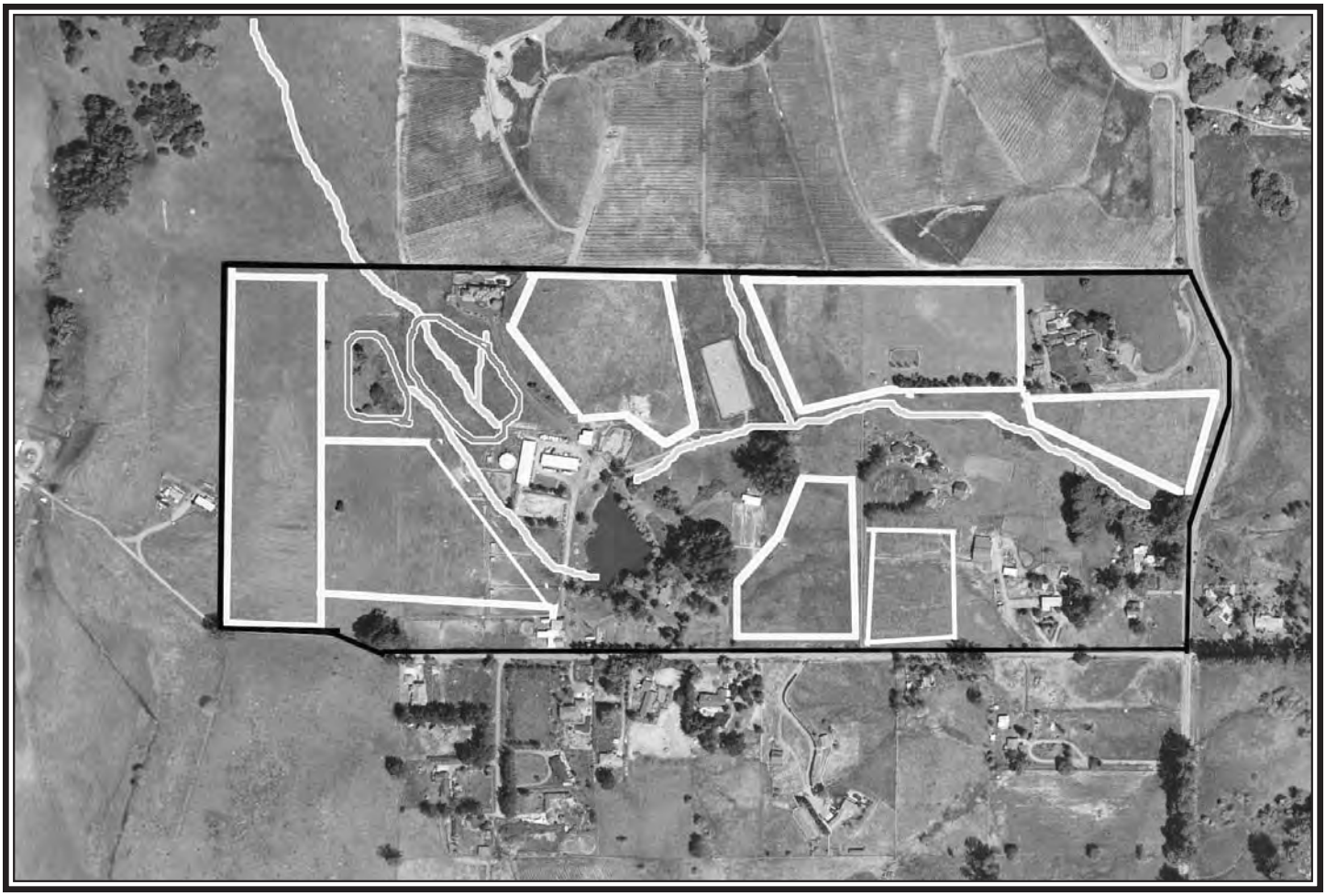

EXAMPLE OF AERIAL MAP WITH POTENTIAL VINEYARD AREAS DELINEATED IN WHITE BOXES

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Slope has an enormous effect on soil erosion, drainage, and land use. Slope magnifies the effects of rainwater runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage.

The vineyard site design should address grape production as well as soil conservation to keep the vineyard productive over the long term. The design should incorporate soil conservation measures including: retention of natural drainage features including ephemeral streams/swales, all year round and seasonal streams; evaluation of the site in small enough drainage units to design a drainage system with a large number of inlets and outlets to avoid concentration of flow and erosion; and avoiding increases in stormwater volumes. Use of mulch, cover crops and other practices to protect soil. Soil protection should be a focus and a goal at all times in the development phase of the vineyard and into the management of the vineyard floor, all roads and avenues.

The Sonoma County Hillside Vineyard Ordinance defines two types of sites that require a permit:

"Level I authorized vineyard planting… has either highly erodible soils and an average acreage slope of less than ten percent (10%), or less erodible soils with an average slope of less than fifteen percent (15%)." Development of Level I new vineyards requires the filing of a notice with the Agricultural Commissioner's office.

"Level II authorized vineyard planting means any vineyard planting… which has either highly erodible soils and an average slope of ten percent (10%) to not more than fifteen percent (15%), or less erodible soils with an average slope of less than thirty percent (30%)."

"Level III authorized vineyard planting means any vineyard planting… which has either highly erodible soils and an average slope of more than fifteen percent (15%) to not more than fifty percent (50%), or less erodible soils and an average slope of more than thirty percent (30%) to not more than fifty percent (50%)."

The ordinance limits vineyard development on slopes of more than 50% to no more than 7.5% of the total vineyard site.

For development of Level II and III vineyards an erosion and sediment control plan must be prepared by a civil engineer approved by the County and the plan must be approved by the Agricultural Commissioner.

The Sonoma County Ordinance requires a level of site review and engineering to reduce soil erosion. The ordinance allows for development of slopes in excess of 30% and for an analytical process of "averaging" the measurement of slopes. Neither of these practices is used in the Fish Friendly Farming program. New vineyards are not recommended on slopes in excess of 30% with slopes measured in actual, not average, slope in order to achieve a high level of protection for water quality and habitats.

Mendocino County currently (Jan 2007) does not have a vineyard or hillside ordinance.

Vineyard Layout

There are several types of vineyard layout – cross slope, on the contour and up and over the hill. The decision of which layout is best for a site is primarily a function of the percent

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slope, the slope length, aspect and the soil type. The vineyard rows must be laid out to be safely accessible to farm equipment working on a sloped hillside. Most tractors cannot operate on slopes over 25% without the danger of rollovers. Therefore the site must be terraced to create a flat and safe surface for the tractor to operate, or the vineyard is laid out up and down the contour if this layout provides for safer operations. In addition, the tractor must also be able to turnaround at the end of each vineyard road without incurring a safety problem, or slipping down the hillside.

Another effect of steep slopes is the reduction in the number of vines that can be planted. Terracing steeper slopes requires more land for the terrace benches and will accommodate fewer vines per acre. Up and over the hill layout may allow for a greater number of vines on a moderate slope than terracing the same site.

With any vineyard layout for a site, the drainage system must include an evaluation of slope length and include adequate numbers of inlets and stormwater diversions to avoid concentration of flow and erosion of the slope. In terraces the bench can be cut to accommodate interception of flow into inlets and underground pipes at frequent intervals.

For up and over the hill layout, frequent diversions or inlets across the vineyard slope may be used to break up flow that will move down the vine rows and middles causing rill or gully erosion. In all cases cover crops over the entire vineyard floor (including all portions of the terrace – both bench flat and face) are needed. Even if the vine row is stripped sprayed or cleared, some mulch should be left particularly for up and over the hill layout. Otherwise the vine row can become an avenue of flow and erode soil from around the vines.

APPLYING SITE DESIGN BMPS: SOIL CONSERVATION AND EROSION CONTROL

- The Sonoma County Hillside Vineyard Ordinance requires an Erosion and Sediment Control Plan for many new vineyards. The ordinance requires that a civil engineer, approved by the County, prepare the erosion control plan and that the erosion control plan should include:
    - Narrative and graphic information describing the project
    - The name of the preparer or civil engineer
    - A description of the site including topography, soil types, vegetation, streams, lakes, reservoirs, roads, homes and existing drainage improvements. Identification of areas on the vineyard site that may have significantly more or less potential for erosion.
    - A summary of temporary and permanent measures to protect disturbed areas and manage storm water runoff on the vineyard site and minimize the discharge of sediment from the vineyard site. A schedule for implementation, maintenance and upkeep of the temporary and permanent measures and provisions for responsibility of maintenance

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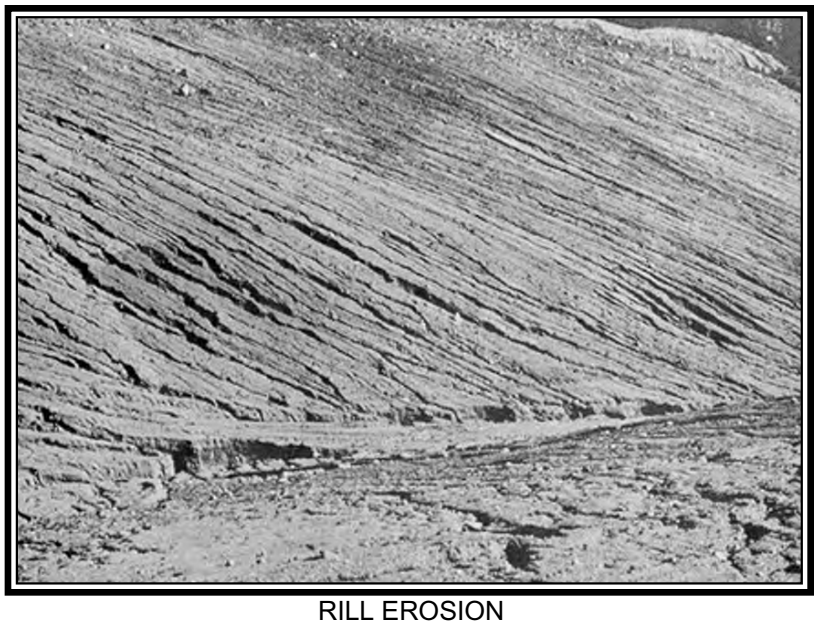
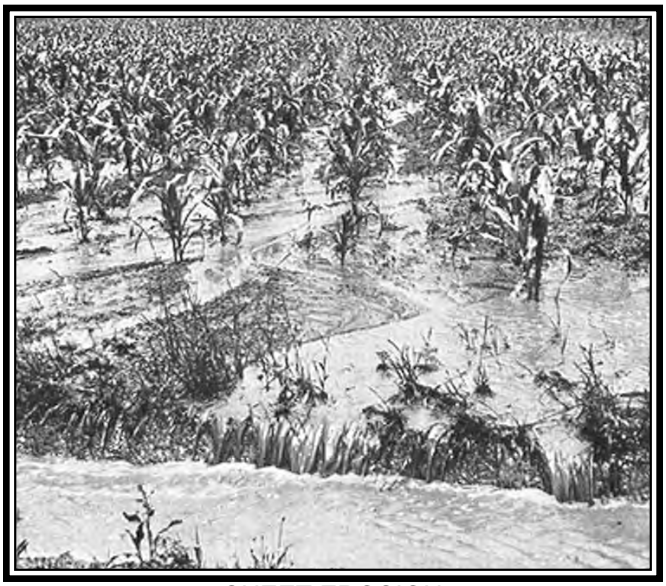
RAINSTRIKE OR SHEET EROSION



RILL EROSION

GULLY EROSION



SHEET EROSION

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LEANING TREES CAN BE AN INDICATION OF A MOVING AND UNSTABLE SLOPE

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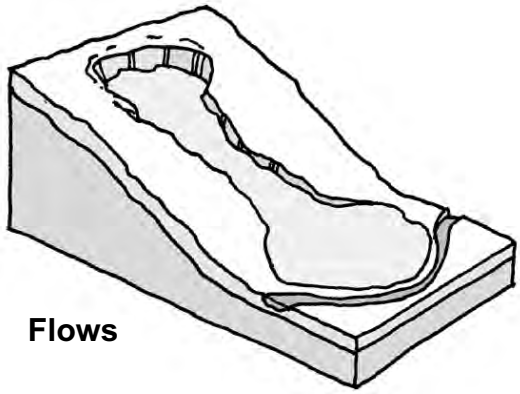
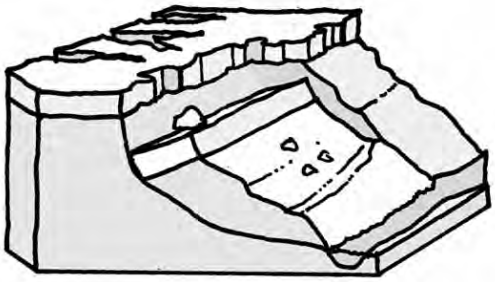
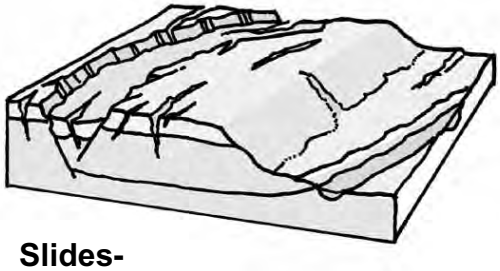


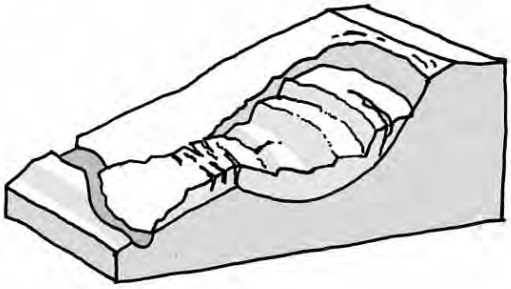
Flows



Slides-Rotational



Slides-Translational



Complex-Slump-Earth Flow

Fish Friendly Farming Environmental Certification Program	TYPES OF LANDSLIDES

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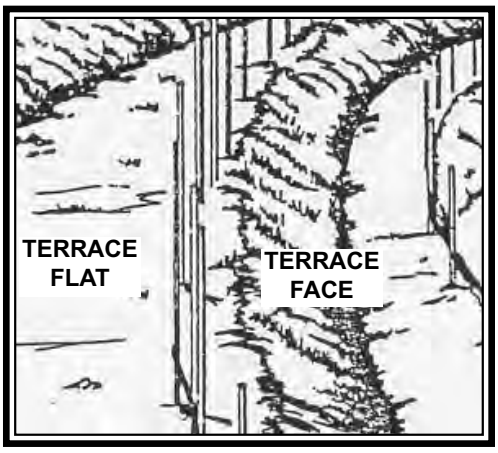
CROSS SLOPE OR WITH THE CONTOUR LAYOUT

UP AND OVER THE HILL LAYOUT



TERRACE OR BENCH LAYOUT

Fish Friendly Farming Environmental Certification Program	VINEYARD LAYOUT

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- ❑ A location map of the vineyard site

- ❑ A topographic map of the site at a scale of 1''=200' showing all the details of the project including vineyard layout and boundaries, existing and finished contours, soil types, stormwater flow lines, creeks and setbacks, vegetation, buildings, wells and utilities, proposed soil protection measures, proposed stormwater management and sediment control measures and calculations for each measure, construction details, drainage area of the stormwater management system

The Fish Friendly Farming Program recommends that an Erosion Control Plan be completed for all new vineyards or areas of vineyards over 5% slope and that in addition to the above features the Erosion Control Plan include:

- ❑ An analysis of sheet erosion from the proposed vineyard using the Universal Soil Loss Equation (USLE) included in Appendix 1 should be completed if not done as part of the Erosion Control Plan. The USLE evaluates the potential for sheet erosion of a particular site with a set of proposed practices. The USLE predicts soil loss over a relatively small area such as a vineyard site by evaluation of rainfall conditions (R), the susceptibility of soil to erosion (K), the length and steepness of slope (LS), the erodibility of soil under various cover cropping scenarios (C), and the effectiveness of the vineyard layout (contour, for example) on erosion control (P).

  The predicted sheet erosion or soil loss is then compared to the T value or soil loss tolerance for specific soil types. Acceptable T values are relatively low at 2 to 4 tons per acre per year. Erosion Control Plans are reviewed to assure they include a variety of practices such as row alignment, drainage improvements, cover crops and tillage, sediment basins and grassed waterways to attain the acceptable soil loss tolerance for sheet erosion.

  The Erosion Control Plan should also review the potential for concentrated flows and rill and gully erosion that is discussed in the following sections. The plan also includes temporary erosion control measures for assuring that any soil loss from the site is contained.

- ❑ If the site appears to have evidence of unstable slopes, a geologist should be hired to carefully evaluate the site before developing a vineyard. Unless the hillside can be completely stabilized, the vineyard could be lost. Smaller slips and erosion sites should be repaired as part of the site development.

- ❑ Attach the Erosion Control Plan to the Farm Plan and fill out the Farm Plan regarding the project features.

- ❑ Using the detailed slope measurements, evaluate revising the proposed vineyard footprint to avoid developing areas over 30% slope.

- ❑ All slopes over 5% require the vineyard be managed using soil conservation BMPs (see Element III).

- ❑ The layout of the vineyard in relationship to slopes should provide for tractor safety, grape production and maximum soil protection.

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- When considering the use of terraces and benches the need for soil conservation requires cover crop on the terrace flat and the berm, or face, of the terrace. Additionally the terrace flats can be easily damaged if tilled when soil is wet. These ruts can create changes in drainage and localized failures in the terrace.

- Filter strips are a strip of dense grass or vegetation between the vineyard slope and waterways. The vineyard design should incorporate filter strips or allow for perimeter vineyard roads to be managed every winter as filter strips.

12. DRAINAGE IMPROVEMENTS

Background: Drainage Improvements

Once the natural drainage pattern is delineated, the need for drainage improvements in the proposed new vineyard areas can be determined. It is important that stormwater be carefully managed to avoid creating concentrated flow that can cause both soil erosion and slope failures. In some hillside vineyards stormwater is routed through diversions and underground pipes. The concept in using diversions and underground systems is to reduce the potential for concentrated surface flows by reducing the distance (slope length) over which the water flows and diverting it into a drainage system. Reducing soil erosion is necessary to protect water quality, fish habitat and the viability of the vineyard.

Benched and terraced vineyards are designed to divert flow from the bench into a series of drop inlets and underground pipes. This system creates numerous points of diversion along the slope significantly reducing the concentration of flow on the slope. There are other types of drainage systems used in terraced vineyards as well. A diversion ditch at the top of a hillside vineyard may be used to limit the volume of water flowing through the site and move a portion of the stormwater into a creek or waterway. In general, the steeper and longer the slope of the vineyard, the greater the speed of the runoff produced and the more diversion points required.

The preferred system for hillside vineyards is to retain natural swales and ephemeral streams to the greatest degree possible. The swale is managed for dense vegetative cover such as native woodland, chaparral, or perennial grassland with some structural components, such as rock check dams, if needed for grade stabilization control. In the case of sites with heavily vegetated oak and woodland swales, dividing the site into distinct blocks of vineyard and retaining the swale with natural vegetation may be the best option. For sites with smaller ephemeral creeks in the proposed vineyard area, grassed waterways with a rock tractor crossing may be advisable. Rock or cement lining swales to increase flow into streams is generally not a good practice as erosion problems will be created downstream.

For some sites, re-contouring has reduced slopes to a gentler gradient and reduce overall soil erosion from concentrated flows. Re-contouring with installation of drainage systems and use of permanent cover crops can reduce soil erosion over the long term. However to achieve this change in the landscape involves a significant amount of initial land movement and disturbance.

While diverting and undergrounding water removes concentrated surface flow from eroding soil, it will increase flow volumes at the pipe outlet. The location of the drain, or diversion outlet, and its potential effect on the creek or waterway where it discharges should be evaluated. The energy and erosional force of the drain water will need to be mitigated with

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the placement of large rock, stilling basins or other structures to act as an energy dissipater. In some instances the installation of stormwater spreaders can dissipate concentrated flows. Stormwater spreaders are pipes with holes staked onto the contour and attached to the outlet of the vineyard drainage pipe. The spreader will not function correctly if water volumes are too great or if holes in the pipe are too small and clog.

Placing many smaller drainage outlets with energy dissipaters, rather than one large one, is another preferred option. If necessary, creating a stilling, or detention, basin to temporarily hold the stormwater before releasing it may reduce effects on a creek. Detention basins should be located off-channel and their use can alleviate the issue of a vineyard increasing the volume of floodwater downstream in smaller (2-, 5-, 10-year) frequency storm events.

The size and configuration of the vineyard drainage system is different for each individual site. There are varying concerns regarding the removal of vegetation and the potential for changes in the volume and timing of runoff from the site. Changes in runoff volume can affect the form and habitats in the creek downstream. This is a complex issue. The slope, vegetative cover types, rainfall volumes, and soil types on a site play major roles in the volume and timing of stormwater runoff from a hillside. Vineyards with dense cover crops do not differ greatly in their infiltration of stormwater from the same site covered in natural grassland. Heavily grazed or compacted lands may have less infiltration and more runoff than the vineyard. A forested site converted to a vineyard can have reduced infiltration and greater runoff.

However for any increase in runoff volume created by the vineyard to affect flood levels in the creek or river, the increase would have to represent a major portion of the total runoff volume in the creek. In general, it is more likely that vineyard development in a tributary watershed could affect the flow levels in the creek over time as many vineyards are put in and all of the conversion added together has an effect. To avoid this cumulative problem each vineyard should create no more than a 10-15% increase in the volume of peak stormwater discharges over the pre-project condition. As part of the FFF program, a Science Advisory Group was convened and discussed peak stormwater discharges. The group agreed that a figure of 10-15% increase could be used if particular models and methods were used in the evaluation. The science group also agreed that monitoring and adaptive management to revise the figure would be needed.

In general, drainage systems are installed to avoid soil erosion and thus reduce the amount of sedimentation in the creek and negative effects on fish habitat. However the system can be made more fish friendly by incorporating the following BMPs.

APPLYING SITE DESIGN BMPS: DRAINAGE IMPROVEMENTS

Consult with NRCS or a qualified engineer or professional to design a drainage system for the vineyard that includes the following:

- ❑ Remove from the vineyard footprint the areas of the site that are natural drainage channels - year round and seasonal creeks and their riparian corridor areas and all major ephemeral streams.

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- For those areas where improvements such as underground pipes or grass-lined waterways must be installed, be careful to address all the features of the drainage in the design for the new vineyard.

- Size and design vineyard drainage systems for the 50- to 100-year frequency, 24-hour duration rainfall event. Diversion ditches are typically designed for a smaller storm ,the 25-year frequency, 24-hour duration event.

- Use a long record of rainfall data and make sure it is close enough to the location of the site to be applicable. Review the information for the highest intensity rainfall event (the greatest amount of rainfall over the shortest period of time) and make sure that this amount does not differ a great deal from the 24-hour figure. This comparison is done to assure that the system will not fail in a very intense, but short, storm event as well as a longer duration rainfall event. This information is available from the National Weather Service at http://www.wrcc.dri.edu/pcpnfreq.html.

- Plans for the system should address whether the soil types on the site are subject to piping. Piping is the movement of water through porous soil types. The water increases erosion and blowouts of the drainage system. Some types of soils are more inclined to undergo piping than others.

- Plans should address inlet clogging with installation of screens, grates or other measures.

- Design the outlets of the system to result in no erosion in swales, streams or creeks. The drainage system should spread the flows out into as many outlet locations as practicable rather than concentrating all the drainage into a few pipes and outlets. Stormwater spreaders may be appropriate in some systems.

- The system should address more than just the drainage produced by the vineyard. The larger upslope areas and the storm flows produced that enter the site need to be included.

- Design the system to result in only very small increases in peak stormwater volumes. The drainage system should not increase peak stormwater discharge over pre-project conditions by more than 10-15% for the 2-, 5-, and 10-year events. If such increases are unavoidable, then detention or water spreader facilities should be included to mitigate the increase. Reducing the volumes and the potential for erosion of creeks is in the vineyard operators' favor. Remember that incision of the creek from increased flows can create failures in the banks of ephemeral streams and undercut and damage the vineyard. The stormwater discharge from the site for various sizes of storms (2-, 5-, 10-, 50-, 100-yr frequency 24-hour duration events) under its pre-project condition whether in agriculture, forest, grazing or other land uses and the post-project conditions needs to be evaluated. The TR-55 model used by the NRCS, or other hydrologic models such as the HEC-1 can be used by the professional designing the drainage system to demonstrate that changes in stormwater from the vineyard are within the 10-15% increase level. Attach the model results and assumptions to the Farm Conservation Plan.

- Winter cover crops are always needed in conjunction with drainage improvements to reduce surface flows and soil erosion.

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- ❑ Indicate the features of the drainage system on the Farm Conservation Plan.

- ❑ All designs and plans need adequate detail to install the drainage system and other features very precisely. These plans will serve to guide annual maintenance and management efforts for outlets, inlets, terraces and other features in Element III.

13. LAND TREATMENT

Background: Land Treatment

Soil testing is a part of evaluating a new vineyard site. The test will determine the soil pH, depth, texture, composition and need for certain amendments such as gypsum for high pH and magnesium for low pH. These amendments are mixed into the soil by disking or ripping the site. The soil is also evaluated for the need to change its structure and increase root penetration. Deep ripping consists of using heavy equipment to break up the deeper soil horizons that may have less porous soil to allow the vine roots to penetrate. Both disking and ripping of the site disturb the soil and can result in great amounts of erosion if not done properly. However, should this practice be used, all disking and ripping should be completed and a dense cover crop established prior to October 15. The cover crop should be irrigated if possible particularly in critical erosion areas and emergency erosion control and winter field inspection by the farmer should be planned out.

APPLYING SITE DESIGN BMPS: LAND TREATMENT

- ❑ Indicate the type of land treatment to be used for each vineyard area in the Farm Conservation Plan.

- ❑ Each area to be graded re-contoured or ripped should be sized so that all soil grading is completed, drainage, irrigation and other improvements are installed and cover crops are seeded and irrigated to produce a dense ground cover prior to October 15. This may require separating a large vineyard area into phases.

- ❑ The last pass, or set of passes, by the grading, ripping or tilling equipment must be a cross-sloped pass to avoid creating any rills up and down the hillside and increasing erosions.

- ❑ All emergency erosion control and a winter inspection program should be in place by October 15.

14. FIELD ROADS

This section addresses the locations of roads through and along the edges of the vineyard and those that connect blocks of vineyard as part of the site development footprint. The primary road system and the design and installation of all roads including these field roads is covered in detail in Element V.

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APPLYING SITE DESIGN BMPS: FIELD ROADS

- ❑ The site design should avoid locating field roads close to stream channels. Floodwaters may create a waterway out of the field road and severely erode it. The main roads should be located through the vineyard with turnarounds along the edge of the vineyard/creek corridor or swale. All turnarounds and field roads adjacent to creek corridors and swales should be winterized and managed as vegetated filter strips.

- ❑ Minimize the number of creek crossings. Construct those crossings necessary for the site at right angles to the creek channel. Construct them to create the least disturbance to the natural form of the channel. Plan to have one, or at most two, seasonal crossings or bridges for larger creeks. Seasonal at-grade crossings can be the least impacting if the banks of the channel allow this design, and the use of the crossing will not disturb in-stream uses of the creek by the fish. Culverted crossings, concrete fords and other types of crossings should be carefully evaluated.

- ❑ Indicate in the Farm Conservation Plan the features of the vineyard field roads.

15. VEGETATION REMOVAL

Background: Vegetation Removal

Potential vineyard sites will typically have vegetation covering the hillside. Removal of vegetation over large areas can increase soil erosion and change drainage patterns. However changing some types of vegetative cover, such as heavily grazed hillsides to vineyard with permanent cover crops can result in a net increase in vegetative cover and reduction in soil erosion. The preliminary evaluation and determination of the vineyard footprint takes vegetation removal into account.

APPLYING SITE DESIGN BMPS: VEGETATION REMOVAL

- ❑ Remove only the minimum of vegetation for the vineyard footprint. Do not overclear the area, as it will require replanting with other vegetation to stop soil erosion. Minimize the road width around the outside perimeter to allow for vegetation retention.

- ❑ Never clear creeks or drainageways of any type – year round, seasonal, or ephemeral, as this can cause severe erosion, sedimentation and directly impact fish habitat.

- ❑ As part of the preliminary evaluation heritage oaks, redwoods and other large native trees are considered for retention. If oaks are removed, replanting in other areas should be done at a ratio of 10:1 using locally derived stock of the same species. Summer irrigation at a three-week interval for the first 3 summers will assist the oaks to grow. Do not water frequently in the summer as oaks are prone to root rot. Swales or outer riparian corridors are often good areas of the site to replant oaks. Some vineyard sites may not be able to retain oaks and replanting should be done elsewhere. There are several theories regarding the spread of oak root fungus into vineyards and whether the removal of the trees helps or hinders the spread of the fungus.

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- ❑ If you have a vernal pool or wetland on your site you will need to apply for a permit to develop the area. Contact the Sonoma and Mendocino County Planning Department, NRCS, Regional Water Quality Control Board and California Department of Fish and Game for information on this permit process.

- ❑ If you plan to remove coniferous forest, you may need a permit. Check with the California Department of Forestry.

- ❑ Evaluate the vineyard design to retain the maximum amount of vegetation in swales/ephemeral streams. Swales hold ephemeral creeks that serve as stormwater channels in large storms and leaving the vegetation intact reduces erosion and drainage problems. It may be possible to break the site into several operational blocks with natural creeks in between. Tractor crossings of the swale or creek should be minimized on the site.

- ❑ Evaluate the vineyard site for the type of vegetation being removed and other areas of the property where vegetation could be planted or enhanced. Past land use may have resulted in a loss of native understory species, forest of dense, even aged stands with little biodiversity or loss of native plant cover in steep areas. Revegetation of areas outside the vineyard can create higher value habitat over the total property.

- ❑ Development of some sites to vineyard may also affect wildlife migration corridors. Deer, for example, move from the canyon bottom to the ridgetop and from the very upper areas of a watershed to its outlet. Evaluate how an animal can cross through the site with the vineyard and accommodate vegetated migration corridors in the design. Wide, well-vegetated creeks and unfenced corridors, or an adequate area of natural vegetation for the animals to easily go around the vineyard site may be incorporated. Appendix 3 includes some considerations for wildlife friendly fencing.

- ❑ Indicate the features of the project vegetation removal/retention and fencing in the Farm Conservation Plan.

16. EROSION SITES

Repair of existing erosion sites should be integrated into the vineyard development of the site. Element III contains an extensive discussion of erosion site repair methods.

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STEEP SLOPE OF ABOUT 50% CLEARED OF VEGETATION IS ERODING EVEN THOUGH PLANTED WITH COVER CROP. EPHEMERAL STREAM/SWALE WAS CLEARED AND IS NOW ERODING AND CREATING MAJOR GULLY.

THIS SITE WAS RIPPED BUT THE EQUIPMENT LEFT FURROWS GOING UP AND DOWN THE SLOPE RESULTING IN EROSION. THE FURROWS SHOULD HAVE BEEN ORIENTED CROSS SLOPE.

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VINEYARD ACCESS ROAD ALONG BOTH SIDES OF STREAM CAN EASILY ADD SEDIMENT TO STREAM AND BE ERODED BY FLOOD FLOWS. ACCESS ROAD SHOULD BE RELOCATED AWAY FROM CREEK EDGE.

RAILCAR BRIDGE IN BACKGROUND IS A GOOD MEASURE FOR STREAM CROSSINGS.

SOME COVER CROPS ARE LOW GROWING AND GOOD FOR ROAD WINTERIZATION.

VINEYARD ROAD LOCATED AWAY FROM WATERWAYS

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VIEW LOOKING DOWN STEEP HILLSIDE SWALE - REMOVAL OF VEGETATION CAN RESULT IN EROSION AND POTENTIAL SLOPE FAILURES.

Fish Friendly Farming
Environmental Certification Program

EPHEMERAL STREAMS WITH DENSE VEGETATION

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Fish Friendly Farming Environmental Certification Program	TWO VIEWS OF VINEYARDS WHERE THE EPHEMERAL SWALES ARE RETAINED IN NATURAL VEGETATION

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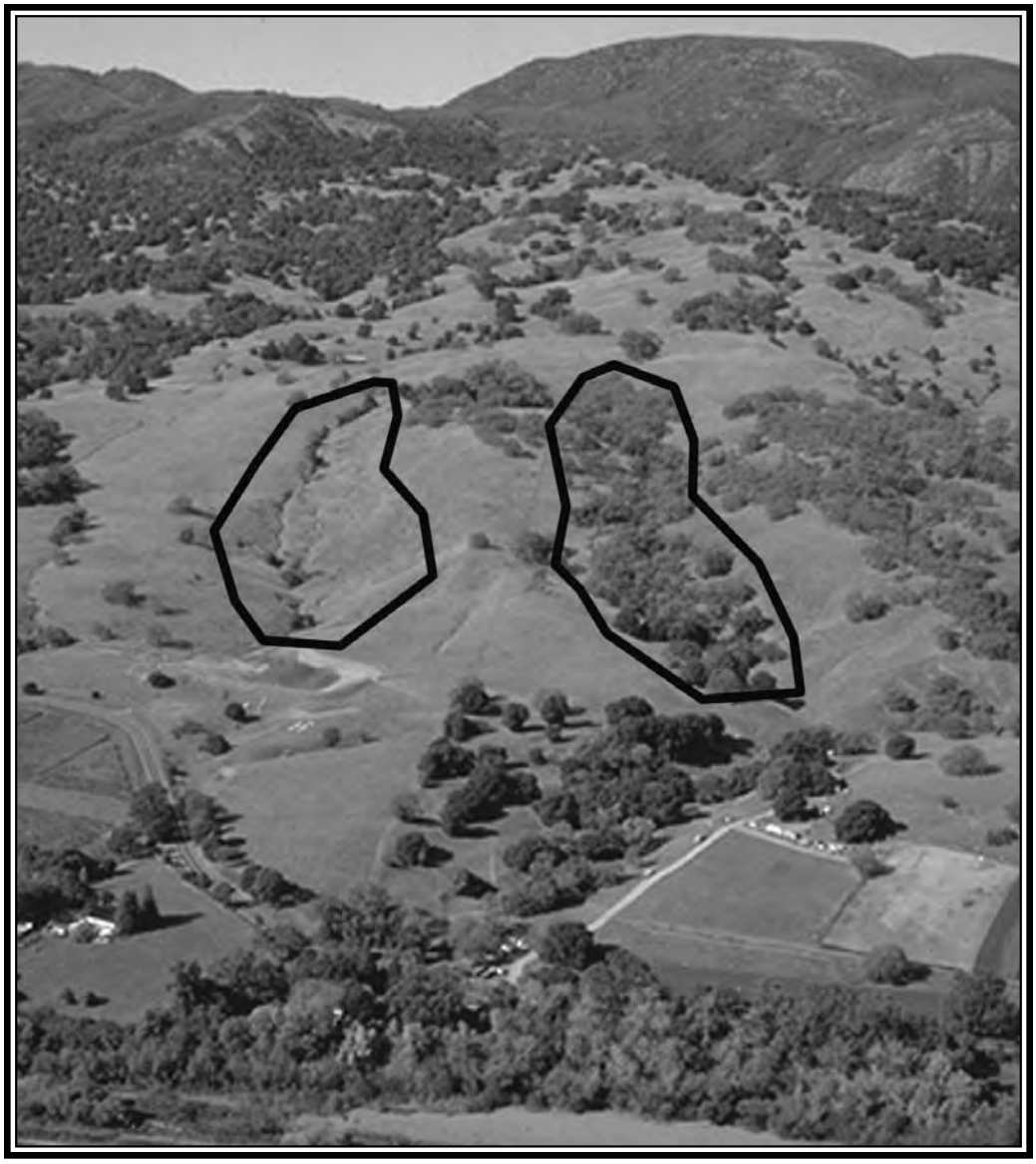

TWO EPHEMERAL STREAMS. LINES INDICATE THE APPROXIMATE OUTER EXTENT OF THE SWALES. GRASSY SWALE ON LEFT NEEDS EROSION CONTROL AND REVEGETATION. SWALE ON RIGHT IS WELL VEGETATED AND SHOULD REMAIN UNDISTURBED.

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THESE PHOTOS SHOW THE RETENTION OF OAK WOODLAND AND SWALES AND THE DEVELOPMENT OF GRASSLAND AS VINEYARD.

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APPLYING SITE DESIGN BMPS: EROSION SITES

- ❑ With assistance from NRCS, or a qualified engineer or soil scientist, evaluate potential solutions for existing erosion sites within the new vineyard footprint or other areas of the property. The evaluation should review drainage on the site, the erosion problem and its cause.

- ❑ The new vineyard development may be able to decrease soil erosion and peak discharge over the previous land condition as long as the cause of the problem is corrected. Otherwise the new vineyard may suffer similar damage.

- ❑ Particular attention should be paid to any terracing or benching of the site and the possibility of concentrated drainage and its effect on already unstable areas. Some soil types are more prone to gully erosion from concentrated drainage.

- ❑ If erosion sites are primarily streams and swales, be very careful to consider fish friendly restoration techniques. Lining streams with rock riprap damages creek habitats downstream due to the effect of rock riprap on increasing the velocity of stormflows. Vegetative solutions, or if the problem is severe, vegetative and structural components combined which will not increase peak flow volumes into downstream creeks are preferred.

- ❑ Once again consider the drainage patterns on the site when fixing erosion problems. Don't fix one problem only to create a bigger problem downstream. As a rule, repairs should stop the cause of the problem, not just repair the symptoms or translate the problem downstream.

- ❑ Fill in the erosion site section of the Farm Conservation Plan.

17. WATER SOURCES/WATER CONSERVATION

Background: Water Sources

You should have a permitted or licensed water source prior to installing your project. In general, for surface water diversions only off-channel reservoirs filled through diversions between December 15 and March 31 will receive new appropriative water rights. If the property has an existing reservoir or diversion review the water right permit and license for potential limitations on transfer to vineyard irrigation. Additionally, the proposed diversion must be considered in the context of all the other diversions and impoundments in the watershed. Appendix 4 includes the guidelines and study requirements for new water rights applications for reservoirs and diversions. These guidelines require that the proposed new diversion, or impoundment, along with the already existing diversions and impoundments not exceed 15% of the “winter 20% exceedence flow” at a location downstream of the property. The “winter 20% exceedence flow” is the 20% exceedence value of the streams daily average flow curve for the period of December 15 to March 31. The studies and analyses required as part of the water rights permit are complex and will require a hydrologist, or engineer, to complete all the necessary studies.

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TOP PHOTO SHOWS GULLY HEADCUT FROM CONCENTRATED DRAINAGE.
BOTTOM PHOTO SHOWS PLACED ROCK WITH VEGETATION REPAIR.

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CHECK DAMS CAN BE MADE OF ROCK, REDWOOD OR OTHER MATERIALS. THEY STABLILIZE THE GRADE AND MUST BE INSTALLED PROPERLY.

Fish Friendly Farming Environmental Certification Program	CHECK DAMS ARE USED TO STABLILIZE GULLIES AND REDUCE SOIL EROSION

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APPLYING SITE DESIGN BMPS: WATER SOURCES/WATER CONSERVATION

- ❑ New reservoirs must be off-channel reservoirs with winter diversion and filling (December 15 – March 31) to gain a state water rights permit to impound surface flows. New water rights must evaluate all the existing diversions and impoundments to determine if there is sufficient water available for a new water right. The analysis needed for permitting this type of reservoir is described in Appendix 4.

- ❑ Use of riparian diversions for irrigation of new vineyards is not advisable. A 1600 permit from the California Department of Fish and Game is required for riparian diversions and seasonal limitations on diversions are likely to be included in the permit conditions. Riparian diversions for frost control may be possible, if surplus flows are available as demonstrated by a study, as defined in Appendix 4 and a regulatory pond is used (see page 169 for additional information on frost control practices).

- ❑ Review your irrigation system and proposed vineyard block size to assure water conservation is maximized (see page 174 for further information on irrigation practices).

- ❑ Review your frost control methods and make sure they minimize the use of water and that the water rights studies and application include rights for frost control water and any diversion site or storage.

- ❑ There are approaches to collecting water from a subsurface system and from frost control applications by installing subsurface perforated pipes, or French drains, and cisterns/sumps which collect and the subsurface water which is then pumped into off-channel reservoirs. In some locations, reservoirs can be designed to collect subsurface flows directly. Some of these approaches represent on-site water recollection allowing water to be conserved and reducing the need for additional diversions or wells.

- ❑ Screens must be placed on all direct riparian diversions according to the NMFS criteria in Appendix 2.

- ❑ Wells can also have an impact on stream levels if they are too close to an alluvial stream channel. If the well affects water flows in the stream, it will need to be permitted as a surface water diversion and go through the same process as an appropriative water right application. If the well is not near the stream, very deep (>100 ft.) or does not affect stream flows, it may be a good source of water with less impact to the fishery than stream diversions or reservoirs.

- ❑ If wastewater is available for irrigation, it may represent another alternative for a portion of the site's water needs.

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Fish Friendly Farming Environmental Certification Program	ON-CHANNEL RESERVOIRS

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TWO AERIAL PHOTOGRAPHS SHOWING OFF-CHANNEL RESERVOIRS

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THIS IS A BYPASS STRUCTURE FOR A RESERVOIR TO ALLOW CONTROL OF WHEN THE RESERVOIR FILLS AND PROVIDE FOR STORMWATER TO GO AROUND THE RESERVOIR INLET THROUGH ADJUSTMENT OF THE OUTLETS AND INTO THE CREEK.

VINEYARDS HAVE ONE OF THE LOWEST LEVELS OF IRRIGATION, USING AN AVERAGE OF ONE ACRE-FOOT OF WATER PER ACRE PER YEAR. BY COMPARISION, SUBURBAN LANDSCAPING CONSUMES UP TO 6-10 ACRE FEET OF WATER PER ACRE PER YEAR. ALMOST ALL VINEYARDS USE HIGHLY EFFICIENT AND WATER CONSERVING DRIP IRRIGATION SYSTEMS.

PHOTO ABOVE SHOWS A CISTERN WHICH COLLECTS FROST CONTROL WATER AND ALLOWS IT TO BE REUSED; PHOTO TO LEFT SHOWS A MICROSPRINKLER

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DESIGN DETAILS AND INSTALLATION: APPLICATION OF BENEFICIAL MANAGEMENT PRACTICES

Once designed, the vineyard must be installed correctly using the BMPs to avoid soil erosion and additional costs. Review the BMPs for vineyard installation with the responsible contractors and workers. Make sure your plan includes:

- ❑ Plans and specifications with the necessary installation details to avoid mistakes or misinterpretation
- ❑ Seasonal restrictions
- ❑ Erosion control preparedness and winterization programs
- ❑ Adequate supervision and inspection
- ❑ Winter site observation, inspection and maintenance with immediate erosion control if needed.

18. TIMING

Background: Timing for New Vineyard Installation

Soil left disturbed and barren after vegetation removal is highly susceptible to erosion from both wind and rain. Few hillside vineyard sites have deep enough soils to withstand major erosion and still remain productive. The most effective method for reducing soil erosion is to protect soils though careful planning and scheduling. The rainy season is predictable and stretches from October 15 to April 15 for most years. During the rains, disturbed and bare soil will be lost if the site is not completely winterized. Any form of grading during the rainy season is sure to result in erosion and soil loss and violates local and state regulations.

Once the potential vineyard site has been thoroughly evaluated, a plan for the vineyard development is prepared. This plan will outline the physical layout of the site, the activities to be completed and the time period for each phase of the development. In general, the development should involve several years and include:

Phase I

- Evaluation of site and preparation of plan, completion of CEQA, water rights permits, local permits and other requirements

Phase II – Year One

- Clearing the land - retaining natural vegetation in drainage areas as much as possible
- Grading, terracing or other major soil disturbance
- Field road construction
- Installation of underground drainage system, grassed waterways, diversion ditches or other drainage improvements in the vineyard

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- Installation/development of primary elements of water supply system
- Planting of temporary cover crop
- Installation of temporary erosion control
- Installation of permanent erosion control
- Observation of site drainage system performance, erosion problems and use of temporary control measures

Phase III – Year Two

- Repair and replacement of any drainage problems erosion sites and problems
- Fine grading of terraces and installation of drip lines
- Planting of vines/installation of trellis
- Planting of permanent cover crops
- Installation of additional permanent erosion control

APPLYING SITE INSTALLATION BMPs: TIMING

- ❑ All Phase II and III activities including the installation of temporary and permanent erosion control for the site must be completed between April 15 (or the end of the rainy season if later) and October 15.
- ❑ Seeding of a temporary cover crop should occur in September. For steep slopes and highly erosive soils, straw mulch should also be applied and irrigation used to promote vigorous growth prior to the rains. If the seeds are planted earlier than September and birds may eat them, seed can be drilled and covered with straw mulch. For terraces make sure all parts of the site are covered with erosion control including cover crops, erosion blanket and other materials.
- ❑ The first winter season allows the grower to watch site drainage, soil movement and perform temporary erosion control as needed. These observations allow the grower to improve on the site system and design if needed prior to planting vines.

19. LAND TREATMENT

<u>Background: Land Treatment</u>

Certain soil types and vineyard sites may require disking and grading of surface and subsurface layers, removal of rock or re-contouring. Erosion control practices must be applied following this amount of soil disturbance. Grading and subsoil chiseling is done to reduce hardpan conditions, to add soil amendments or to improve soil texture and is not recommended for most steep slopes.

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APPLYING SITE INSTALLATION BMPs: LAND TREATMENT

- ❑ Phase the project such that all earthwork and installation of all drainage improvements are completed prior to the end of September to ensure that cover crops, filter strips and other erosion protection practices are completely installed before the rains begin.

- ❑ Make sure that final grade and equipment passage leaves cross-sloped soil contours. If equipment leaves up and down slope trenches, erosion is almost a certainly with expensive re-grading and potential siltation for creek areas.

- ❑ Cover crops should be seeded at higher densities and applied with fertilizers and mulch and irrigated to assure the maximum coverage possible by October 15.

- ❑ Sites that undergo extensive soil disturbance should be carefully monitored over the rainy season with immediate attention to any small erosion problem and installation of temporary control practices before the problems become large.

20. COVER CROPS FOLLOWING INSTALLATION

Background: Cover Crops Following Installation

The soil layers of the cleared and graded site need protection from the winter rain. According to the NRCS, soil loss that is observable, as in a rill or gully, is already in excess of 15 tons per acre. Soil loss of 1-2 tons per acre is barely noticeable. However all soil loss will reduce agricultural productivity over time. Cover crops serve to directly protect soil from rain-strike erosion and surface flows as well as holding the soil with dense fibrous roots, and improving infiltration.

APPLYING SITE INSTALLATION BMPs: COVER CROPS FOLLOWING INSTALLATION

- ❑ A primary goal of planting a cover crop is to create a dense protective cover of plants to protect the soil. Grasses alone or a combination of grasses, legumes and natural vegetation will protect soils. You may also want to evaluate using a perennial cover crop that may take longer to establish but is less water consumptive, requires less tillage, and less maintenance. See Tables IIIA, B, and C for details on types of cover crops.

- ❑ Seed the cover crop between September 15 and October 15 to assure that sufficient coverage is achieved before the rains.

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COVER CROPS SHOULD BE SEEDED AFTER LAND PREPARATION TO PROVIDE A DENSE PROTECTIVE COVER FOR SOILS.

Fish Friendly Farming Environmental Certification Program	COVER CROP ON GRADED NEW VINEYARD SITE

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- ❑ Cover crops should cover "all areas" of the new vineyard site during the winter from October 15 through the end of April or later if the rainy season is longer. "All areas" is defined as the "middles" or the area between the vine rows, in the vine row and, for terraced vineyards, both the flat and the slope or face of each terrace. Turnarounds or headlands, roads and buffer areas should also be planted or covered with straw mulch as part of the winterization process. If winter access is needed, gravel should be placed on road.

- ❑ Fertilizer may be needed to stimulate growth and be applied with the cover crop seed. All legume seeds should be inoculated with rhizobium. Check the PLS (pure live seed) rating of your cover crop seed to make sure you are using a rating of 80% or better or germination may be poor. Adjust the planting rate in proportion to the PLS percentage to assure desired coverage.

- ❑ Planting methods include broadcasting seed mix and fertilizer over the site, drilling with a seed drill and broadcast over steep areas with a helicopter. Broadcast seed with an ATV, tractor-mounted seeder, or hand equipment for small areas. Mulching with straw and rolling of mulch should also be done if seed is planted late in the season. Compost can also be used as mulch if readily available.

- ❑ Hydro-seeding involves application of seed, fertilizer and a tacking agent in a slurry sprayed onto the site. This method allows for the slope face of the terrace vineyard to be seeded. This method requires very specific mixes of seed, tacking agent, fertilizer and water for different equipment and materials. Check with a hydro-seed and fertilizer manufacturer. If legume seed is used it should be inoculated with rhizobium. Mulch may also be included in the hydro-seed mix and may be required if applications are made after October 15.

- ❑ Certain erosion control blankets combined with seed, hydro-seeding or erosion control products that include seed can be the most effective method for establishing a cover on the terrace face and other steep areas. A broadcast seeder that is fully opened and mounted on an ATV can also seed the terrace face, if a high concentration of seed with fertilizer is used.

21. DESIGN DETAILS AND INSTALLATION: THE DRAINAGE SYSTEM

Background: Designing and Installing the Drainage System

Developing a hillside vineyard usually requires installing some type of drainage system. In general retaining the natural drainage features and vegetation is highly advisable. On some sites, surface flows need to be collected and diverted around or through the vineyard area.

There are different measures that can be used. The application of various measures to a vineyard site depends upon the layout of the vineyard, the slope and length of the slope, the area of the contributing watershed, rainfall amounts and maximums, and soil types. The BMPs for this element of a new vineyard address the installation of the system and a few of the most important design considerations; however, all drainage system designs should be prepared by the NRCS, a civil engineer, or other qualified professional.

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APPLYING DESIGN DETAILS AND INSTALLATION BMPs: DRAINAGE SYSTEMS

Diversion ditch - Diversion ditches are used across the top of the site to intercept runoff and move it away from the developed slope. The ditch reduces the total amount of water moving down the vineyard slope. The diversion ditch usually crosses the slope along the contour at the top of the vineyard or mid-slope between vineyard areas. The features of the diversion ditch should include:

- ❑ Design the ditch to carry a 25-year frequency, 24-hour duration rainfall event.
- ❑ A gentle (less than 5%) slope to allow the water to flow at non-erosive velocities.
- ❑ Diversion to an underground outlet or other facility designed to accommodate the flow volume.
- ❑ Construction of the diversion ditch requires that all fills are compacted thoroughly and the ditch is sized larger in cross-sectional area than needed for stormflow to avoid overflow and gully formation.
- ❑ Berms for the diversion ditch should be four feet thick to reduce the potential for piping.
- ❑ Install culverts if crossings of the diversion ditch are needed.
- ❑ Revegetate the ditch area and line the ditch with rock if erosion becomes a problem.

Underground drainage system - A system of drainage collection pipes and inlets are installed with terraced and hillside vineyards. The water flows from the inside of the bench into an inlet and downward into the pipe. The underground pipes collect flow and direct it down the slope to a protected outlet.

The benches of the terraced vineyard and inlet locations are designed to allow for a limited amount of water to concentrate before it is directed into the drainage system. This constant diversion of flows over the entire vineyard area and at short intervals along the slope keeps water flow from concentrating and gullying the slope. Installing an underground drainage system should include the following features:

Inlets

Install inlets to provide positive hydraulic flow into the pipe system. If the inlet is set too high or too low it will affect the flow in the pipe and from the bench. The inlet should line up with the ditch on the backslope of the bench and be at, or slightly below, grade.

- ❑ Protect inlets from siltation, equipment, trash, and animals. Mark inlets with a painted post to reduce equipment damage.
- ❑ Install inlets large enough to carry the runoff from a 50 to 100-year frequency, 24-hr. duration rainfall event from the area drained. Install more inlets and drain smaller areas of vineyard rather than larger areas. Do not substitute smaller sizes of pipes or inlets during construction from the designed size.

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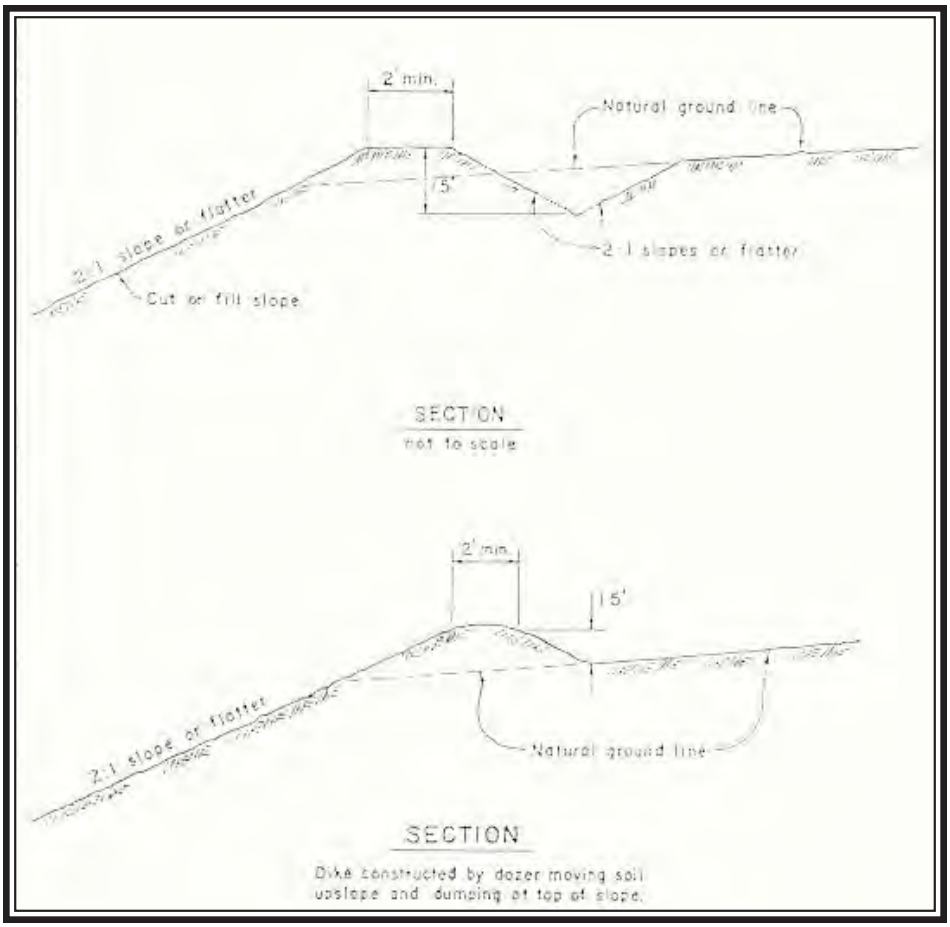

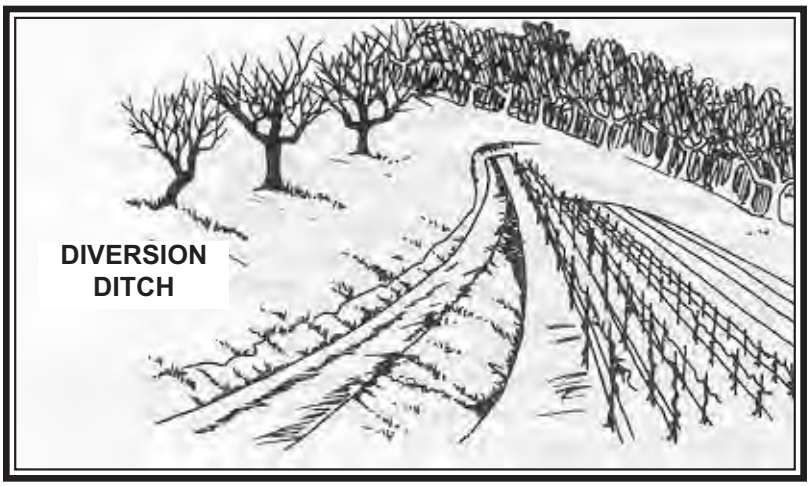

Fish Friendly Farming Environmental Certification Program	DIVERSION DITCHES ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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- ❑ Backfill around the inlets to create a tight seal between the structure, the soil, and the bench ditch. The water should not be able to flow around the inlet and down the slope.

Underground outlets

- ❑ Pipe sizes should be adequate to carry the runoff from a 100-year frequency, 24-hr. duration rainfall event to avoid overflows and erosion.

- ❑ Designs must consider water pressures. Pipe joints and the inlets can blow out due to pressure differences in the system. An adequate number and distribution of inlets should be placed to avoid this problem. The connection of the drop inlet to the underground pipe should always be installed at a 90-degree angle.

- ❑ The pipe should be placed on compacted soil and supported by an adequate number of cutoff collars. The cutoff collar holds the pipe in place. Should the water flow around and along the outside of the pipe and erode the soil, the pipe can loose its support base and collapse. The cutoff collars support the pipe regardless of erosion of the soil around the pipe and reduce the likelihood of a major failure.

- ❑ If the pipe alignment is within an equipment use area compact the top fill to assure the pipe is not crushed. A minimum of 36 inches of top fill is recommended.

- ❑ The pipe must be installed at a uniform grade, no bumps.

- ❑ Install an energy dissipater, rock basin or other facility to reduce erosion from concentrated flow at all pipe outlets, spread the flow or detain it if possible.

- ❑ Use more outlets and drain smaller areas of vineyard to each outlet to reduce water concentrations and erosion at the outlets.

- ❑ Include detention facilities at the outlet if site development increases stormwater runoff by more than 15% over pre-project conditions for stormwater volumes for comparable storm events.

The discussion of terracing includes additional information of relevance to the drainage system installation.

Flexible pipe drop - This drainage practice can be installed in small swales within the vineyard where flows are relatively small. The practice consists of a small section of flexible plastic pipe set in a barrier made of sacks of concrete. The stack of concrete sacks temporarily ponds surface flows and directs the flow into the pipe and to the next downhill stack and pipe. The practice creates a stair-step of pipes down through the vineyard to conduct surface flows off-site and avoid erosion.

- ❑ The sack concrete barriers should be grouted with the pipe to avoid leakage and be secured into the slope with rebar.

- ❑ Do not use this practice where water flows may be too great for the pipe and blow out any of the pipe drops.

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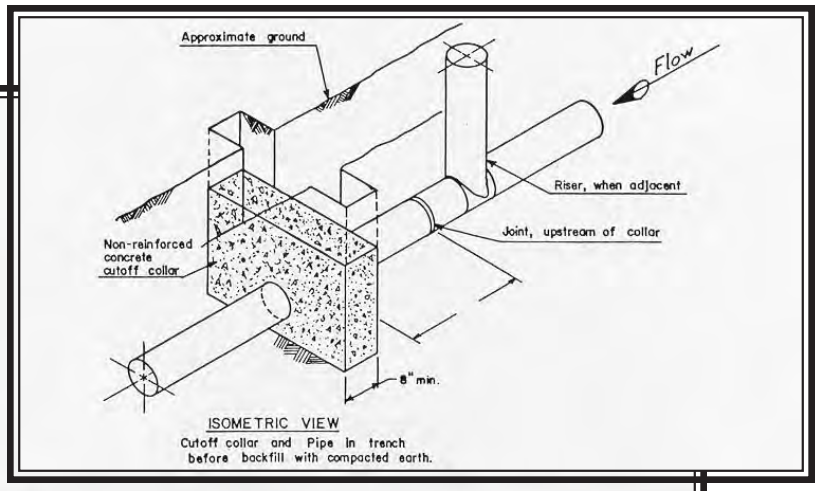

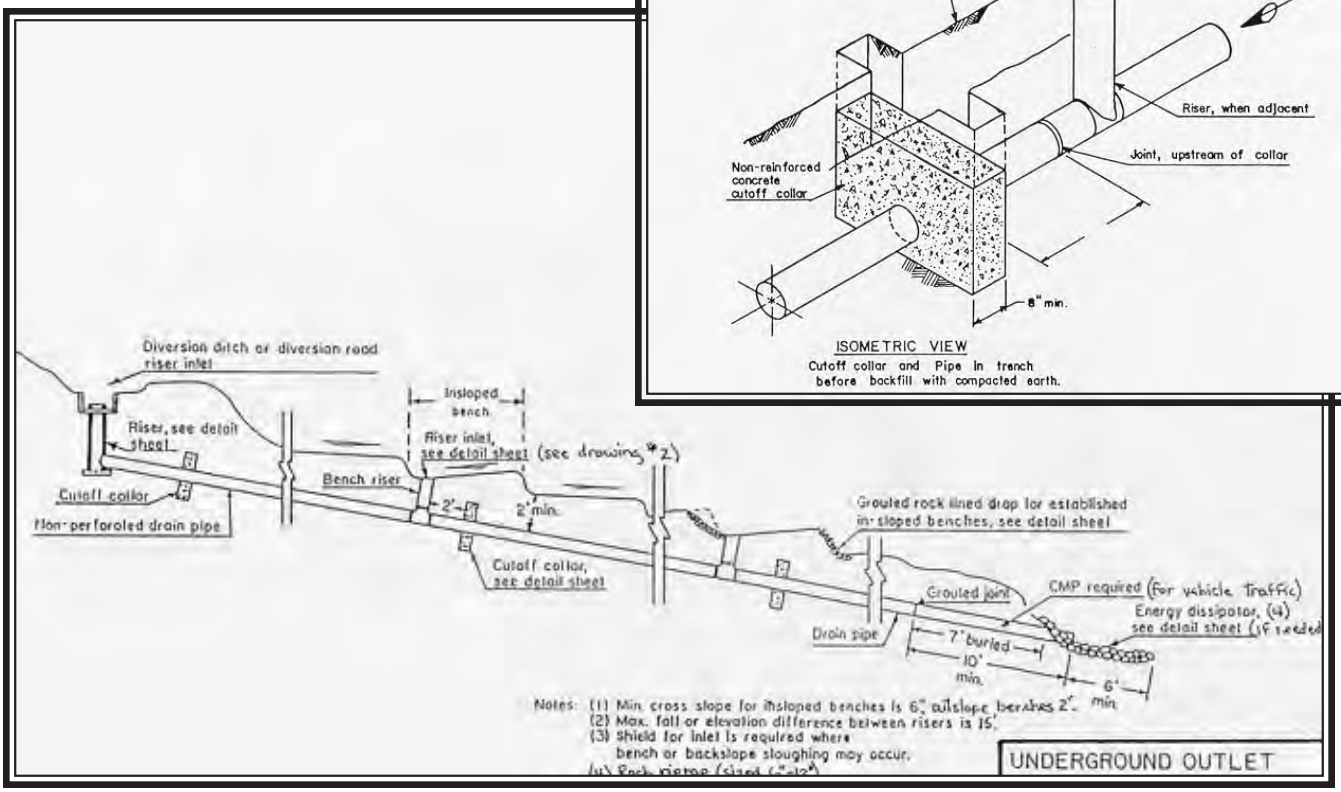

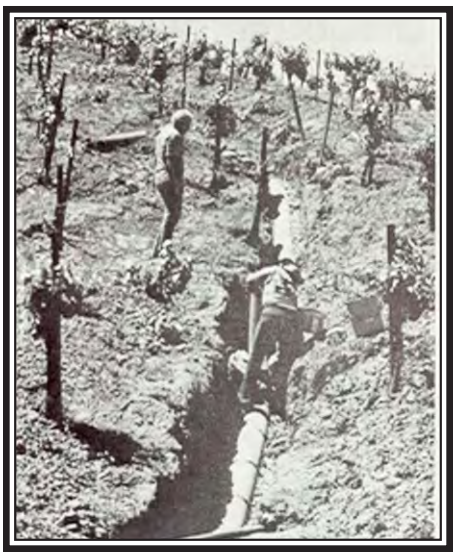

INSTALLING AN UNDERGROUND PIPE

Fish Friendly Farming Environmental Certification Program	UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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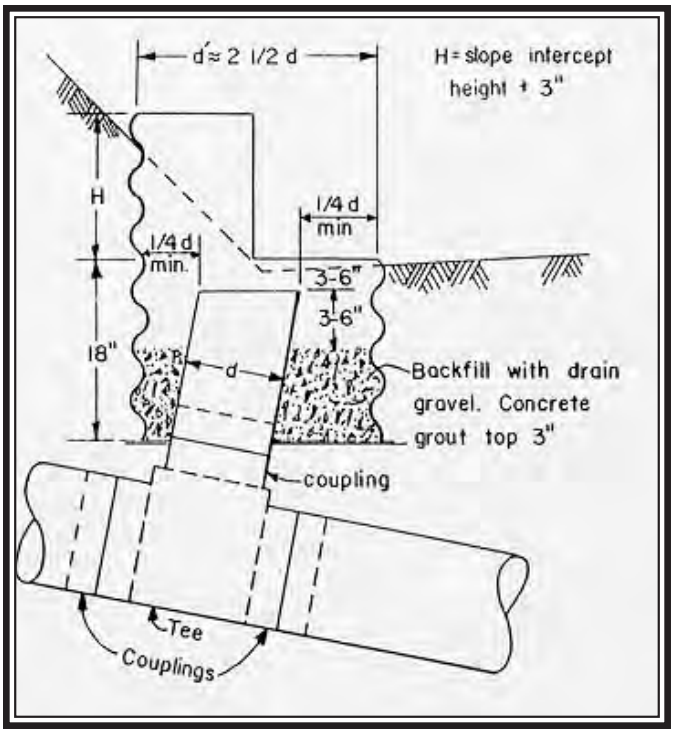

DROP INLETS MUST BE SET IN THE GROUND PROPERLY OR WATER WILL ERODE AROUND THEM. TRASH RACKS ARE ALSO NEEDED AS WELL AS CONSISTENT MAINTENANCE AND WINTER INSPECTIONS.

Fish Friendly Farming Environmental Certification Program	INLETS AND UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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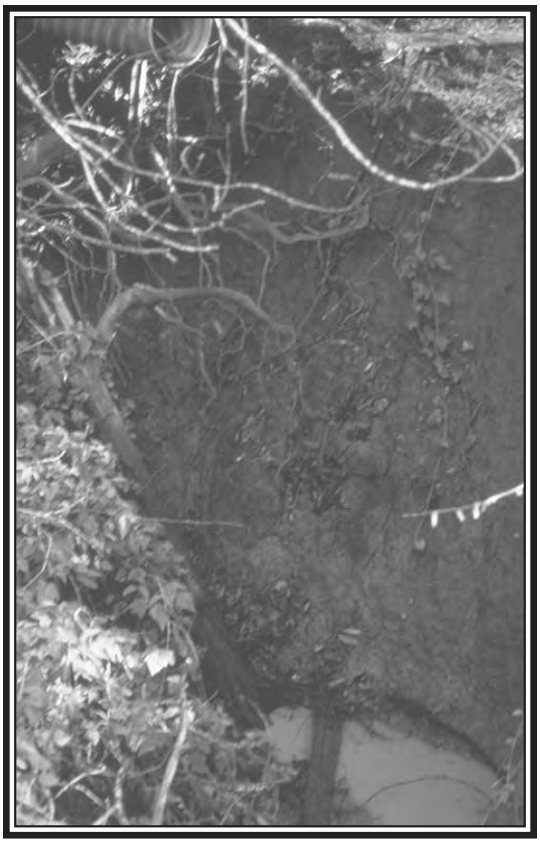
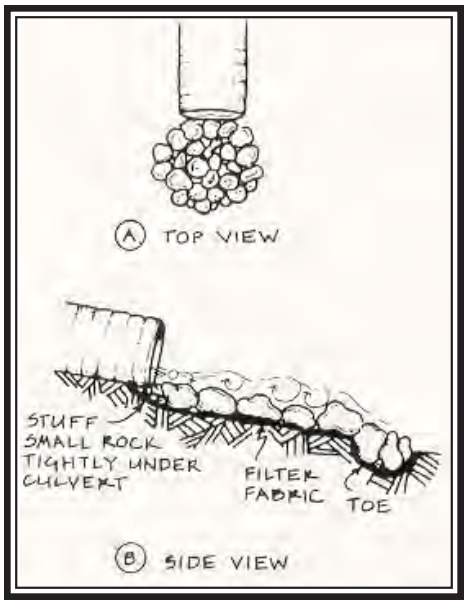
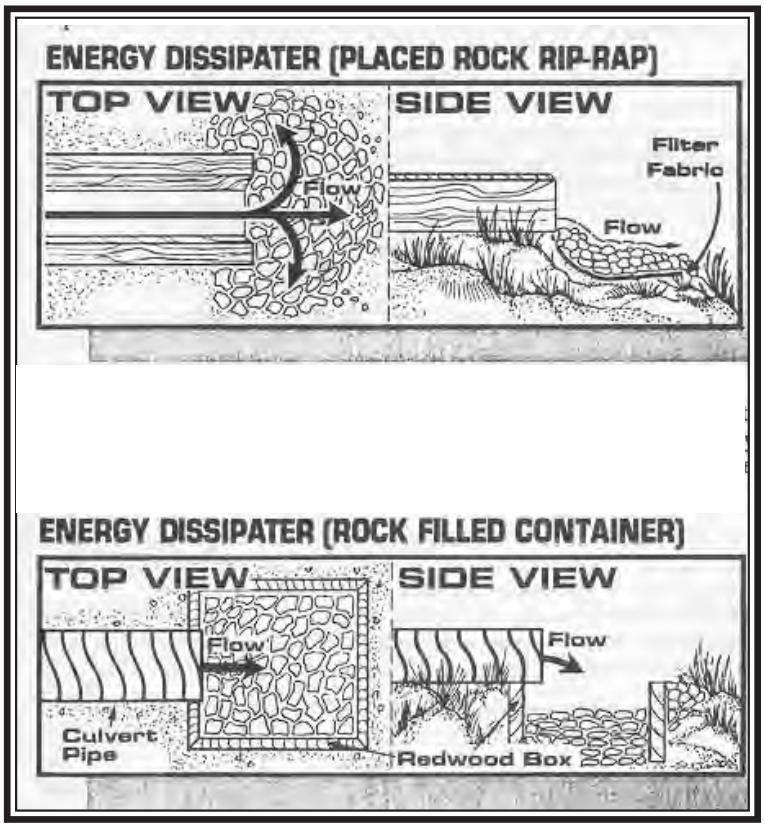


OUTLETS WITHOUT
ENERGY DISSIPATERS
CAN RESULT IN EROSION.





Fish Friendly Farming Environmental Certification Program	PIPE OULETS AND ENERGY DISSIPATERS ALL OUTLETS MUST HAVE A PROPERLY SIZED ENERGY DISSIPATER

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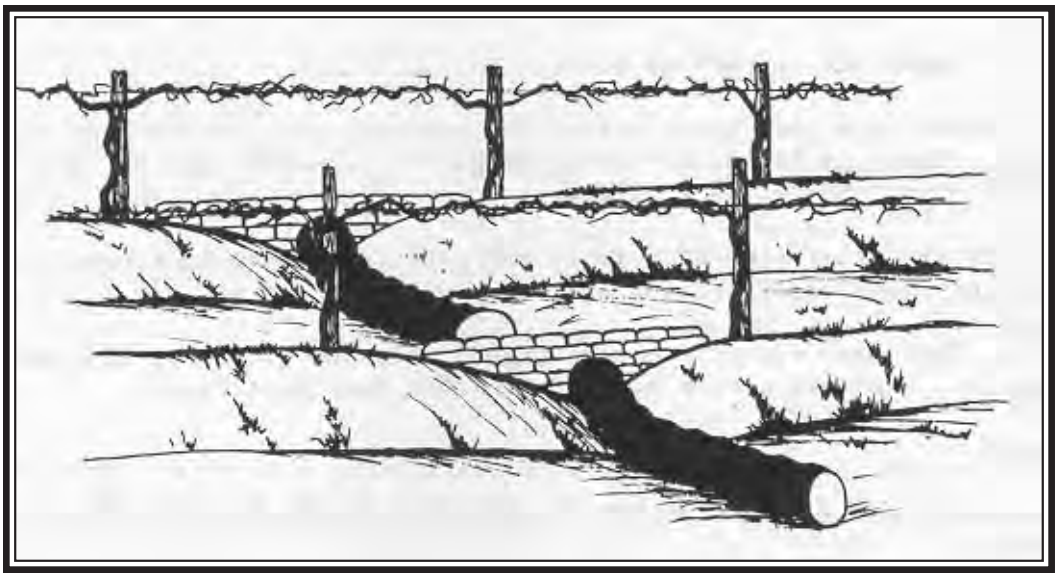

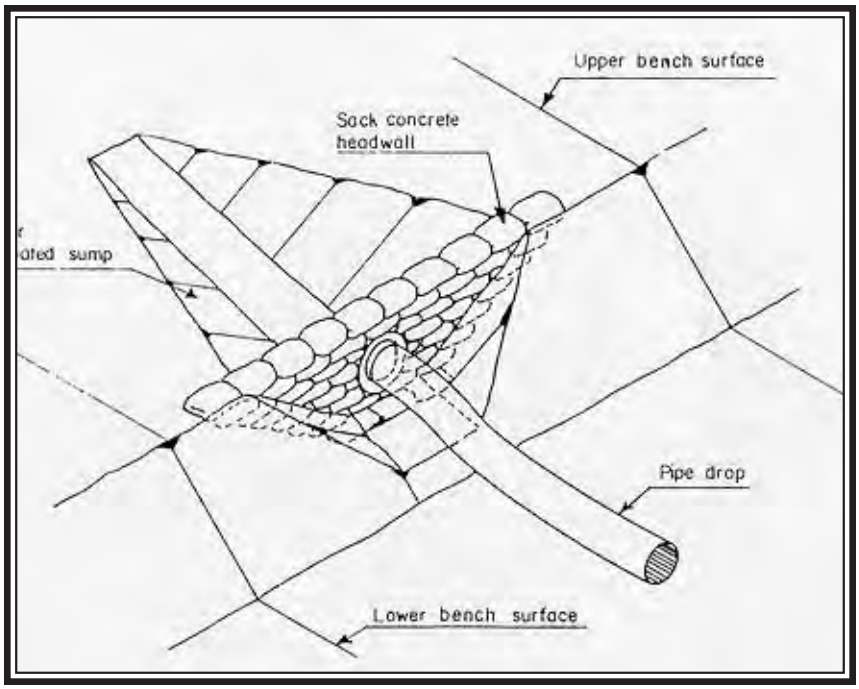

Fish Friendly Farming Environmental Certification Program	PIPE DROP SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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- ❑ Place the sack concrete barrier at the outer edge of the vineyard bench to avoid damage from equipment.

Grassed waterway - Grassed waterways can be used in vineyards with gentle slopes to convey stormwater in areas of concentrated flow such as swales. Grassed waterways are applied to areas with seasonal short-term waterflow. Areas with extended periods of seasonal flow from springs should not necessarily be approached using this practice. The grassed waterway should connect to a natural drainage feature or the vineyard drainage system. Use of the grassed waterway can result in a more natural approach to site drainage, but is generally not applicable to sites with slopes over 12%. Grassed waterways can be combined with a diversion at the top of the vineyard. The grassed waterways should include the following features:

- ❑ Design the grassed waterway to accommodate predicted stormflow amounts at non-erosive velocities for the slope of the waterway. Maximum flow velocity should not exceed 5 ft. per second with dense grass or 3 ft. per second with annual grasses. Greater velocities may require use of geotextile fabric or other erosion control features. If non-erosive velocities cannot be achieved this practice may not be applicable to the site, or may require diversions, grade control structures or other additional practices.

- ❑ Designate one to several equipment crossings on the waterway if needed and install rock or other materials for the equipment to drive over. Do not allow equipment to cross the waterway at any other point. The vineyard layout should accommodate adequate tractor turnaround outside the grassed waterway.

- ❑ Plant perennial deep-rooted grasses to achieve the greatest degree of stability. Annual grasses are shallow rooted and cannot withstand as much flow velocity as deep-rooted grasses.

- ❑ Plant the waterway immediately after clearing and grading to avoid gully formation.

- ❑ Avoid use of herbicides or disking of the grassed waterway as part of the overall vineyard management.

22. TERRACE OR BENCH DESIGN

Background: Terrace or Bench Installation

For vineyard sites in excess of 15% slope terracing of the slope is often done. A large part of the design and installation of a terraced vineyard involves assuring positive drainage to the underground outlet system and a reduction in concentration of flow across the vineyard slope. Concentrated drainage can cause the terraces to fail and the vineyard to gully.

Terrace vineyards are expensive to install and great care should be taken to assure the drainage features will function, the benches are adequate in width for equipment use and vine growth, and tractor turnaround and access roads are adequate, but not oversized. Because they require cut and fill of the hillside terraces have a greater potential to cause slope failures. Alternative designs for up and over the hill layout should be considered. The following BMPs summarize some of the most important design and installation issues;

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however, all terrace construction designs should be prepared by the NRCS, a civil engineer or other qualified professional.

APPLYING DESIGN DETAILS AND INSTALLATION BMPs: TERRACE OR BENCH

- ❑ All drainage features of the site - springs, swales and ephemeral streams must be addressed in the bench and drainage system design. Frequent inlets to the underground drainage system may be necessary particularly on long slopes to assure that surface flows do not concentrate and cause the benches to fail.

- ❑ Diversion at the top of the slope above the benches may be used to divert the flow from the watershed area above the vineyard and reduce the total volume of water moving through the vineyard site.

- ❑ Benches should be designed to avoid excessive ponding leading to overflow and erosion. The features of the bench design should include:

- ❑ The number of inlets and underground outlets should be adequate such that no single bench and inlet has too much flow and either overflows, or slides.

    - o Runoff collected by one bench should not exceed 1.0 cubic feet per second (cfs).

    - o The bench back slope should not exceed 1.5 horizontal to 1 vertical.

    - o If the site has lenses of impervious material, such as clay, a subsurface drain may be needed. Areas of greater instability due to springs or saturated conditions may also require additional drainage improvements.

    - o Flow over the bench face is not recommended as part of the design. Every bench should have inlets to collect stormflows form that bench.

- ❑ The slope of the ditch on the in-sloped bench should be 1-5%. A slope greater than 5% may create water flow velocities high enough to erode the bench.

- ❑ Compact fill areas around inlets and pipes after installation as changes in grade through settlement that may lead to erosion problems.

- ❑ All areas of the bench - the flat and the face, should be seeded with cover crops and mulched. The face may require erosion blanket or other materials to protect soil from erosion.

23. EMERGENCY EROSION CONTROL MEASURES

<u>Background: Emergency Erosion Control Measures</u>

During the first rainy season a new vineyard is the most vulnerable to erosion. There are a number of temporary, or emergency, erosion control measures which can be installed both prior to the onset of winter and during the rainy season as problems arise. These measures provide soil protection, or reduce the movement of soil into waterways, and protect fish

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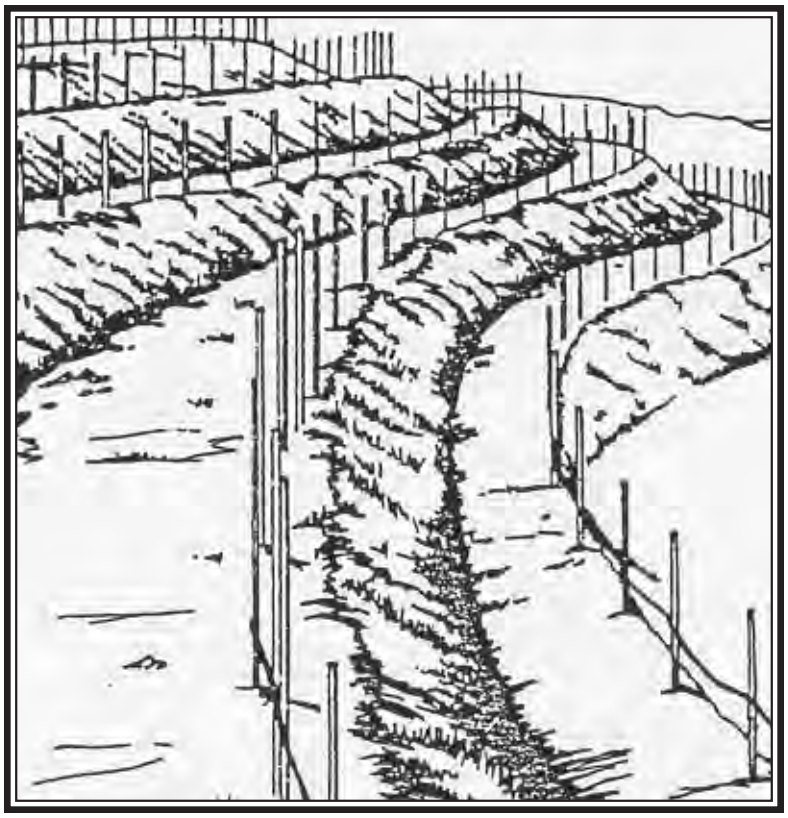

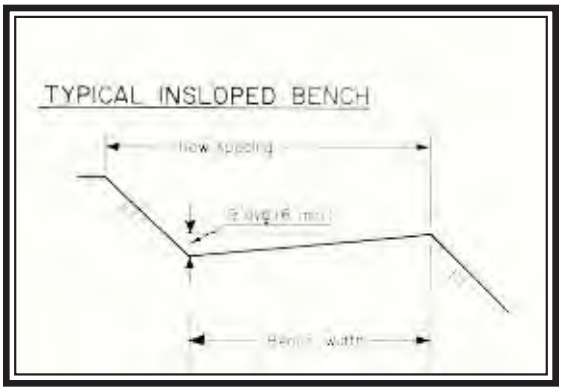

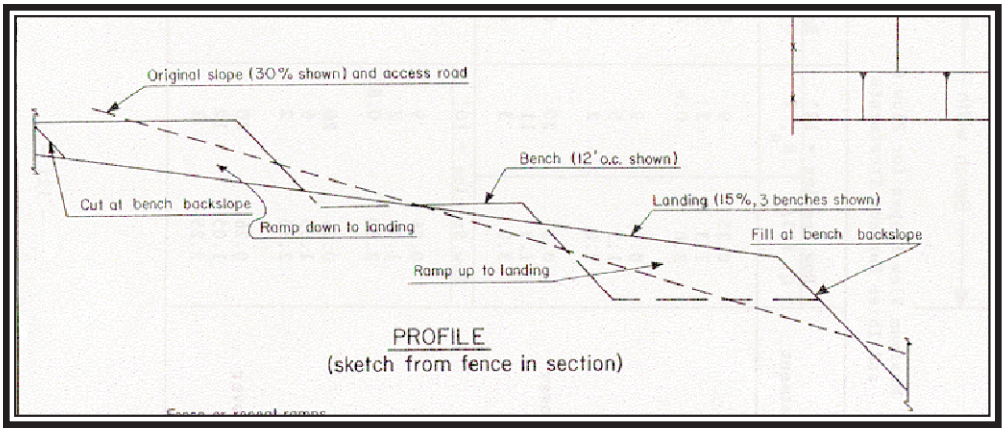

Fish Friendly Farming Environmental Certification Program	SPECIFICATIONS FOR TERRACE BENCH

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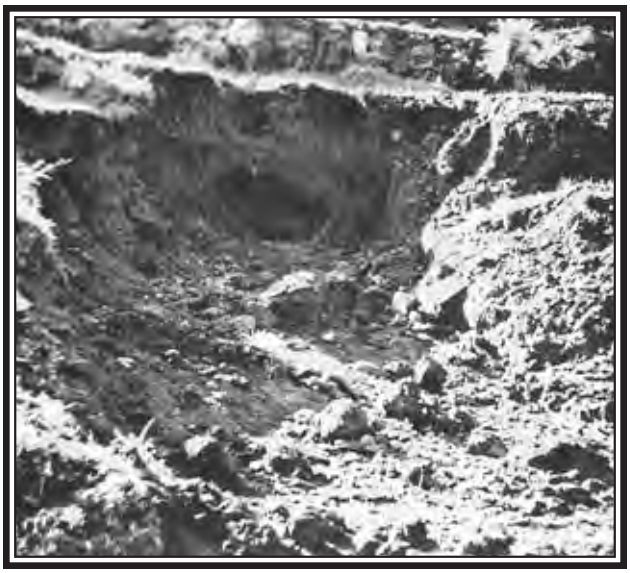

PHOTOGRAPHS SHOWING VARIOUS PROBLEMS WITH TERRACED VINEYARDS. YEARLY INSPECTION AND MAINTENANCE OF TERRACE AND DRAINAGE SYSTEM IS REQUIRED. YEAR ROUND COVER CROPS PROVIDE ADDITIONAL PROTECTION FOR SOILS.

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habitat for the rainy season. These measures are short-lived and only last for the rainy season, or even one large storm event.

The most important part of using temporary measures is to have materials on-site and be familiar with installation methods before the rainy season. It is also important to inspect the new vineyard often to make sure small erosion problems are addressed quickly.

APPLYING SITE INSTALLATION BMPs: EMERGENCY EROSION CONTROL MEASURES

Soil surface protection

- **Mulching**- Straw mulch should be spread over the vineyard site after the cover crop has been seeded. The mulch provides an extra-added layer of protection until the seed germinates. The mulch should be applied at a rate of 2 tons per acre, cover 80-100% of the ground surface and be anchored, or punched, using hand tools, rollers or other non-compacting equipment. The straw can also be sprayed onto the site with a tacking agent to bind it together. Field roads may also be mulched.

- **Composted Clean Green Mulch** – This type of mulch is effective in the control of erosion from hillside vineyards. The mulch is spread under the vine row and in the avenues to protect surface soil layers. Care should be taken to avoid piling mulch against vines. The mulch is created from municipal garden waste and is composted to kill weed seeds. Studies from the California Integrated Waste Management Board have found that the composted mulch is effective for 2 years.

- **Jute Netting** - Jute netting can be used on steep areas where straw cannot be anchored. This practice is appropriate for bench terrace faces and the netting should be anchored with staples or pins. Anchor pins should be rigid galvanized wire with a minimum length of 10 inches. Staples should be U shaped and have two prongs of 6 inches in length. Netting should be overlapped by 12” along the edges to assure coverage of soil.

- **Erosion control blankets** –These blankets are made of biodegradable material that covers over the soil. These are also used on steep sites such as the faces of terrace benches. The treated areas must be reasonably smooth and the blanket must be anchored over the site with an overlap of several inches between each blanket. Each manufacturer has slightly different directions for anchoring the blanket.

Intercepting surface soil movement

- **Silt fence** – A barrier of filter fabric cloth stretched between fence posts is called a silt fence and is placed across a slope to reduce surface soil movement. The posts need to be firmly anchored three feet into the ground, or an adequate depth for the soil type and slope. The fabric is stretched tightly and firmly trenched several inches into the slope surface. Posts should be four feet apart or less and staples on the fabric should be on the uphill side of the silt fence. Silt fences are often used at the base of the slope. A series of cross-slope silt fences can be used from top to bottom of the slope.

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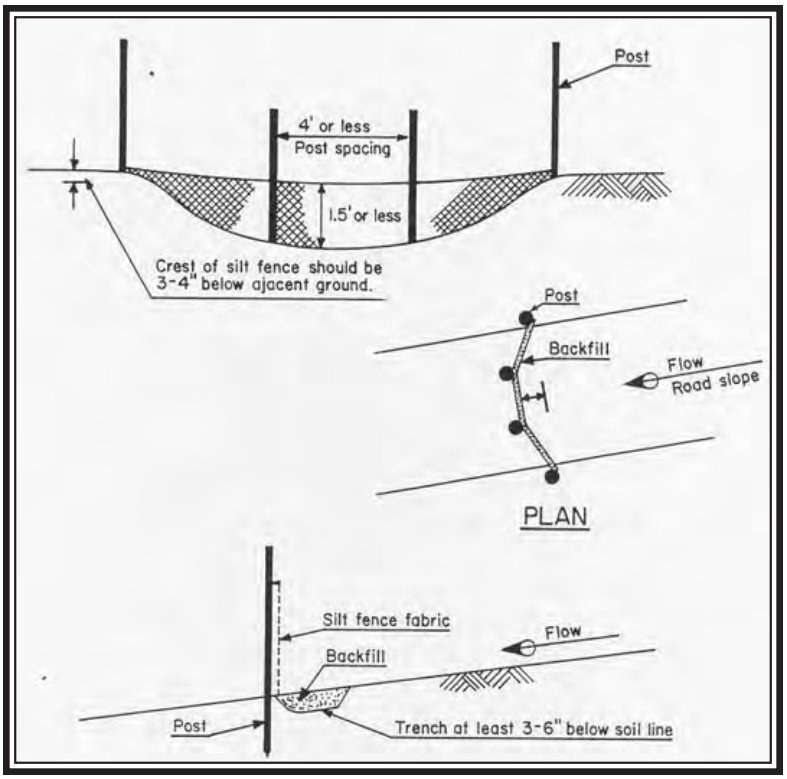

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL SILT FENCE

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- **Straw wattles** – Straw or other fibers bound in a cylindrical casing can be used in a similar manner as strawbales. The wattles can be transported by hand and have to be anchored by stakes, or rebar, driven into the ground 1.5 to 2 feet. The wattle needs to be set into the ground and two can be staked together. They can be installed in a series on the contour of a slope, or perpendicular to the flow path.

- **Strawbale waterbars** - Strawbales can also be used to create a temporary water bar across a road or a temporary sediment barrier to protect a drop inlet from siltation. A series of strawbale checkdams, or waterbars, may be needed for a long slope. They should cross the entire width of the slope and be spaced to allow for sediment accumulation between. There are also erosion control products such as "sediment logs"which can be used in the same way as the strawbales. The length of slope, or area above each strawbale waterbar should not exceed 100 ft. or one acre.

- **Temporary sediment basin** – A temporary sediment basin is used during the first winter to catch and settle out sediment before it can enter a waterway. These are usually placed at the base of a slope, or drainage area. Sediment basins are designed for small watershed areas (no greater than 5 acres) and small storm sizes (10-year recurrence interval). A small basin can be created from compacted soil, rocks, or straw bales. The embankment should not exceed four feet in height and a drain, or outlet, restricts flow from the basin to allow for sediment to be trapped. A small berm, or square of strawbales, can be created around the drop inlet of the new vineyard drainage system to reduce siltation. Be sure that the strawbales are securely anchored with stakes or rebar.

- **Plastic-lined ditch** - When a vineyard field road, or road ditch, begins to erode plastic can be placed over the eroding site to reduce soil loss temporarily. Strong plastic should be used to avoid puncture by rocks and sticks. The plastic sheets should be anchored so that surface runoff, or wind, cannot move the plastic. Stakes, or rebar, are preferable; placing rocks on top of the plastic is not sufficient. Sheets of plastic should be overlapped a minimum of 12 inches and tightly staked at the overlap. The maximum length for the plastic lining is 400 ft.

There are many other erosion control products on the market. Always use them as the manufacturer recommends and install them according to directions.

24. ADDITIONAL EROSION CONTROL

Background: Additional Erosion Control

Steep hillside vineyards can incorporate several types of permanent erosion control: permanent cover crops over the entire vineyard floor, terrace flat and face, adequate sized filter strips between the vineyard and all waterways, permanent sediment basins to intercept soil and protect waterways. Cover crops are discussed in Element III and are a required part of the Farm Conservation Plan. Filter strips and sediment basins must be designed into each project and sized accordingly.

APPLYING SITE INSTALLATION BMPs: ADDITIONAL EROSION CONTROL

Filter strip - A strip of dense grass, or other vegetation, between the vineyard site and waterways serves as an additional protection against siltation in streams. Surface flows

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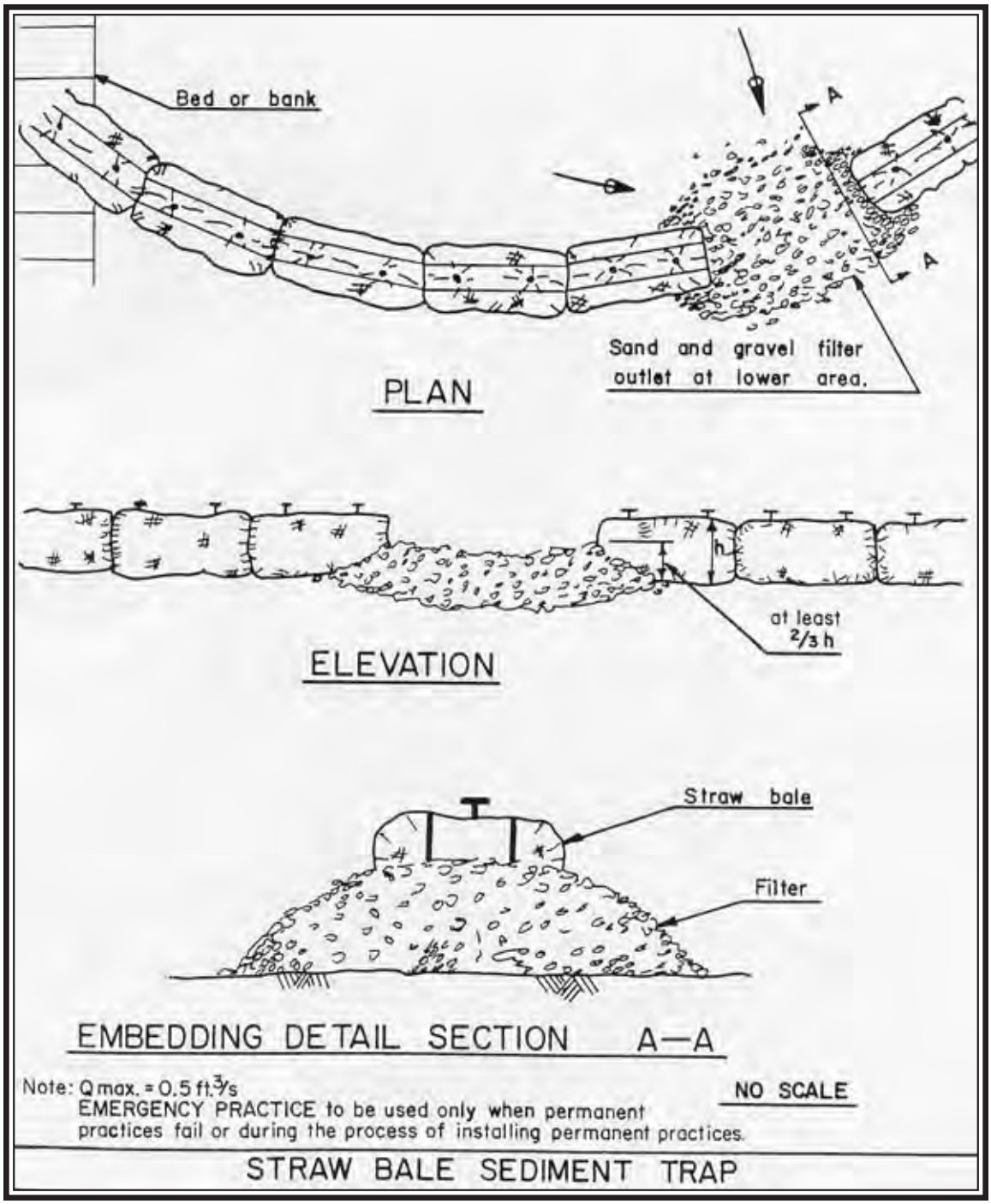

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE SEDIMENT TRAP

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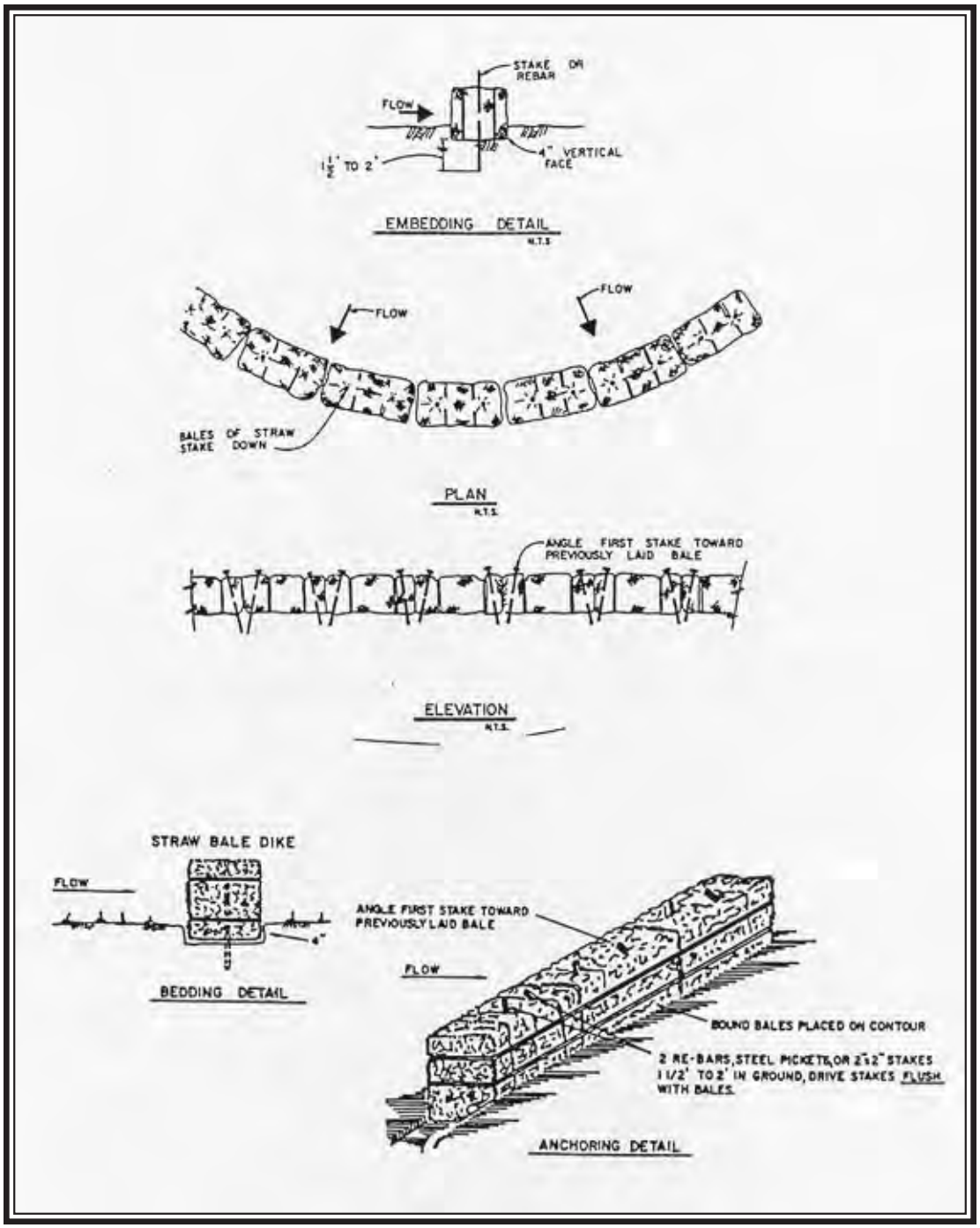

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE BERM

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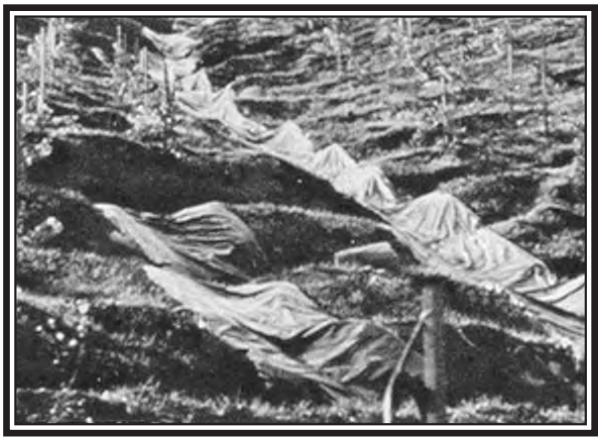
INSTALLING EROSION BLANKET - A TEMPORARY FORM OF EROSION CONTROL- BLANKET MUST OVERLAP AND AND BE INSTALLED WITH STAPLES OR STAKES.

PLASTIC SHEETING CAN PROVIDE SOME EMERGENCY EROSION CONTROL FOR ONE STORM BUT MUST BE CHECKED FREQUENTLY AND REPLACED.



STRAW WATTLE STAKED IN EROSION SITE

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carry soil through the filter strip before reaching the waterway. The dense grass slows the water and catches the sediment providing another protective measure. The filter strip should include these features:

- ❑ Filter strips should be planted along all the waterways adjacent to the vineyard. Filter strips may also be used across the vineyard slope between blocks of vines as an additional practice to reduce sediment movement though sheet flow.

- ❑ The size of the filter strip varies according to the slope of the area draining to the strip. For slopes of less than 1%, the strip should be at least 10 ft. in width and increase proportionate with the increase in slope up to 25 ft. in width for slopes of 30%.

- ❑ Plant the filter strip in September to allow for adequate vegetative cover to develop. Plant density should be a minimum of 80% and may consist of annual grasses or native bunchgrasses. Fertilization and irrigation may be needed.

- ❑ Do not till the filter strip until after April 30 to provide the greatest degree of protection. If frost is a concern and the strip is near to vines, it can be mowed.

- ❑ Depending on the site the filter strip area may be further enhanced as a permanently vegetated buffer. Native species should be used and chosen carefully to promote beneficial insects or block the movement of pest insects. Additional amenities such as bat boxes, raptor and owl roosts may increase wildlife values and take advantage of the benefits of these animals for control of insects and rodents. However the use of these additional plants should not reduce the basic cover of grasses needed for catching sediment.

Sediment basin – Sediment basins are usually located at the downstream end of a vineyard drainage system and meant to settle out eroded soil. Basins can be effective in some locations, but also require frequent clearing out. Temporary sediment basins, during and for several years after, vineyard development can be effective in reducing movement of sediment into waterways. Typical sediment basins are designed to accommodate the runoff from a 10-year frequency 24-hr duration rainfall event without overtopping. The basin is created by constructing an embankment, basin emergency spillway and a release structure, such as a standing pipe. Sediment basins may be located at the bottom of the vineyard slope where drainage enters a natural waterway. These basins should be designed by NRCS, or a civil engineer, on a site-specific basis and installed using proper construction and compaction for the berm and correct sizing and construction for release structures and spillways. The basin should not be located on a stream.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share and grant funds.

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FILTER STRIPS OF DENSE GRASSES AT THE BASE OF A VINEYARD CAN PROTECT WATERWAYS FROM SEDIMENTATION.

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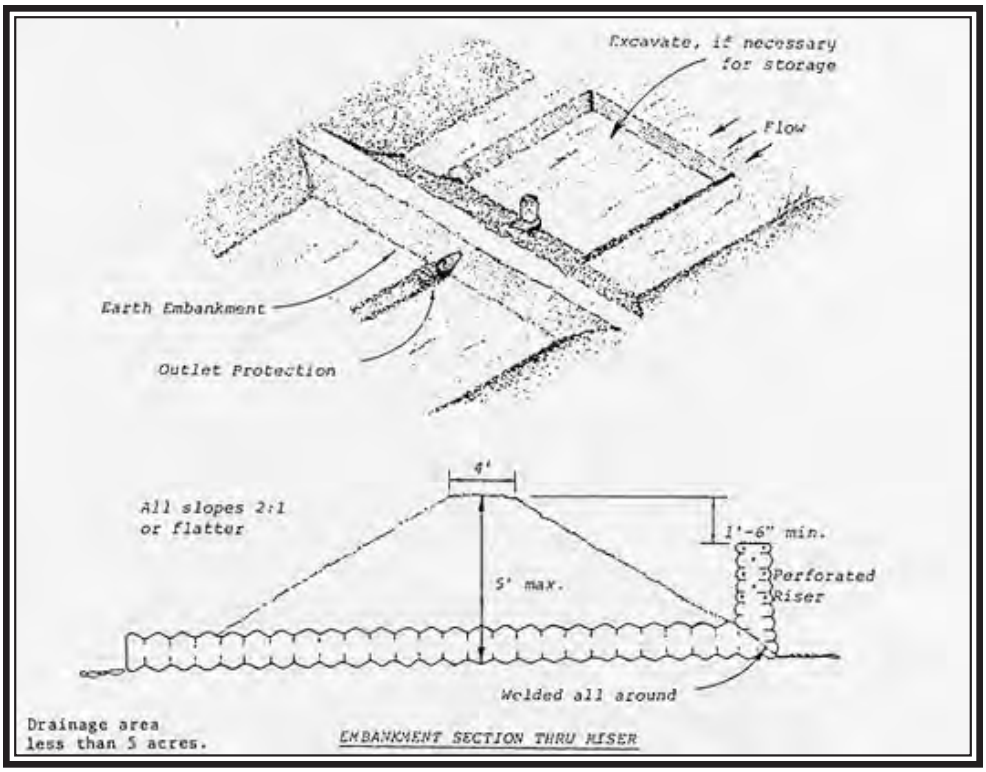

Fish Friendly Farming Environmental Certification Program	SEDIMENT BASIN

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ELEMENT III - MANAGING THE VINEYARD*: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for existing vineyards* and new proposed vineyards*. It includes:

- ❑ Inventory/Assessment of the features of the vineyard.
- ❑ Evaluation of current management methods.
- ❑ Application of the Beneficial Management Practices (BMPs) for the vineyard.

Background on various subjects related to the BMPs is included both here and in the Appendices as indicated. Use this section as a guide to filling out Element III of the Farm Plan template.

MANAGING THE VINEYARD*

Managing a vineyard includes making seasonal decisions on tillage and weed control, selection and management of cover crops, winterization and erosion control, maintenance of the drainage system, use of nutrients, chemicals and other materials, and irrigation practices.

Hillside vineyards can be managed to mimic the natural processes of a watershed. For example, complete winterization with careful post-storm inspections and use of emergency erosion control can greatly reduce the delivery of fine sediment into creeks. Ephemeral creek networks are the drainage system on a hillside and they conduct both floodwater and sediment to downstream areas. Regular maintenance of the vineyard drainage system and retaining vegetation in natural creek channels can keep the ephemeral creek system stable and reduce erosion.

On relatively flat vineyards appropriate management practices can conserve soil and water, avoid drift of chemicals into riparian corridors and increase biodiversity with varied cover crops.

The Beneficial Management Practices (BMPs) in this section describe recommendations for those aspects of vineyard management most related to soil and water conservation, chemical use, drainage and erosion repairs. Creek/river corridors and roads are included in separate elements. The vineyard manager applies these BMPs to create an integrated system in the vineyard to protect waterways and water quality and grow a high quality crop.

* "Vineyard is used in text, but also applies to orchards

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SITE INVENTORY

Fill out the site inventory section in the Farm Conservation Plan template for existing vineyards. For new vineyards fill in the methods intended for use

This evaluation creates an inventory of the features of the site and will better define the vineyard areas, the improvements needed and ways to apply the program BMPs. Each section has some background information and directions for the Farm Conservation Plan. Use Element III of the Farm Conservation Plan template, your maps and aerials and take site photos as instructed.

1. FEATURES OF THE PROPERTY AND VINEYARDS

- ❑ Make full-size color copies of your aerial photograph and topographic map and outline different features on each copy such as the property boundary, vineyard areas, roads and buildings, adjacent land uses, creeks and water sources, roads and replanting areas. You may want to create an enlarged copy of each vineyard area to map the vineyard drainage system.

- ❑ Outline the property on the copy of the aerial or topographic map.

- ❑ The location of each vineyard area should be outlined on the copy of the aerial photo. Give each separate area a number, or name.

- ❑ Estimate the acreage of each vineyard area.

- ❑ Indicate the primary vineyard field roads used for year round access and those used only seasonally.

- ❑ Outline the vineyard drainage system including inlets, outlets, underground pipes, and perforated pipes. Further details on how to complete this element are included in Section 8.

- ❑ Indicate and label the following features on the aerial to create a complete and accurate picture of the operation:
    - ❑ ephemeral streams, year round and seasonal creeks and their riparian corridors – more detail is included in Section 4
    - ❑ water sources such as diversion points, wells, or reservoirs
    - ❑ farm buildings
    - ❑ main access and all other roads except the vineyard avenues and seasonal field roads
    - ❑ areas of other land uses on the property

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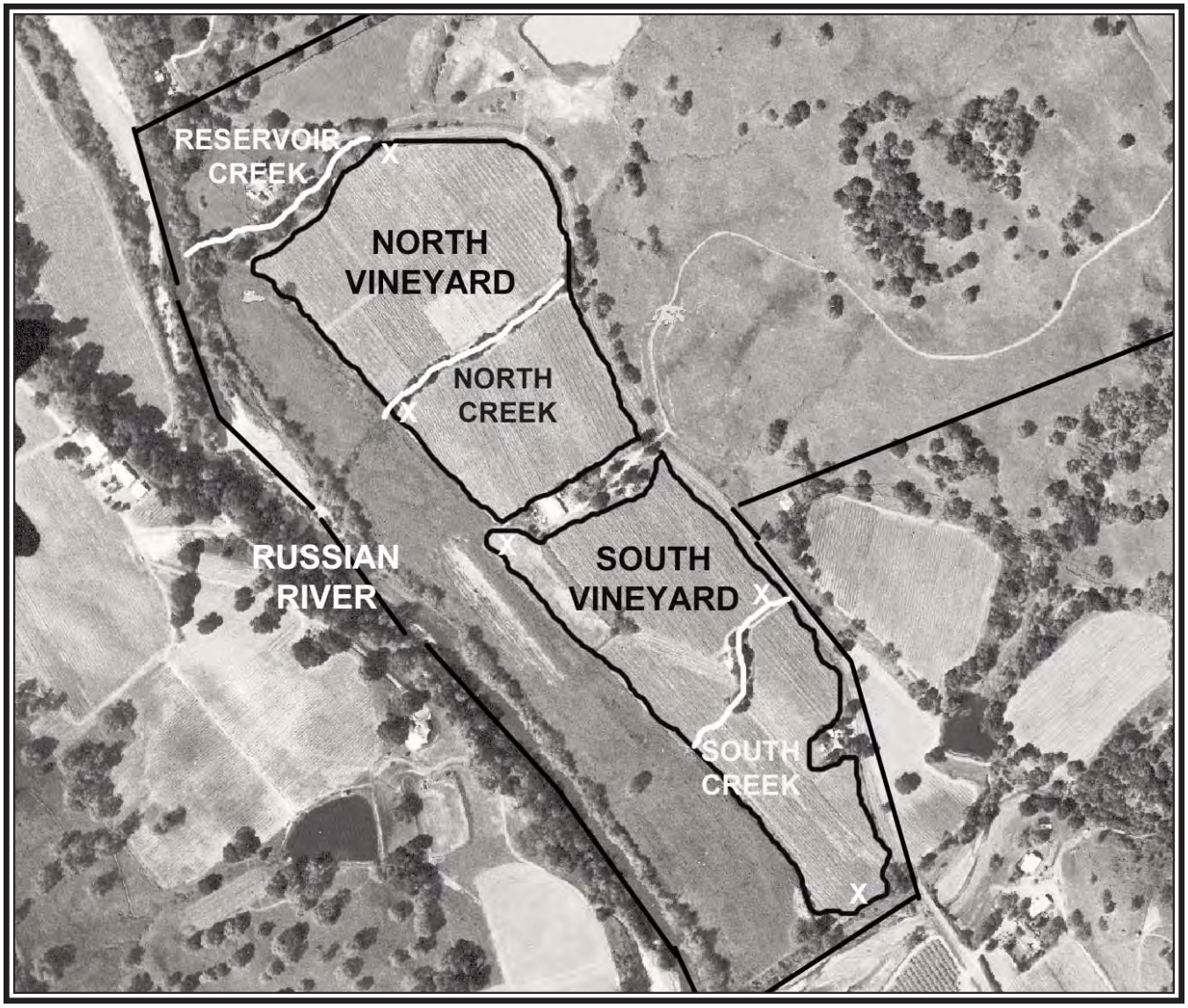

Fish Friendly Farming Environmental Certification Program	FARM PLAN MAP SHOWING VINEYARD AREAS AND CREEKS

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2. SOIL TYPES AND EROSION RATINGS

Background: Soil Types

Soil is the fundamental resource for all types of agriculture and will determine both the suitability of a site for various crops as well as the potential for erosion. Soil is formed through the slow weathering of the parent rock material through physical and chemical processes. Soils take thousands of years to develop and vary greatly in their depth, texture and properties including erosion potential. Agriculture is one of the few land uses that is economically dependent on protecting the soil and managing for long-term soil health. Vineyards and orchards can disturb soils far less than annual crops and can employ cultivation practices to promote both soil conservation and soil health.

The easiest way to determine the soil types on a site is to look in the county Soil Survey available from the Natural Resource Conservation Service. Soil maps and information will be provided for enrolled properties in the FFF workshops.

Soils are grouped into series according to their physical properties. Within each series of soils are various soil types. For example, the Haire series has several soil types: Haire loam, 0 to 2 percent slopes, Haire loam, 2 to 9 percent slopes, Haire clay loam 0 to 2 percent slopes, Haire clay loam 2 to 9 percent slopes, Haire clay loam 9 to 15 percent slopes and Haire clay loam 15 to 30 percent slopes. These soil types are also called mapping units in the Soil Survey and are delineated on the aerial photos included in the soil survey.

Each soil series and type is described in the Soil Survey. For example:

"Haire Series

> *"The Haire series consist of well-drained soils on old terraces and alluvial fans. Slope is 0 to 30 percent . elevation is 20 to 300 feet. These soils are formed from alluvium derived from sedimentary rock.. The vegetation in uncultivated areas consists of annuals grasses and forbs."*

The description of each type of Haire soil includes an erosion hazard rating. For example:

> *"Haire clay loam, 9 to 15 percent slopes (149). Runoff is medium and the hazard of erosion is moderate.*
> *Haire clay loam, 15 to 30 percent slopes (150). Runoff is rapid and the hazard of erosion is moderate."*

Soil types also include a range of slopes. The change in slope for a soil type changes the erosion rating. The slope classes typically used are:

0 - 5 % or 0 - 9%
5 - 15 % or 9 - 15%
15 - 30 %
30 - 50 %
50 - 75%

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AERIAL PHOTOGRAPH FROM SOIL SURVEY
THE SOIL SURVEY INCLUDES INFORMATION ON THE EROSION HAZARD RATING AND OTHER FEATURES OF EACH SOIL TYPE.

Fish Friendly Farming Environmental Certification Program	EXAMPLE SOIL SURVEY MAP

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One property may have several soil types and slope classes. The erosion hazard of each soil type /slope class is different and should be listed separately.

The Napa and Solano County Soil Surveys and Appendix 1 provide information on each soil type that can be used to evaluate the potential for sheet erosion. Sheet erosion involves the loss of a thin layer of topsoil across the overall hillslope and is also called sheetwash. This type of erosion is not as noticeable as gullies, but it constitutes the largest type of soil loss. Rain striking bare soil can mobilize the surface soil layer and particle by particle the soil flows off the land. Slope plays a major role in increasing sheet erosion as does rainfall intensity and soil type. Sheet erosion can result in several tons of soil loss per year and not be noticeable. One ton of soil loss per acre is comparable to the thickness of 2 to 3 sheets of paper.

The Universal Soil Loss Equation (USLE) provides a general tool for evaluating the potential for sheet erosion on a particular site using various management methods and vineyard layouts. For an existing vineyard an analysis using the USLE may be useful to determine whether current practices are sufficient to obtain the target tolerance level for annual soil loss for a particular soil mapping unit. If the loss level is too great, some changes or retrofitting are needed to attain this target tolerance value. Appendix 1 includes a description of the USLE and a list of K and T values. The K value indicates the susceptibility of a soil to erosion. The T value represents the soil loss tolerance for a soil type, usually between 1-5 tons/acre/year.

Assessment: Soil Types

- ❑ Look up your site in the Soil Survey. Soils maps and descriptions will be provided as part of the FFF workshops.
- ❑ Fill in the table in the Farm Conservation Plan for each soil type in each vineyard area from the Soil Survey. Make a copy of the written information about each of the soil types on your site.
- ❑ Fill in the slope classification and erosion hazard rating for each soil type.

3. SLOPE

Background: Slope

Slope has an enormous effect on soil erosion. Slope magnifies the effects of water runoff and its ability to carry soil as well as increasing the likelihood of hillside slippage and mass movement. Steep slopes (greater than 30%) have high to extreme erosion hazards for most soil types. The slope classifications listed in the Soil Survey are generalized and a more specific look is often needed for site evaluation.

The United States Geologic Survey (USGS) topographic maps can be used to determine the general steepness of the slopes on the site. The contours on a topo map indicate elevations and by adding up the number of contours one can determine generally the change in elevation on a hillside. The percent slope of a hillside is measured as rise over

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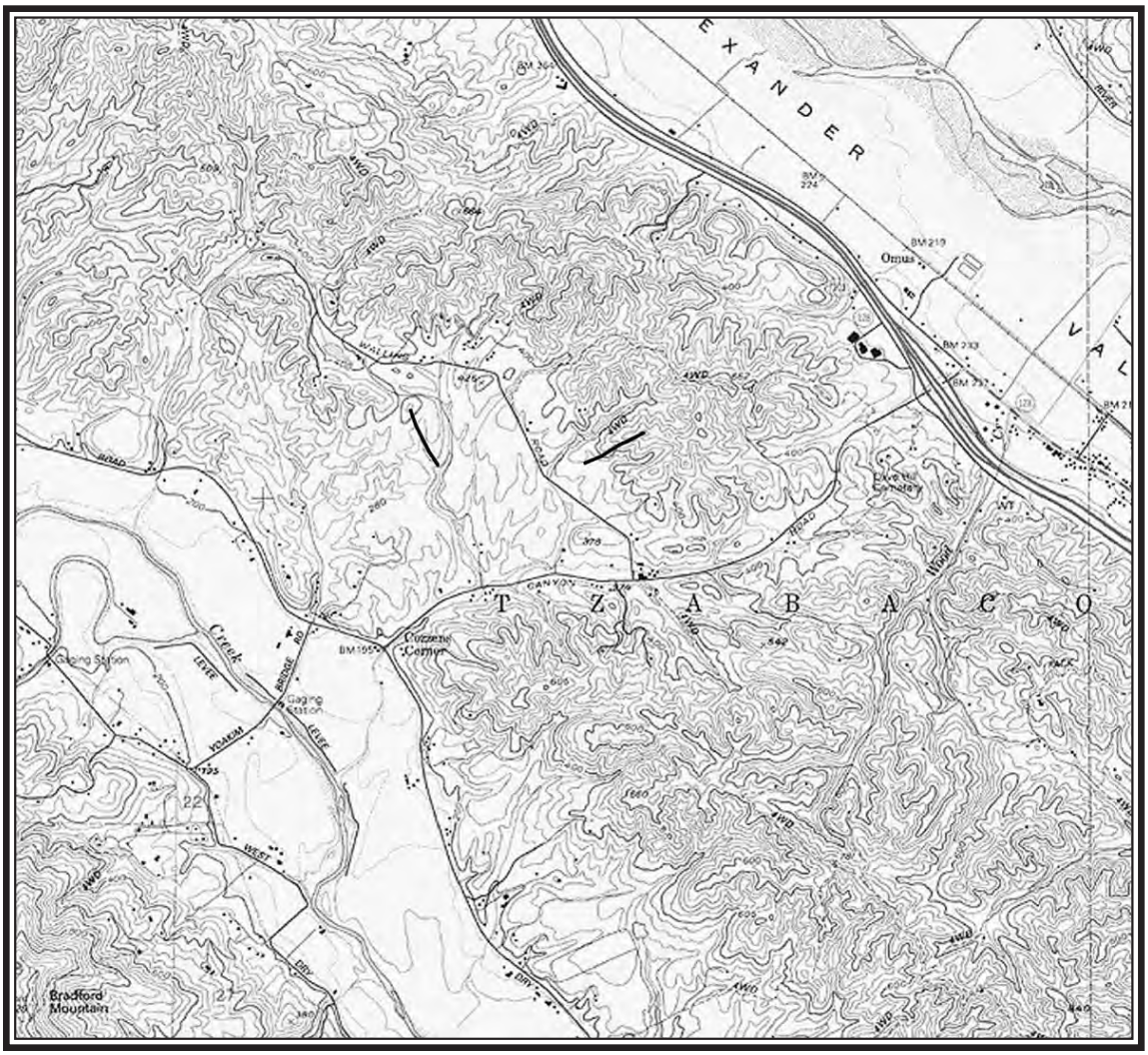

Fish Friendly Farming Environmental Certification Program	TOPOGRAPHIC MAP LINES SHOW MEASURMENTS FOR PERCENT SLOPE AND SLOPE LENGTHS

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run multiplied by 100. The first step is to measure the elevational increase along a hillside (shown by the contours on the map) and divide by the linear distance or length over the same area measured to the scale of the map (1"=2000' for most topo maps). The number is then multiplied by 100 to get the percent slope.

For example, a hillside which measured a 200 foot elevation increase in a 2000 foot linear distance would have a 10% slope (200/2000 x 100). Another hillside with a 200 foot elevation gain in a 1000 foot linear distance would have a 20% slope (200/1000 x 100). A short steep slope such as a 200 foot elevation rise in a 500 foot linear distance would have a 40% slope (200/500 x 100).

Short steep slopes can create erosion problems if not addressed with additional drainage and soil protection. Review the vineyard areas and identify any areas with steep slopes within a gentler hillside. These areas may require more erosion protection and vigilance in winter inspections and the use of emergency erosion control. The length of the slope in the vineyard is also important to note as it represents the length over which runoff can travel, concentrate, and erode soil.

Site Inventory: Slopes

- ❑ Using the Soil Survey, topo map, and a detailed site survey if you have one, list the percent slope for each vineyard area. If there are areas of steep slopes within a vineyard area indicate this and whether those areas are in cultivation or not. This step is done to allow for increased erosion control of any steep areas if needed.

- ❑ Record the length of the slopes you measure in each vineyard area. The slope length is an important consideration in drainage systems.

- ❑ Slope can be field checked using a clinometer, if the soil survey slope classes are incorrect.

4. NATURAL DRAINAGE FEATURES

Background: Drainage Networks and Stream Systems

Watersheds include a network of creeks and channels that stretch from the ridgetops to the main river channel. This network conducts surface water flow and sediment and consists of a variety of channels. Many hillside channels are typically steep and carry water only during large storms. These are termed ephemeral or temporary creeks. They may have dense woodland and large boulders in hilly areas, or in more moderate sites be open and grassy. In flat areas, ephemeral creeks may be drainage ditches.

Downstream of ephemeral creeks are intermittent or seasonal streams and perennial, or year round, creeks. These streams often flow well into the dry season, or on a perennial basis, in an average rainfall year.

Assessing the location and condition of this drainage network and its relationship to the vineyards is an important part of the Farm Conservation Plan. Fish bearing streams are typically perennial and seasonal creeks with summer pools. Ephemeral drainage networks

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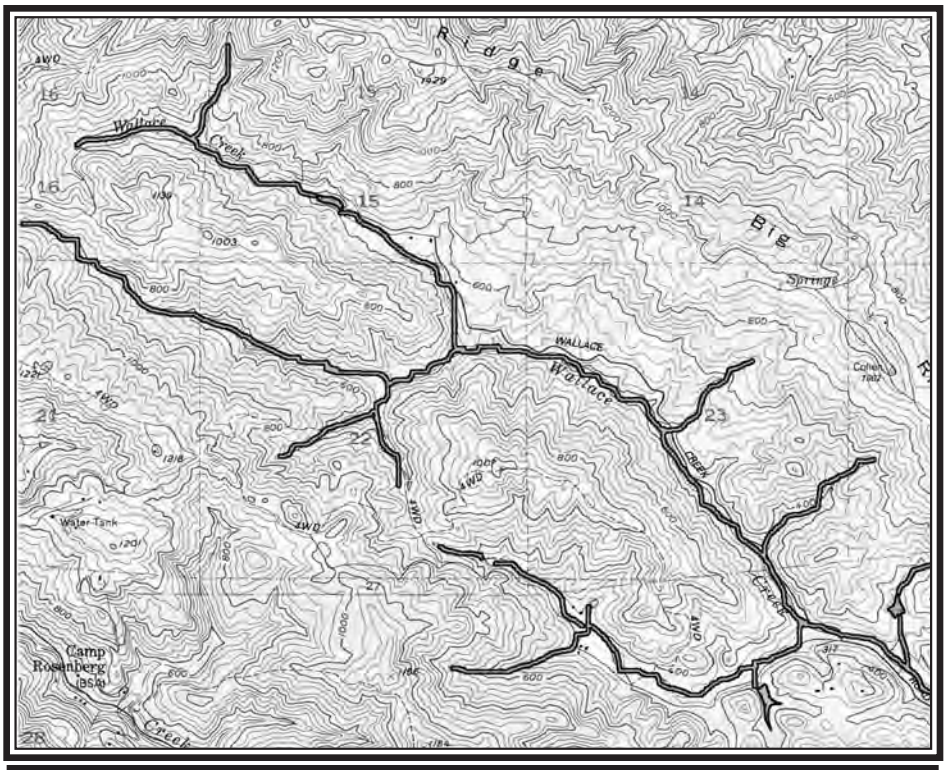
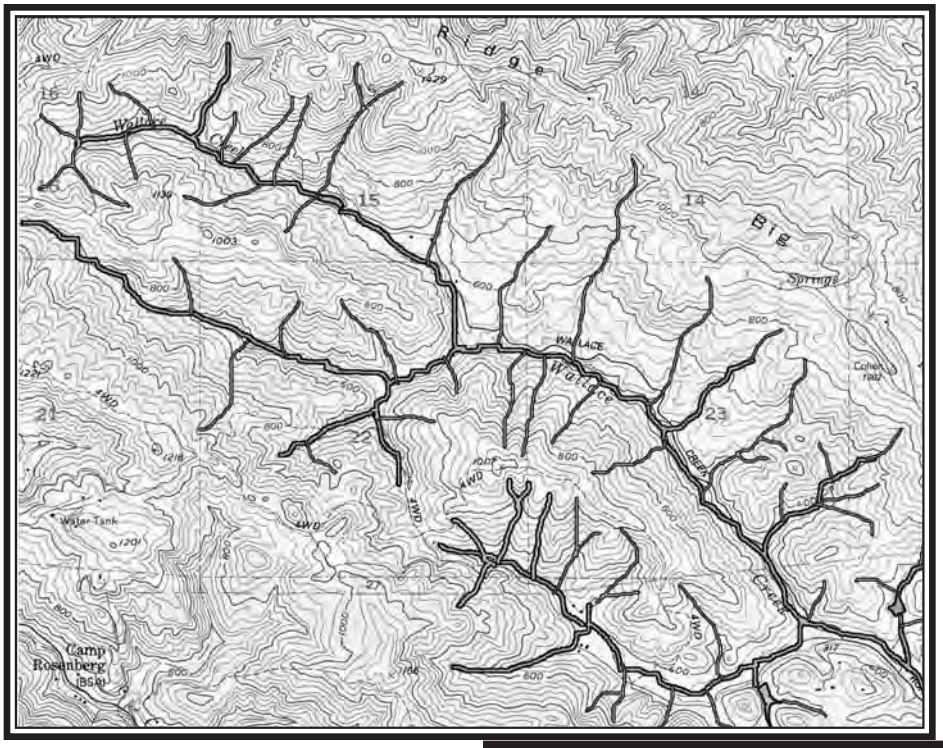


YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED



EPHEMERAL CREEKS AS WELL AS YEAR-ROUND AND INTERMITTENT STREAMS OUTLINED

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EXAMPLE OF TOPOGRAPHIC MAP
WITH CREEKS OUTLINED

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supply sediment and flood flows to fish bearing streams. Restoring and managing ephemeral drainages is often the best method to reduce sediment delivery to creeks.

Site Inventory: Natural Drainage Features

- ❑ Delineate the year round and seasonal streams on the site from your USGS topo map. Year round streams are indicated with solid blue lines. Seasonal creeks are indicated with dashed blue lines. Although the topo quads are very accurate maps, it is not unusual for a creek indicated blue as year round, to dry up in the summer. The maps are based on aerial photographs from a particular year and season and are field checked for general accuracy. Each map does not necessarily depict creek flow conditions for every year correctly. The year the map was completed as well as any updates are indicated at the bottom of the quad sheet. Element VI addresses management and restoration of major creeks on the property. Give any unnamed creeks a separate letter, number or name.

- ❑ Delineate the ephemeral creeks on the property. The creeks on a hillside property are not delineated on USGS topographic quads. Ephemeral, or temporary, creeks are not indicated in blue, but can be delineated by reviewing topographic contour lines on the map. To delineate the system of ephemeral creeks involves reviewing the contour lines on the topographic map for where the lines indicate a set of V's pointing up the slope. Trace as many of these V's on the hillside as possible then check your delineation with the aerial to make sure you have found all the ephemeral creeks. Give each ephemeral creek a separate letter, number, or name.

- ❑ Delineate any seeps, springs, or wetlands on the property.

- ❑ Delineate areas where natural drainages have been changed as part of the vineyard drainage system as described in Section 8.

- ❑ Estimate the distance of the vineyard edge to the outer canopy of the stream corridor, or natural vegetation, along the creek and to the edge of the actual channel.

- ❑ Fill in the table regarding the general condition of each creek.

ASSESSMENT OF CURRENT VINEYARD MANAGEMENT PRACTICES

5. COVER CROPS

Background: Cover Crops

Cover crops are the grasses, legumes, and forbs planted in the vineyard to protect soil from erosion. Cover crops are selected with the goal of providing particular benefits to the vineyard. A permanent cover crop differs from the temporary cover crop planted when installing the vineyard in that the permanent cover crop must provide both soil protection and be fine-tuned for compatibility with grape or fruit/nut production for each particular vineyard/orchard.

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COVER IN VINE ROWS MAY BE STRIP SPRAYED TO REDUCE COMPETITION WITH VINES.

ALL AREAS OF THE VINEYARD SHOULD HAVE COVER CROPS IN THE WINTER TO REDUCE SOIL EROSION.

COVER CROPS SHOULD COVER ALL AREAS OF TERRACES.

INSECTIARY PLANTS FOR COVER CROP TO ATTRACT AND SUPPORT BENEFICIAL INSECTS

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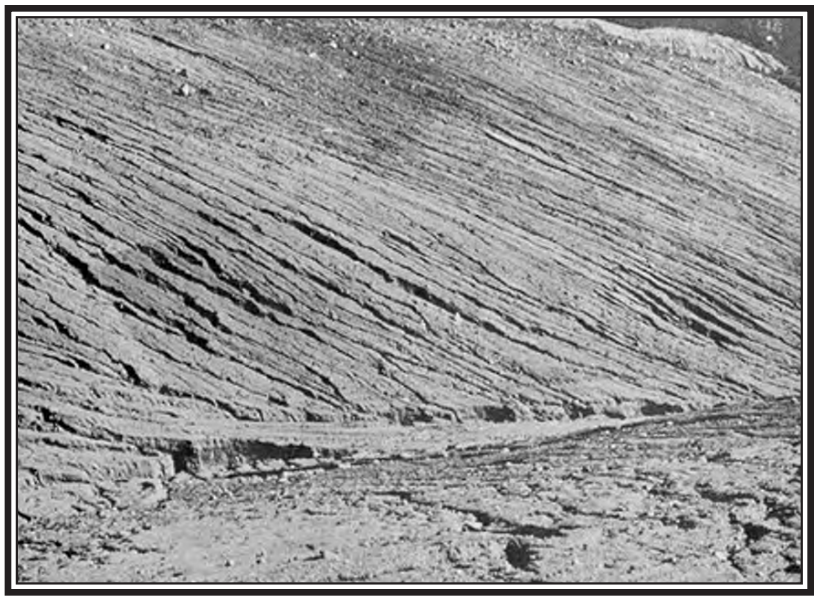
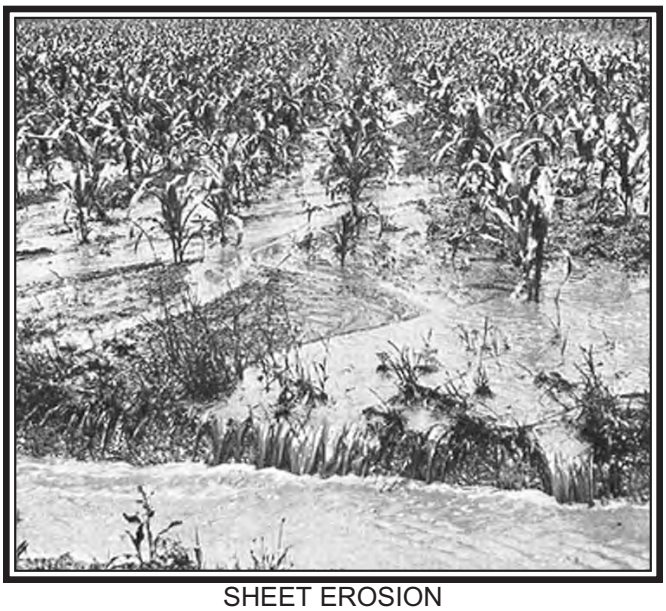
RAINSTRIKE OR SHEET EROSION



RILL EROSION

GULLY EROSION



SHEET EROSION

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Hillside vineyards cannot tolerate significant soil erosion before loss of productivity can occur. Cover crops are the most cost-effective method to cover the soil with dense vegetation and reduce the effects of rainstrike, or sheet erosion, on bare soil. In addition, cover crops, particularly deep-rooted species, can increase water infiltration (in the winter) and reduce the potential for surface runoff and gullying of the vineyard.

Cover crops may be annual, or perennial, mowed or disked during the growing season. Plant species can be selected for a variety of features and management schemes. Cover crops offer the grower an opportunity to protect soil and improve many other factors in the vineyard. The vineyard manager should evaluate his/her goals in choosing cover crop species. Perennial cover crops provide the greatest degree of erosion control and can be the least expensive once established. Annuals managed with a no-till system can also protect soil, but may be less effective than perennials in early season storm events.

The benefits of permanent cover crops include:

- Reduction of soil erosion from wind and water
- Suppression of dust and reduced mite problems
- Increased infiltration of rainwater and reduction in the potential for sheet erosion
- Addition of nitrogen to low fertility soils
- Decrease in soil compaction and increase in infiltration
- Reduction of overly vigorous vine growth in highly fertile valley vineyards through managed competition between the grapevines and the cover
- Reduction of soil temperatures and air temperatures in the vine micro-climate
- Encouragement of beneficial insect populations
- Increase in the accumulation of organic matter in the soil and improvement of soil structure
- Increased ability to drive and use equipment in the vineyard earlier after the rainy season

Tables IIIA through IIIC list the features, planting and management needs for many cover crop species. Each vineyard manager should try out different mixes until the best mix for the particular vineyard with its particular soil types and conditions is identified.

<u>Assessment: Cover Crops</u>

- ❑ On the Farm Conservation Plan template, describe your current use of cover crops including:
  - ❑ Where you actively plant cover crop seed, where you have perennial cover crops, where you allow natural vegetation to grow as cover

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- ❑ How often you re-seed
- ❑ What seed mixes you have used and why you chose them (cost, availability, deep rooted, annuals vs. perennials, nitrogen needs etc.)
- ❑ If you allow natural vegetation to grow and become the cover
- ❑ If you mow or disk the cover, when do you begin and how often in a season
- ❑ If you spray in the vine rows, with what materials and how often
- ❑ If you mechanically control weeds in the vine row describe methods
- ❑ If you vary management or have changed practices recently, make a note of the changes and why you've made them

❑ Be as detailed and accurate as possible.

❑ Take photos of each vineyard with cover crops.

APPLYING VINEYARD MANAGEMENT BMPS: COVER CROPS

❑ A primary goal of planting a cover crop is to create a dense protective cover of plants to protect the soil. Grasses alone may work well or a combination of grasses, legumes and natural vegetation. Before planting, evaluate the natural species in the vineyard. If there are plants such as Bermuda grass, Harding grass, or Timothy grass that are invasive, they should be eradicated prior to seeding a cover crop. You may also want to evaluate using a perennial cover crop that may take longer to establish but is less water consumptive and less maintenance.

❑ Set goals for the use of cover crops in different areas of the vineyard. These might include species with low water needs and low competition, use of flowering species to attract certain beneficial insects, some vineyard blocks might benefit from managed competition from vigorous cover species, other blocks may benefit from nitrogen enrichment with legumes and tillage. Decide upon your goals and choose a mix of species.

❑ Seed the cover crop between September 15 and October 15 or earlier to assure that sufficient coverage is achieved before the rains.

❑ Cover crops should cover "all areas" of the vineyard during the winter from October 15 through the end of April or later if the rainy season is longer. "All areas" is defined as the "middles", or the area between the vine rows, in the vine row and, for terraced vineyards, both the flat and the slope, or face, of each terrace. Turnarounds, or headlands, roads and buffer areas should also be planted, or covered, with straw mulch as part of the winterization process. If winter access is needed, gravel should be placed on roads.

❑ Fertilizer may be needed to stimulate growth and be applied with the cover crop seed. Legume seeds should be inoculated with rhizobium. Check the PLS (pure live seed)

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rating of your cover crop seed to make sure you are using a rating of 80% or better, or germination may be poor.

- ❑ Planting methods include broadcasting seed mix and fertilizer over the site, drilling with a seed drill, and broadcast over steep areas with a helicopter. Broadcast seed with an ATV, tractor-mounted seeder, or hand equipment for small areas. Mulching with straw and rolling of mulch should also be done if seed is planted late in the season. Compost can also be used as mulch if readily available.

- ❑ Hydro-seeding involves application of seed, fertilizer and a tacking agent in a slurry sprayed onto the site. This method allows for the slope face of the terrace vineyard to be seeded. This method requires very specific mixes of seed, tacking agent, fertilizer and water for different equipment and materials. Check with a hydro-seed and fertilizer manufacturer. Mulch may also be included in the hydro-seed mix and may be required if applications are made after October 15.

- ❑ Certain erosion control blankets combined with seed, hydro-seeding, or erosion control products that include seed can be the most effective method for establishing cover on the terrace face and other steep areas. A broadcast seeder that is fully opened and mounted on an ATV can also seed the terrace face if a high concentration of seed with fertilizer is used.

- ❑ Managing the cover crop may include disking, mowing, or a combination. Disking involves turning all ground cover into the soil after seed has matured or turning a portion of the ground cover into the soil and leaving some materials on the surface. Pruning and plant residues may also be disked in. Mowing operations for cover crops may be timed to minimize frost danger, to reduce competition with vines and later in the season, to encourage re-seeding of the site. On steep sites before all chance of rain has passed, mowing, not disking, should be done if the cover crop needs management. Disking should not be started until the late spring and after the ground has dried. Perennial or annual covers managed through mowing are the preferable method for hillside vineyards.

- ❑ When first seeded, the desired plant species may face competition from broadleaf weeds and other grasses. Mowing before seed set and selectively applying herbicide can remove any unwanted plants and assist the seeded plants to establish.

- ❑ Every other row may be disked prior to seed set to remove the undesired plants. The disked row should then be reseeded with cover crop. Monitor the cover plants to determine the best time for mowing. Not all species reseed easily and may require replanting each year. Establishing a no-till cover crop appropriate for your vineyard may be far easier to manage overtime.

- ❑ It is not desirable to have cover crops directly beneath the grapevines during the growing season, particularly in young vineyards. Many growers strip spray this area early in the season with low concentration Round-up and retain the mulch from the cover crop to protect the soil. Spraying is done before the vines leaf out.

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TABLE IIIA - PERENNIAL COVER CROPS FOR USE WITH NO TILL MANAGEMENT

COVER CROP	Strawberry Clover	White Clover	Birdsfoot Trefoil	California Brome	Blue Wildrye	Meadow Barley
SCIENTIFIC NAME	*Trifolium fragiferum*	*Trifolium repens*	*Lotus corniculatus*	*Bromus carinatus*	*Elymus glaucus*	*Hordeum brachyantherum*
SUGGESTED CULTIVARS	O'connors Legume, Salina	New Zealand White Dutch	Empire, Viking	California brome	Berkeley	Meadow Barley
SEEDING RATE (LBS./ACRE)	5-15	5-15	5-10	10-20	10-15	20-30
POTENTIAL NITROGEN (LBS. PRODUCED per ACRE)	30-60	30-60	30-60	0	0	0
TOLERANT TO TRAFFIC	Yes	Yes	Yes	Yes	Yes	Yes
WEED COMPETITION	Fair to Good	Fair to Good	Good to Very Good	Good to Very Good	Good to Very Good	Fair to Good
REQUIRES SPRING MOWING	Yes	Yes	Yes	Yes, post seedset	Yes, post seedset	Yes, post seedset
FERTILIZERS	Ca, P, K, S	Ca, P, K, S	Ca, P, K ,S	N	N	N
CANOPY HEIGHT	Low, 3"-12"	Low, 6"-12'	Low to Medium	High, 12" -30"	Medium-High	Medium-High
OTHER FEATURES	Slow to start; can withstand water logging; use in conjunction with grasses for best erosion control	Slow to start	Slow to start; tolerates many soil types- alkaline and saline;	Vigorous native grass; slow to establish but long-lived; attracts beneficial insects if planted with legumes; summer dormant, little water uptake	Vigorous native grass; slow to establish but long-lived; attracts beneficial insects if planted with legumes; summer dormant, little water uptake	Vigorous native grass; slow to establish but long-lived; attracts beneficial insects if planted with legumes; summer dormant, little water uptake

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TABLE IIIA (cont.) - PERENNIAL COVER CROPS FOR USE WITH NO TILL MANAGEMENT

COVER CROP	Tall Fescue	Perennial Ryegrass	Red Fescue	Idaho Fescue	Sheep /Hard Fescue	Orchard Grass
SCIENTIFIC NAME	*Fescue Arundinacea*	*Lolium perenne*	*Festuca rubra*	*Festuca idahoensis*	*Festuca ovina*	*Dactylis glomerata*
SUGGESTED CULTIVARS	Many	Many	Many	Many	Covar	Potomac; Palestine; Paiute
SEEDING RATE (LBS./ACRE)	15-25	40-50	15-40	15-25	15-25	15-25
POTENTIAL NITROGEN (LBS. PRODUCED per ACRE)	0	0	0	0	0	0
TOLERANT TO TRAFFIC	Yes	Yes	Yes	Yes	Yes	Yes
WEED COMPETITION	Very Good to Excellent	Very Good to Excellent	Fair to Good	Fair to Good	Fair to Good	Good to Very Good
REQUIRES SPRING MOWING	No	No	No	No	No	Yes
FERTILIZERS	N	N	N	N	N	N
CANOPY HEIGHT	Low-Medium 6"-18"	Low to Medium	Low 6"-12"	Very Low 3"-6"	Very Low 3"-6"	Low to Medium
OTHER FEATURES	Vigorous; can tolerate many extreme conditions	Vigorous; may compete with vines; mix with clover and trefoil	Low growth habit; meadow-like effect with legumes; resistant to poast herbicide	Low growth habit; meadow-like effect with legumes; resistant to poast herbicide	Low growth habit; meadow-like effect with legumes; resistant to poast herbicide	Vigorous; high water uptake- may compete with vines; not recommended

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TABLE IIIB - ANNUAL COVER CROPS FOR USE WITH NO-TILL MANAGEMENT

COVER CROP	Subterranean Clover	Rose Clover	Crimson Clover	Zorro Fescue	Blando Brome	Annual Ryegrass	Bur Clover Bur Medic
SCIENTIFIC NAME	*Trifolium subterraneum*	*Trifolium hirtum*	*Trifolium incarnatum*	*Festuca megalura*	*Bromus mollis*	*Lolium multiflorum*	*Medicago polymorpha*
SUGGESTED CULTIVARS	Karridale; Koala; Trikkala; Junee; Clare	Hykon; Overton; Wilton	Dixie; Flame	Same	Same	Gulf; Common	Santiago (no burs); Circle valley
SEEDING RATE (LBS./ACRE)	20-30	15-20	20-30	10-15	10-12	60-90	15-20
POTENTIAL NITROGEN (LBS. PRODUCED per ACRE)	30-60	30-60	30-60	0	0	0	30-60
TOLERANT TO TRAFFIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WEED COMPETITION	Good to Excellent	Fair to Good	Good to Excellent	Good	Good to Excellent	Excellent	Good to Excellent
REQUIRES SPRING MOWING	Yes	Yes	No	Yes	Yes	Yes	Yes
FERTILIZERS	Ca, P, K, S	Ca, P, K, S	Ca, P, K, S	N	N	N	Ca, P, K, S
CANOPY HEIGHT	Low 6"-12"	Low 6"-12"	Medium	Low 6"-12"	Low 6" -12"	Low 6"-12"	Low 6"-12"
OTHER FEATURES	Self seeding; use with grasses for erosion control	Flowers host beneficial insects; use with grasses for erosion control	Attracts lady bugs; use with grasses for erosion control; re-seeds well	Very light seed use coated type; excellent re-seeder if mowed correctly	Excellent re-seeder; supports predatory mites	Rapid growth and late maturity; may compete with vines	Self seeder; tolerates clayey and sandy soils

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TABLE IIIC - ANNUAL COVER CROPS FOR USE WITH TILLAGE MANAGEMENT

COVER CROP	Phacelia	Purple Vetch	Common Vetch	Lana Vetch	Field Peas	Berseem Clover
SCIENTIFIC NAME	*Phacelia sp.*	*Vicia benghalenis*	*Vicia sativa*	*Vicia dasycarpa*	*Pisum sativum*	*Trifolium alexandrinum*
SUGGESTED CULTIVARS	Phaci	Purple Vetch	Common Vetch	Lana Vetch	Magnus; Miranda; Austrian Winter Peas	Multicut
SEEDING RATE (LBS./ACRE)	15-30	50-60	60-75	50-75	20-70	15-20
POTENTIAL NITROGEN (LBS. PRODUCED per ACRE)	0	150	150	150	120	200
TOLERANT TO TRAFFIC	Yes	No	No	No	No	Yes
WEED COMPETITION	Very Good	Good to Excellent	Good to Excellent	Good to Excellent	Good to Excellent	Good to Excellent
REQUIRES SPRING MOWING	No	No	No	No	Yes	Yes
FERTILIZERS	N, P	Ca, P, K, S	Ca, P, K, S	Ca, P, K, S	Ca, P, K, S	Ca, P, K, S
CANOPY HEIGHT	Low 12"-14"	Sprawling 18"-24"	Sprawling 18"-24"	Sprawling 18"-24"	Sprawling 18"-24"	Medium 12"-24"
OTHER FEATURES	Supports blue orchard bee, hover flies	Tolerates waterlogging; establishes quickly; attracts aphidophagous hover flies, parasitic wasps; resistant to root knot nematodes; use with grasses for erosion control	Tolerates many soil types but needs good drainage; attracts aphidophagous hover flies, parasitic wasps; use with grasses for erosion control	Quick to establish; aggressive climber; supports blue orchard bee, parasitic wasps, aphidophagous hover flies; self-seeding; use with grasses for erosion control	Not self seeding; intolerant of drought and water logging; supports pea aphid and aphidophagous insects; use with grasses for erosion control	Does best with multiple mowing; does not self seed

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TABLE IIIC (cont.) - ANNUAL COVER CROPS FOR USE WITH TILLAGE MANAGEMENT

COVER CROP	Barley	Oats	Fava (bell) Beans	Mustard
SCIENTIFIC NAME	*Hordeum vulgare*	*Avena sativa*	*Vicia faba*	*Brassica sp.*
SUGGESTED CULTIVARS	Uc 476	Cayuse; swan	Diana, many	Many
SEEDING RATE (LBS./ACRE)	60-90	60-90	190-200	5-12
POTENTIAL NITROGEN (LBS. PRODUCED per ACRE)	0	0	10	0
TOLERANT TO TRAFFIC	No	No	No	No
WEED COMPETITION	Good to Excellent	Good to Excellent	Fair to Good	Good to Excellent
REQUIRES SPRING MOWING	Yes	Yes	Yes	No
FERTILIZERS	N, P	N, P	Ca, P, K, S	N, P
CANOPY HEIGHT	Tall 30"- 60"	Tall, 30"- 60"	Tall, 30"- 60"	Tall, 12" - 60"
OTHER FEATURES			Attracts beneficial insects: lacewings ichneumonid wasp; does not self seed	Attracts: hover flies and honeybees; tilling produces less soil improvements than other crops, use with grasses for erosion control

Information for these tables is derived from: Cover Crops for North Coast Vineyards - Glen McGourty, Practical Winery and Vineyard, August 1994; Cover Crop Profiles, UC Sustainable Agriculture Research and Education Program 1996; Hillside Vineyard Cover Corp Demonstration Planting Report 1983-1984, NRCS; Cover Crops: Resources for Education and Extension, UC Sustainable Agriculture Research and Education Program,1997; Selecting the Right Cover Crop Gives Multiple Benefits, Chuck Ingels, California Agriculture October 1994; Robert Bugg UC Sustainable Agriculture Research and Education Program, Entomological Aspects of Vineyard Cover Cropping; Robert Bugg UC Sustainable Agriculture Research and Education Program, Farmscaping with Insectary Plants; Valley Habitats: Establishing Permanent Grassland Habitat with California Native Perennial Grasses; and many other articles.

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Certain pre-emergent herbicide sprays such as Simizine are not recommended due to their leaching into groundwater. Other pre-emergent herbicides like Goal or Chateau are allowed. Mechanical methods such as French ploughs and similar equipment, or burners, are available for controlling and reducing the vigor of the cover in the vine row.

- ❑ It may be useful to keep records of the cover crops you plant, the quantities of seed planted, how well it grew, what types of other weeds invaded and how well it did with traffic, etc. Also keep records of what mowing was needed and what spraying and irrigation was used. Record both the tonnage and quality for the block and evaluate which mix seems to work best. At the end of each season evaluate your records and change, or fine-tune, your cover crops and your management.

- ❑ Some cover crops allow for gophers and voles to live in the vineyard. Increasing the predatory bird population can help to control these rodents. Specifications for the construction of raptor and owl roosts and other activities to increase beneficial wildlife in the vineyard are available by request. In some cases, limited disking of every third row, every third year is done to control rodents and reduce build-up of vegetation.

6. TILL/NO-TILL MANAGEMENT

Background: Till/No-Till Management

For many decades the area beneath trees and vines in orchards and vineyards was tilled each year to clear it of any undergrowth and keep the area "clean". In recent years with more hillside vineyard development, the need for protective cover crops to conserve soil has changed views of how the vineyard floor should be managed.

No-till farm management involves leaving a cover of plant material over the soil year round. For vineyards this can be achieved through the use of permanent cover crops that are mowed with additional mechanical, or chemical control, in the vine row. The advantages of a no-till system of management include: less soil erosion, improved water infiltration, less dust, less compaction of soils, the potential to attract beneficial insects, and support beneficial microorganisms in the soil. Some of the disadvantages of a no-till operation include: increased need for water if certain cover crops are used, the potential for more rodents in the cover crop and the potential for competition between the cover crop with the vines. The vineyard field roads and turnarounds should not be tilled as this practice provides no improvement to the vines and increases sheet erosion.

Assessment: Till/No-Till Management

- ❑ On the Farm Conservation Plan template describe your current tilling practices for each vineyard area including:

  - ❑ What parts of the vineyard you till and why?

  - ❑ Describe the frequency of tilling. Do you till every row every year, every other row, every third row or some other method?

  - ❑ If you use no-till how often do you mow, clear the vine row by mechanical means or spray?

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SUMMER TILLAGE OF COVER CROPS
IN VINEYARD.

MOWING RATHER THAN TILLING COVER IN THE SPRING WILL REDUCE FROST PROBLEMS AND AVOID DISTURBING SOIL PRIOR TO THE END OF THE RAINY SEASON

VINEYARD WITH DENSE
COVER CROP AND
VEGETATED SWALE

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- ❑ If you vary management or have changed practices recently make a note of the changes and why you've made them.

APPLYING VINEYARD MANAGEMENT BMPS: TILL/NO-TILL MANAGEMENT

- ❑ No-till management decreases the potential for soil loss and sediment in creeks from rainstrike and wind erosion and is the preferable management practice for many steep hillside sites. No-till practices also increase infiltration and reduce the potential for concentrated flow and gully erosion.

- ❑ The major goal is to protect soil during the rainy season, tillage of the vineyard during the summer with cover crops on the vineyard for the winter is also acceptable.

7. WINTERIZATION OF VINEYARD ROADS AND TURNAROUNDS AND INSTALLATION OF FILTER STRIPS

Background: Winterization Practices

In addition to cover crops for the vineyard floor, all vineyard field roads and turnarounds, or headlands, should be winterized. If the field road is located between the vineyard and a creek, or swale, it can be densely seeded and serve as a filter strip to collect eroded sediment before it reaches the waterway. The area between any creek and a vineyard should be managed as a filter strip to collect sediment. The field roads and turnarounds should not be tilled unless a cover crop is being planted.

Some cover crop species such as fescue and others (see Tables IIIABC) can handle light traffic and are good choices for field roads and turnarounds. Filter strips need dense grass for best performance and need to be wide enough to slow and filter the runoff from the slope above.

If the main vineyard road is in close proximity to the creek corridor or swale edge and must be used all year, consider relocating it to the middle of the vineyard. Or use another field road in the vineyard away from the stream for the year round access road and manage the road near the corridor as a filter strip.

Assessment: Winterization Practices

- ❑ On the Farm Conservation Plan template describe your winterization practices for all vineyard avenues, seasonal field roads, and vineyard turnarounds including:

  - ❑ Whether you actively seed avenues and turnarounds with cover crops

  - ❑ When you seed, in what month

  - ❑ Whether you let natural vegetation invade

  - ❑ When you winterize

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VINEYARD ACCESS ROAD ALONG BOTH SIDES OF STREAM CAN EASILY ADD SEDIMENT TO STREAM AND BE ERODED BY FLOOD FLOWS. ACCESS ROAD SHOULD BE RELOCATED AWAY FROM CREEK EDGE.

RAILCAR BRIDGE IN BACKGROUND IS A GOOD MEASURE FOR STREAM CROSSINGS.

SOME COVER CROPS ARE LOW GROWING AND GOOD FOR ROAD WINTERIZATION.

VINEYARD ROAD LOCATED AWAY FROM WATERWAYS

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- ❑ Whether you gravel any road areas

- ❑ Whether you actively establish filter strips next to creek corridors and with what plants

- ❑ Where do you mow, or spray, roads and turnarounds, at what time of the year and what materials you use?

- ❑ If you vary management, or have changed practices recently, make a note of the changes and why you've made them.

APPLYING VINEYARD MANAGEMENT BMPS: WINTERIZATION

- ❑ Actively seed field roads and turnarounds with dense grasses to protect against rainstrike erosion.

- ❑ Field roads and turnarounds should be seeded with fast growing grasses no later than October 15 to promote development of a dense cover crop prior to heavy winter rains. If harvest occurs later than October 15, install temporary erosion control practices such as straw bale barriers between the road and the creek to intercept sheet wash from early rains. Species commonly used for winterization of field roads and turnarounds are Zorro fescue, hard, sheep or red fescue, soft chess, or blando brome. Blando brome is established by seeding at 6 lbs. per acre and is adapted to many climatic conditions. Zorro fescue is established by seeding at 10 lbs. per acre and grows very quickly. These species work effectively to protect soil by rapid germination after rains and developing a dense growth habit. Both species die back during summer and may require re-seeding for the next winter. Seed with fertilizer is more effective. Mulch roads with straw as well and install waterbars on slopes over 10%. For roads with year round use, gravel may be needed.

- ❑ Incorporate filter strips into the vineyard at the base of each vineyard slope and between the vineyard and waterways to catch sediment.

  - ❑ **Filter Strip** - A strip of dense grass or other vegetation between the vineyard site and waterway that serves as an additional protection against siltation in streams. Surface flows carry soil through the filter strip before reaching the waterway. The dense grass slows the water and catches the sediment providing another protective measure.

    The filter strip should include these features:

    - ❑ Filter strips should be planted along all edges of the vineyard adjacent to waterways. These areas are typically the lower edge of the vineyard between the vineyard and the vegetation of the waterway. Filter strips may also be used across the vineyard slope between blocks of vines as an additional practice to reduce sediment movement though sheet flow.

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Fish Friendly Farming
Environmental Certification Program

FILTER STRIPS OF DENSE GRASSES AT THE BASE OF A VINEYARD CAN PROTECT WATERWAYS FROM SEDIMENTATION. STRIP MUST BE SIZED FOR SLOPE OF THE VINEYARD.

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- ❑ The size of the filter strip varies according to the slope of the drainage into the filter strip. The filter strip should be at least 10 ft. for slopes of less than one percent and proportionately increased in size up to at least 25 ft. or greater for 30% slopes.

- ❑ Plant the filter strip in September to allow for adequate vegetative cover to develop. Plant density should be a minimum of 60% and may consist of annual grasses, or if the area will not be mowed or driven on, perennial grasses. Fertilization and irrigation may be needed.

- ❑ Do not mow the filter strip until the late spring to provide the greatest degree of protection.

- ❑ Depending on the site, the filter strip area may be further enhanced as a permanently vegetated buffer. If the area will not be mowed or driven on, native species can be used and chosen carefully to promote beneficial insects or block the movement of pest insects. However the use of these additional plants should not reduce the basic cover of grasses needed for catching sediment.

- ❑ Additional amenities such as bat boxes, raptor and owl roosts may increase wildlife values and take advantage of the benefits of these animals for control of insects and rodents.

8. VINEYARD DRAINAGE SYSTEM

Background: Drainage System

Underground pipes, inlets and outlets, perforated pipe, terraces and ditches must be inspected and maintained on a regular basis. One small problem in the system may cause water to back up and blow out another part of the system. If kept in good shape the system will operate as it was designed and problems can be avoided.

Assessment: Vineyard Drainage System

On the Farm Conservation Plan template, describe the features of your in-vineyard drainage system.

- ❑ Take photos of all the inlets, above ground features, outlets and energy dissipaters.

- ❑ Indicate the type of system for each vineyard area by number.

- ❑ On a copy of the aerial photo indicate where the drainage system is in each vineyard area. Indicate an **O** for each inlet, || for underground pipes, **X** for outlets, **D** for energy dissipaters or stilling basins, **= =** for above ground diversions including diversion ditches, grassed, or lined, waterways, or pipe drops. Indicate any permanent sediment basins. The FFF program staff will assist with this map.

- ❑ Indicate the area of the vineyard the drainage system serves and its outlets.

- ❑ Indicate if there is an energy dissipater at each outlet and any erosion.

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- ❑ Include the plans/specifications for the drainage system, if available, including the size diameter of all pipes, inlets and outlets and the size storm event the system is sized to handle if this feature is known.

- ❑ Indicate all vineyard areas that have no drainage system.

- ❑ Describe your yearly maintenance program for the drainage system including:

  - ❑ Debris removal from inlets and outlets

  - ❑ Inlet inspection, resetting and repair

  - ❑ Outlet inspection, energy dissipater replacement and repair

  - ❑ Repair of ruts and other changes on terraces

  - ❑ Reseeding of grassed waterways

- ❑ Time of year for maintenance program

- ❑ Describe your winter inspection program and emergency management actions for the drainage system

- ❑ Describe problems with the system. This will help to determine if the system is sized correctly and has occasional problems, or is in need of some replacement or upgrade.

  - ❑ Blowouts, or failures, of inlets, pipes, terraces, outlets, ditches or lined waterway

  - ❑ Slips, or erosion sites, in any installed channel, or natural waterway

  - ❑ Indicate how often each site has problems

Also describe:

- ❑ Repairs made on each site and how successful each has been

- ❑ Future planned upgrades to install drainage. Indicate these sites on the aerials and describe the type of system to be installed or type of upgrade.

APPLYING VINEYARD MANAGEMENT BMPs: VINEYARD DRAINAGE SYSTEM MAINTENANCE

Timing

- ❑ Inspect all the parts of the installed drainage system after harvest and before cover crop seeding.

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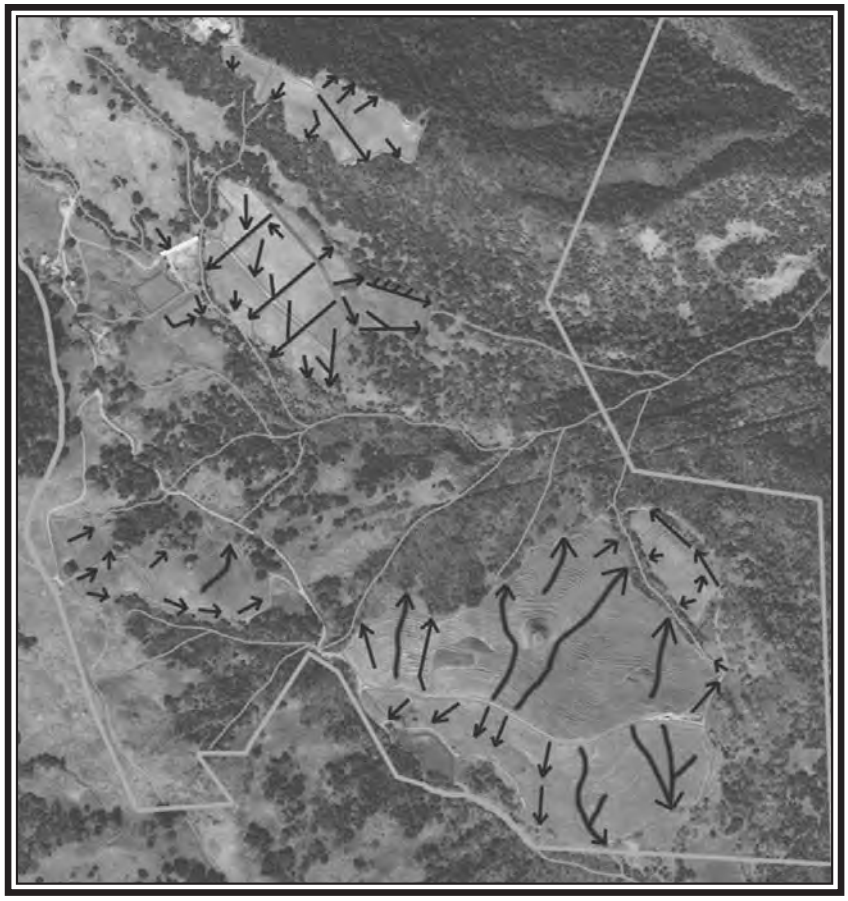

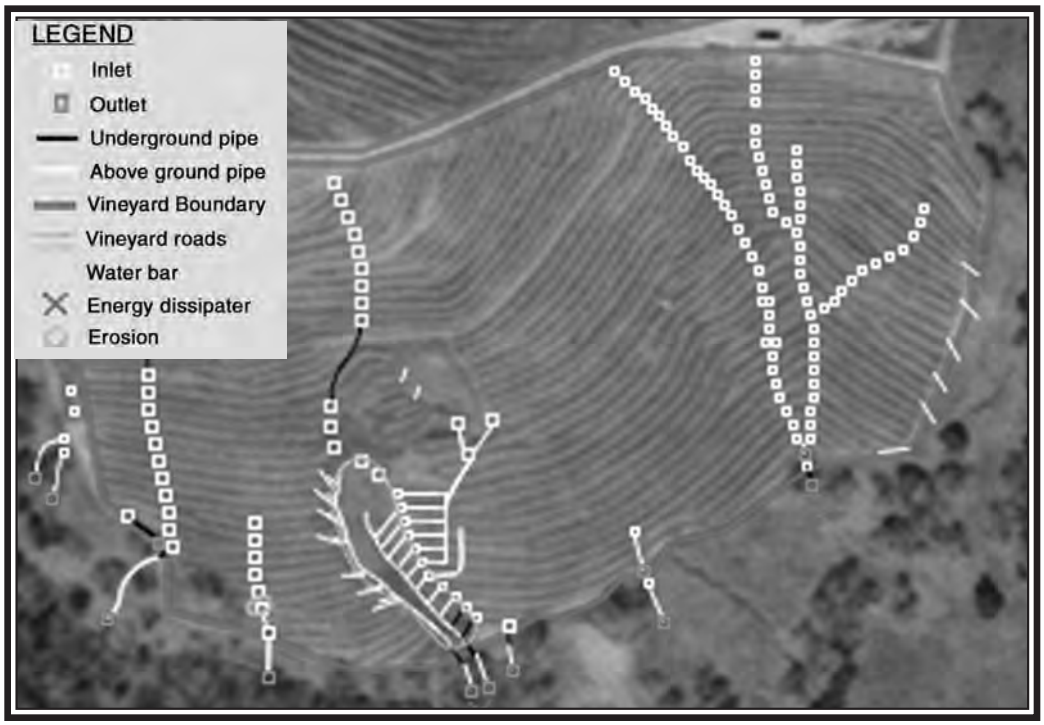

Fish Friendly Farming Environmental Certification Program	FARM PLAN SHOWING VINEYARD DRAINGE MAPS

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- ❑ Complete any re-grading, or other earthwork, before seeding the cover crop. Repairs to ditches and inlets can then be done following seeding.

- ❑ Inspect and maintain the system during and after storms to remove plugs and other problems before they cause erosion or a failure.

- ❑ If a problem has already occurred, implement emergency erosion control measures to keep sediment from entering waterways.

Diversion Ditch

- ❑ Remove sediment and debris before the rainy season.

- ❑ Mow or cut vegetation as needed to reduce fire danger or to open the ditch; do not regularly spray with herbicide. Residual grass or vegetative cover reduces ditch erosion.

- ❑ Repair cracks, holes or leaks promptly.

- ❑ Control gophers and other rodents.

- ❑ Install loose rock dams or rock lining if the bottom of the ditch erodes.

- ❑ Remove material eroded from the sides of the ditch and repair any slips with compacted earth and rock.

- ❑ Ditches with a slope over 8% may have chronic erosion problems and need to be replaced with a different drainage system.

- ❑ Ditches with consistent bank erosion may be too narrow for the slope or amount of water flow. Set banks back and revegetate.

Underground Drainage System

<u>Inlets</u>

- ❑ Remove sediment and debris after each storm. For large or long storms, debris should be removed during the storm period.

- ❑ Repair any damage to inlets and risers before the rainy season.

- ❑ A heavy wire mesh fence, installed for the spring through fall period will reduce the number of animals entering the inlets.

- ❑ A painted post placed between the inlet and equipment areas may reduce vehicle damage to inlets.

- ❑ Lower the inlet and riser if the adjacent ditch level is lowered. This may require a new inlet installation.

- ❑ Inspect, and if needed, repair and replace energy dissipaters at outlets every year.

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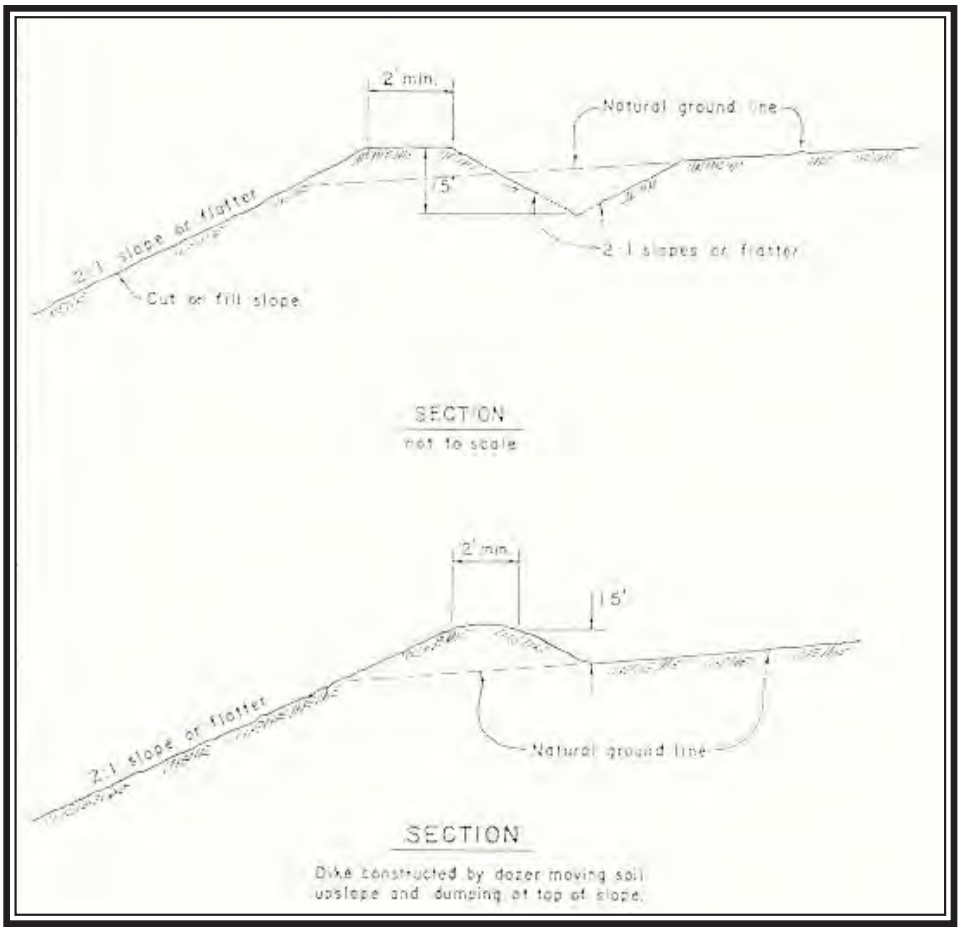

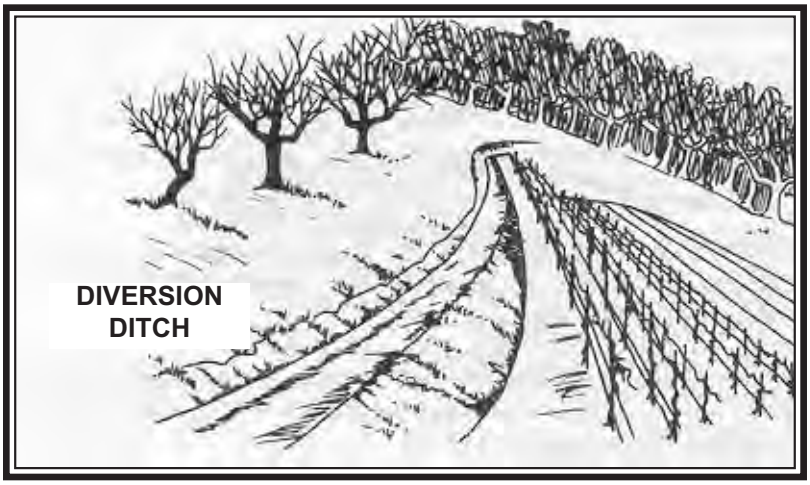

Fish Friendly Farming Environmental Certification Program	DIVERSION DITCHES ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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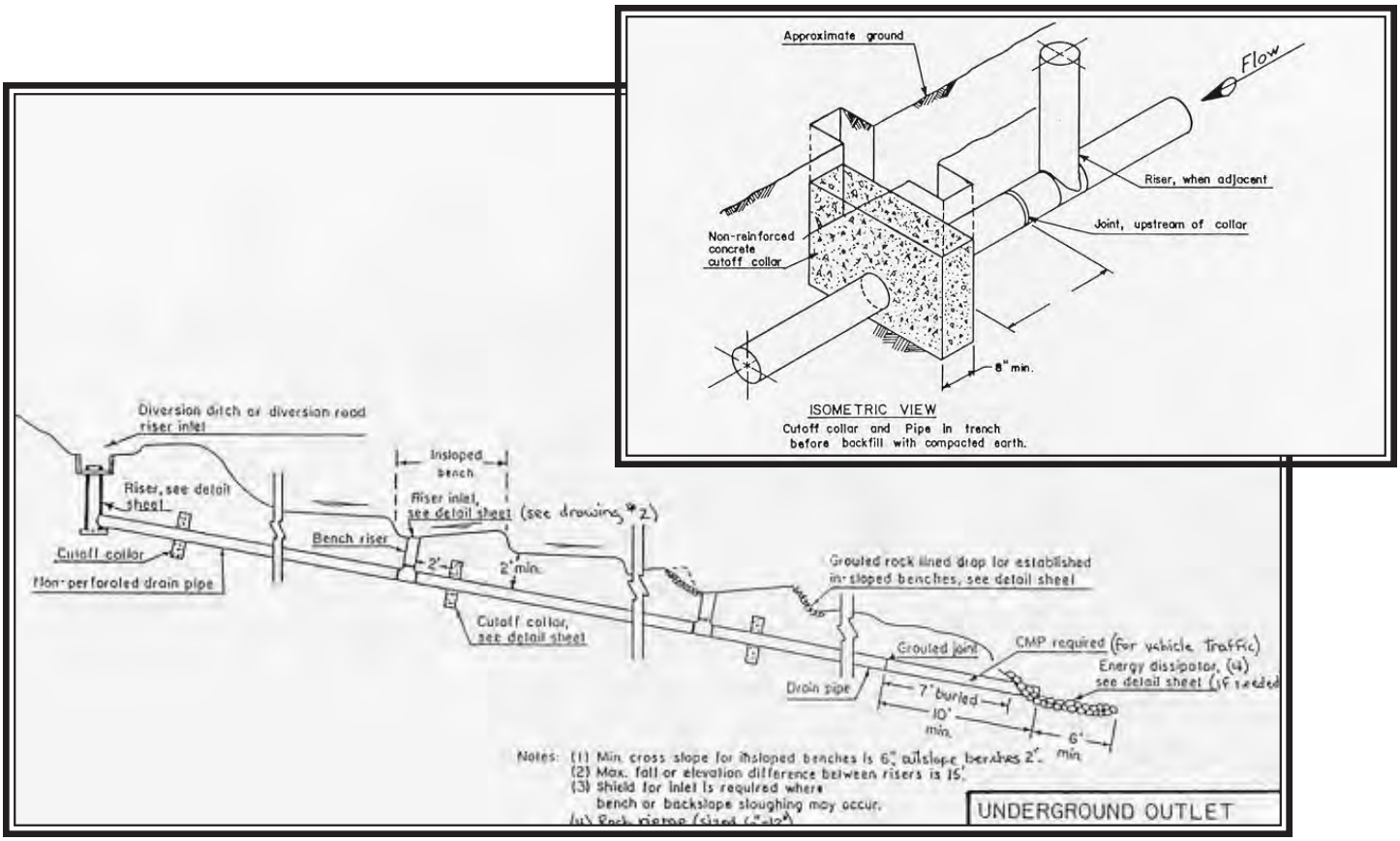

INSTALLING AN UNDERGROUND PIPE

Fish Friendly Farming Environmental Certification Program	UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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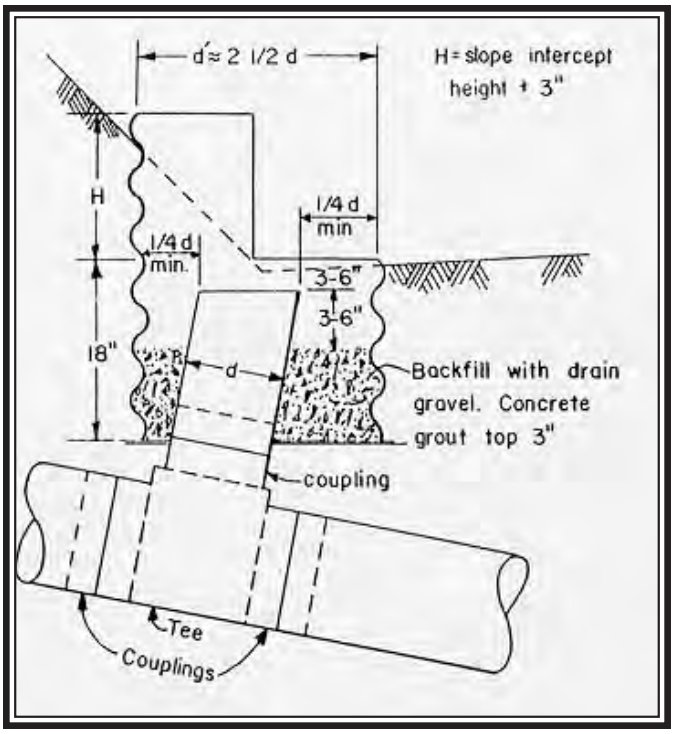

DROP INLETS MUST BE SET IN THE GROUND PROPERLY OR WATER WILL ERODE AROUND THEM. TRASH RACKS ARE ALSO NEEDED AS WELL AS CONSISTENT MAINTENANCE AND WINTER INSPECTIONS.

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INLETS AND UNDERGROUND PIPE SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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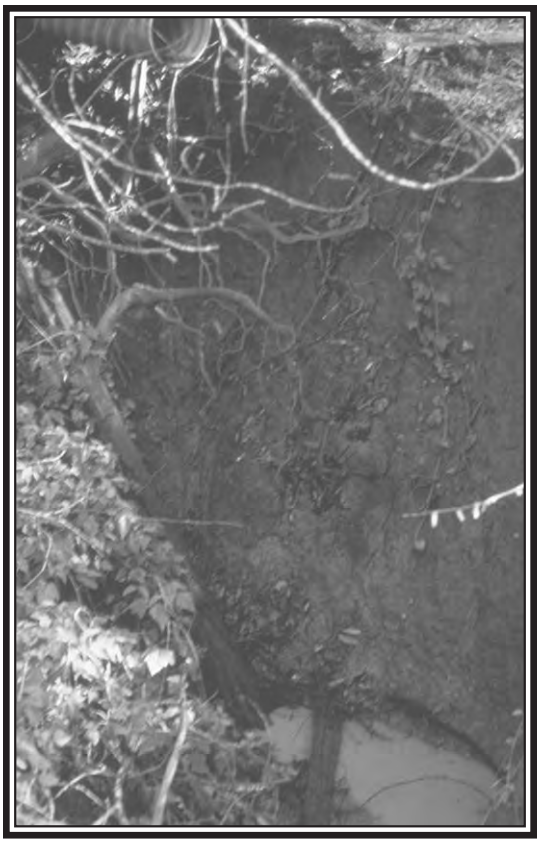
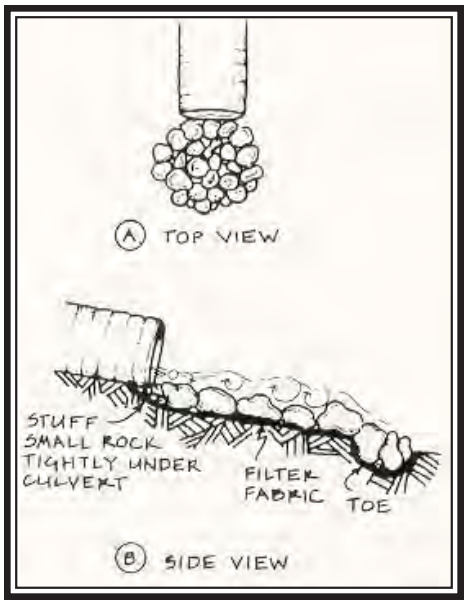
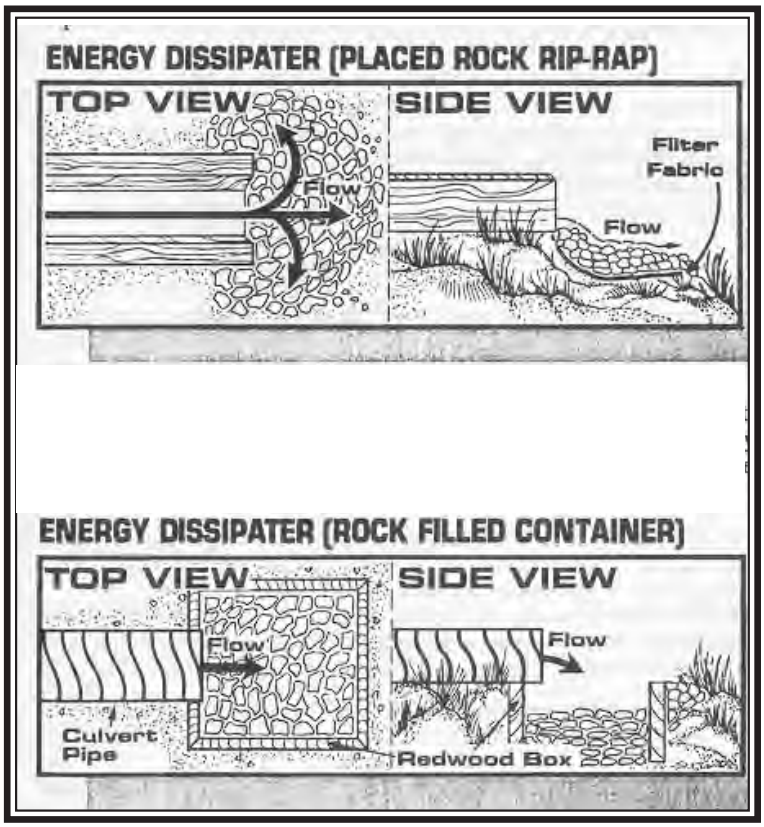


OUTLETS WITHOUT ENERGY DISSIPATERS CAN RESULT IN EROSION.





Fish Friendly Farming Environmental Certification Program	PIPE OULETS AND ENERGY DISSIPATERS. ALL OUTLETS MUST HAVE A PROPERLY SIZED ENERGY DISSIPATER.

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Underground pipes and outlets

- ❑ Repair damage to pipe, cutoff collars, inlets and outlets as they occur.
- ❑ Repair and revegetate with native plants any erosion of natural creeks at outlets.
- ❑ Replace and compact any soil eroded from the pipe trench before the rainy season.
- ❑ Clean sediment and debris from pipeline annually.
- ❑ Check along pipeline for any damaged, or displaced, pipe or joints immediately after large storms while soil still shows leak evidence.
- ❑ Check for soil creep as indicated by bent, or leaning, vines or stakes or large cracks in the ground. If you find these conditions, contact a civil engineer or geologist.
- ❑ Keep design drawings for the drainage system. These will help in repairs and replacement.

Terrace Bench

- ❑ Remove material eroded from the bench backslope if it interferes with the drainage.
- ❑ Benches should be re-graded after cultivation to restore the design slope.
- ❑ Benches should be inspected during large storms to ensure that debris has not accumulated and can cause concentrated flow, or blockage of inlets.
- ❑ No-till benches should be re-graded when sediment or equipment ruts interfere with the waterway, or may cause concentrated flow.
- ❑ Waterbars, or end berms, in benches should be repaired or replaced before winter.
- ❑ Repairs to bench backslopes should be made immediately if damage occurs from faulty or broken irrigation systems.
- ❑ No edge berms should be allowed to remain on outsloped benches.
- ❑ The bench slope and flat areas should be seeded and managed with cover crops during the rainy season.
- ❑ Gopher holes and runs can cause erosion. If numerous, consider aggressive gopher control measures.

Perforated Pipe System

- ❑ Check for any ponding indicating a section of perforated pipe may be clogged.
- ❑ Check for subsidence in pipe areas indicating pipe is crushed.
- ❑ Replace gravel overlying pipe, as needed.

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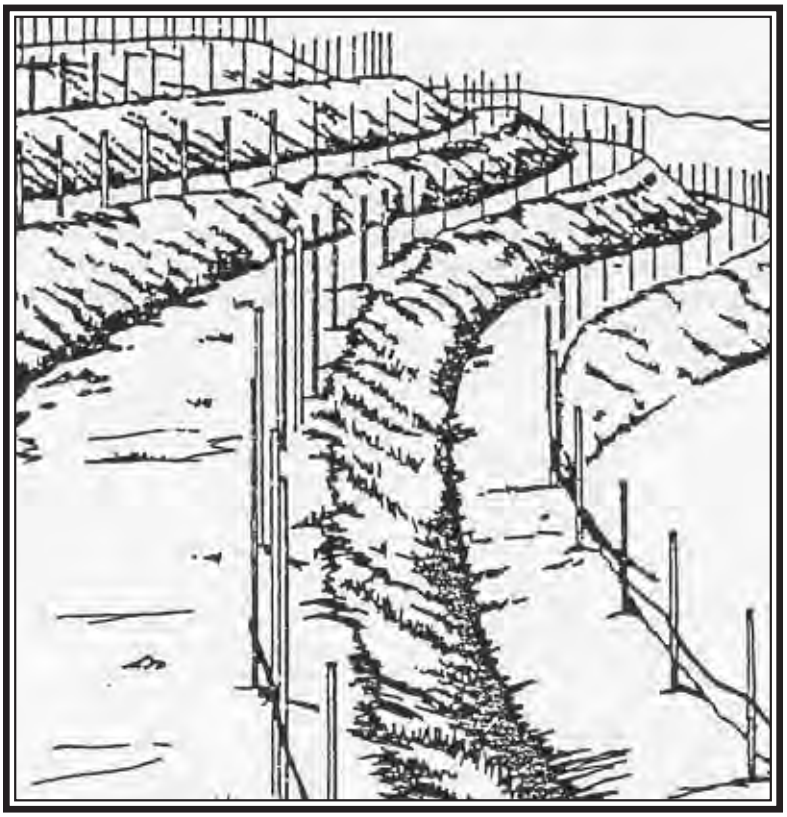

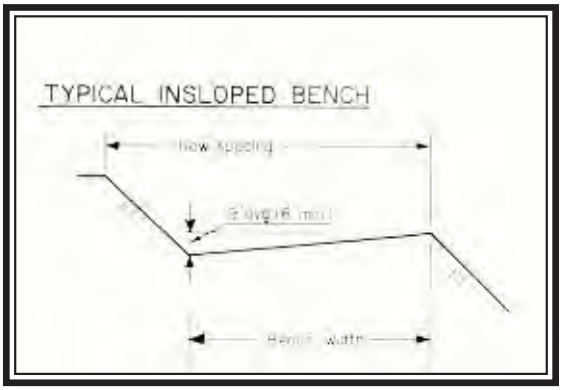

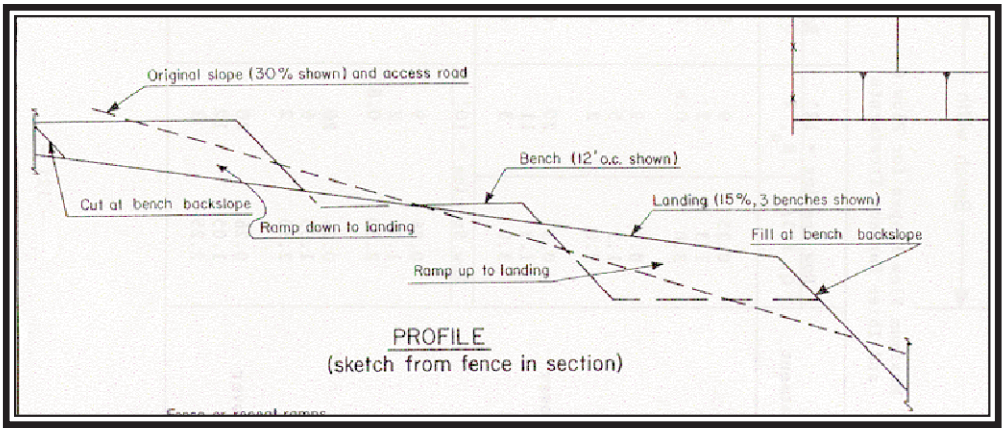

Fish Friendly Farming Environmental Certification Program	SPECIFICATIONS FOR TERRACE BENCH

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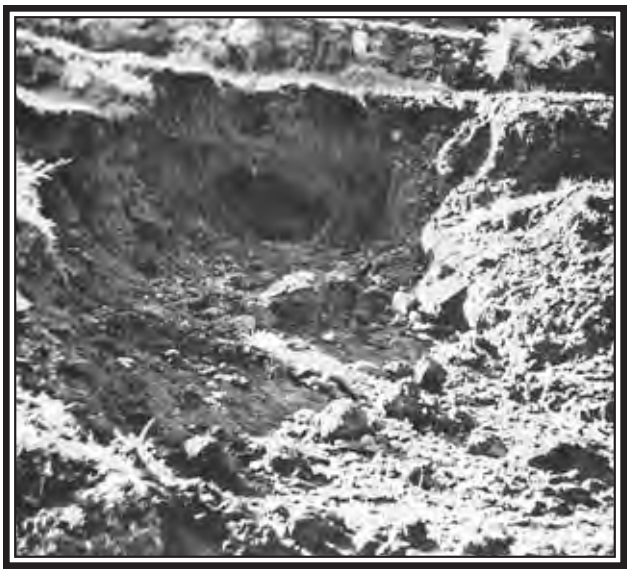

PHOTOGRAPHS SHOWING VARIOUS PROBLEMS WITH TERRACED VINEYARDS. YEARLY INSPECTION AND MAINTENANCE OF TERRACE AND DRAINAGE SYSTEM IS REQUIRED.
YEAR ROUND COVER CROPS (LOWER LEFT PHOTO) PROVIDE ADDITIONAL PROTECTION.

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- ❑ Repair and replace energy dissipaters at outlets every year.
- ❑ Keep design drawings for perforated pipeline systems for use in repairs and replacement projects.

Flexible Pipe Drop

- ❑ Remove sediment and debris before the rainy season and after each large storm.
- ❑ Repair any damage promptly.
- ❑ Check pipe for sun damage each year and replace if brittle.
- ❑ Check headwalls for uneven settlement, repair cracks.
- ❑ Reset flexible pipe before the rainy season.
- ❑ Check connections between sections of flexpipe for leaks and repair and reset.

Miscellaneous

- ❑ Remove sediment from stilling and sediment basins and either place on the field, or place in another area not in, or near to, waterways. Stabilize with cover crops.
- ❑ If springs are a problem on the site, evaluate increasing the drainage in these areas, or removing cultivation from the spring site.

Background: Upgrades and Replacement of Vineyard Drainage Systems

Older vineyards may have inadequate drainage systems, or have an undersized system, more prone to failure. If the vineyard is on the flat valley floor and has adequate ditches and streams to conduct water through the site, no additional drainage system may be needed. The best times to install, or upgrade, the drainage system is when replanting, or if a major erosion problem has occurred. The considerations for designing and installing a new, or upgraded, drainage system in an existing vineyard will be very similar to those for a new vineyard.

The most important design features for an upgrade are:

- ❑ For underground pipes and for benches size the system for the 100-year frequency, 24-hour duration storm event.
- ❑ Use as many inlet points and outlet points as possible.
- ❑ Use large enough energy dissipaters at all outlets.
- ❑ Consider all the drainage entering the site; size drainage diversion ditches for the 25-year frequency, 24-hour duration storm event.
- ❑ Avoid increasing the overall stormwater discharge from the site by more than 10-15%.

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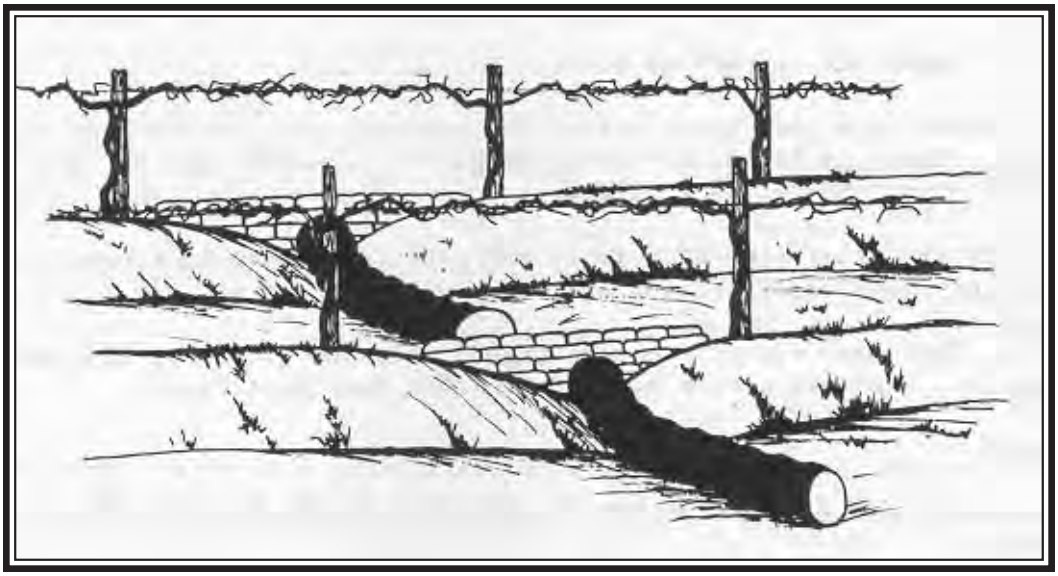

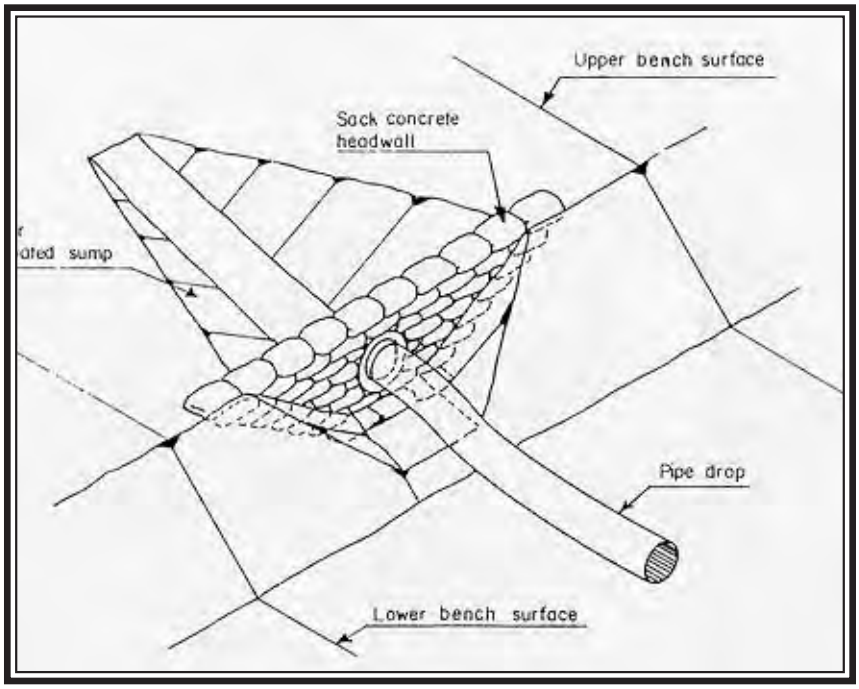

Fish Friendly Farming Environmental Certification Program	PIPE DROP SYSTEMS ARE USED TO MANAGE WATER FLOWS AND REDUCE EROSION

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- ❑ Supervise the installation and make sure:
  - ❑ Backfill is properly compacted
  - ❑ Inlets and outlets and cutoff collars are correctly installed
  - ❑ Pipes that are installed are the design size

9. NATURAL DRAINAGE FEATURES

Background: Managing and Maintaining Natural Creek Systems

Often installed drainage systems in hillside vineyards are integrated into natural drainage networks. Installed drainage may include re-direction of natural flow away from the vineyard through the use of a diversion ditch upslope of the vineyard. Ephemeral creeks may be piped, or channelized, where they pass through the vineyard. The vineyard drainage system likely releases stormwater into a natural creek. In addition, vineyard road crossings and year round road crossings with culverts may affect the natural creek and its functions.

Ephemeral creeks are typically steep and only carry water during storms. Due to their limited period of flow, they are often overlooked. However these steep channels can become unstable and create slides and debris flows if vegetation is removed, or too much stormwater is released into the creek from a drainage system. Native vegetation, particularly woody plants such as oaks and bays with their dense root systems, provide significant structural stability to ephemeral waterways.

Management and maintenance of the natural creeks can improve their natural watershed functions, reduce erosion, increase vegetation and stability. Revising fencing on the property may restore these natural creeks as wildlife corridors (see Appendix 3).

Assessment: Natural Creek System

- ❑ The system of year round, seasonal and ephemeral creeks on the property was outlined and described in Section 4. Ephemeral creeks are the most common hillside creek and are addressed in detail in this element. Year-round and seasonal “blue-line” creeks and valley floodplain creeks and rivers are addressed in Element VI.
- ❑ The outlets and features of the vineyard drainage system were inventoried in Section 8.
- ❑ The proximity of the vineyard to the stream channels and vegetation was measured in Section 4.
- ❑ Inspect the creek for signs of erosion where outlets, culverts, reservoirs or other structures release storm flows. Look down to the base of the channel not just next to the pipe or culvert. Circle all erosion sites on your map, or aerial, and give each a number. Indicate all erosion sites and sites where energy dissipaters are needed.

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APPLYING VINEYARD MANAGEMENT BMPS: MANAGING AND MAINTAINING NATURAL CREEK SYSTEMS

- ❑ Replace/repair energy dissipaters at all drainage outlets and culverts. Installing a flexible plastic pipe to the culvert outlet and extending the pipe to the bottom of the slope can reduce erosion. The connection of the flexible pipe to the culvert needs to be secure.

- ❑ If there are erosion sites in the ephemeral creeks, review your drainage system map to determine if there are a large number of vineyard drainage outlets located in the erosion area that may be contributing to the problem. Evaluate relocating the outlets using flexpipe to the bottom of the channel, or through a more long-term project to release stormwater into a bedrock, or less steep section of the channel. Also review the size and extent of the energy dissipaters at the outlets. Note these erosion sites for review as part of the site visit for additional expert review and advice.

- ❑ Temporarily repair any erosion in the ephemeral creek (see Sections 10 and 11). If the erosion is severe you may need to use a structural approach to stabilize the erosion, and then revegetate. FFF program staff can assist you in evaluating erosion sites. Include vegetation in all repair programs to increase the filtering and retention of fine sediment and increase wildlife habitats. Revegetate with native plant species such as live oak, toyon, ceanothus, bay laurel and other appropriate species.

- ❑ Revegetate any cleared area by planting native species up to the topographic edge of the swale, or ephemeral creek channel. The greater the amount of woody vegetation in a swale, or ephemeral creek, the more stable in a large storm event. As part of the Farm Conservation Plan process, an ecologist can determine the extent of the revegetation and the appropriate plants.

- ❑ Review the current fencing layout on the property and outline it on your aerial. Remove fencing from across natural creeks and open the creek as a wildlife corridor. The FFF program staff can assist with this review.

10. EMERGENCY EROSION CONTROL MEASURES

Background: Emergency Erosion Control Measures

During the rainy season even the best-managed vineyard is vulnerable to erosion. There are a number of temporary, or emergency, erosion control measures that can be installed both prior to the onset of winter and during the rainy season as problems arise. The measures provide soil protection, or reduce the movement of soil into waterways and protect fish habitat for the rainy season. These measures are short-lived and only last for the rainy season, or even one large storm event.

The most important part of using temporary measures is to have the materials on site and be familiar with installation methods. It is also important to inspect the vineyards often to make sure small erosion problems are addressed quickly. Take note of where problems occur and revise winterization measures next year to avoid repeating the same problems.

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THESE TWO PHOTOS SHOW THE RETENTION OF OAK WOODLAND AND SWALES AND THE DEVELOPMENT OF GRASSLAND AS VINEYARD.

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TWO VIEWS OF VINEYARDS WHERE THE EPHEMERAL SWALES ARE RETAINED IN NATURAL VEGETATION

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VIEW LOOKING DOWN STEEP HILLSIDE SWALE OR EPHEMERAL STREAM REMOVAL OF VEGETATION CAN RESULT IN EROSION AND POTENTIAL SLOPE FAILURES.

Fish Friendly Farming Environmental Certification Program	EPHEMERAL STREAM WITH DENSE VEGETATION

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Assessment: Emergency Erosion Control Measures

On the Farm Conservation Plan template describe your winterization practices for all vineyard field roads, buffers between waterways, or creek corridors, and the vineyard turnarounds including:

- ❑ Whether you regularly have materials available for emergency erosion control
- ❑ Whether you complete regular winter inspections
- ❑ Whether the vineyard staff are aware of how to implement emergency erosion control measures

APPLYING VINEYARD MANAGEMENT BMPS: EMERGENCY EROSION CONTROL MEASURES

Soil Surface Protection

- ❑ **Mulching** - Straw mulch should be spread over the vineyard site after the cover crop has been seeded. The mulch provides an extra-added layer of protection until the seed germinates. The mulch should be applied at a rate of 2 tons per acre, cover 80-100% of the ground surface and be anchored, or punched, using hand tools, rollers or other non-compacting equipment. The straw can also be sprayed with a tacking agent to bind it together. Compost can also be used for mulch if readily available. Vineyard field roads should also be mulched.

- ❑ **Composted Clean Green Mulch** – This type of mulch is effective in the control of erosion from hillside vineyards. The mulch is spread under the vine row and in the avenues to protect surface soil layers. Care should be taken to avoid piling mulch against vines. The mulch is created from municipal garden waste and is composted to kill weed seeds. Studies from the California Integrated Waste Management Board have found that the composted mulch is effective for 2 years.

- ❑ **Jute netting** - Netting can be used on steep areas where straw cannot be anchored. This practice is appropriate for bench terrace faces and the netting should be anchored with staples, or pins. Anchor pins should be rigid galvanized wire with a minimum length of 10 inches. Staples should be U shaped and have two prongs of 6 inches in length. Netting should be overlapped by 12” along the edges to assure coverage of soil.

- ❑ **Erosion control blanket** - These blankets are made of biodegradable material that covers over the soil. These are also used on steep sites such as the faces of terrace benches. The treated areas must be reasonably smooth and the blanket must be anchored over the site with an overlap of several inches between each blanket. Each manufacturer has slightly different directions for anchoring the blanket.

Intercepting surface soil movement

- ❑ **Silt fencing** – A barrier of filter fabric cloth can be purchased and stretched across a slope to further reduce surface soil movement. The posts need to be firmly anchored into the ground, or an adequate depth for the soil types and slope. The fabric is

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stretched tightly and firmly trenched several inches into the slope surface. Posts should be four feet apart or less. Staples attaching the material to the posts should face upslope. Silt fencing is often used in several areas of a long slope as one silt fence at the bottom of the slope is not likely to be sufficient.

- **Strawbale checkdam** – Bales of clean straw bound with wire or plastic twine can be placed across an area of surface sheet flow, or rilling, and anchored into the soil surface with rebar or stakes. Anchor the bales tightly together to form a barrier across the entire area of surface flow. Don't create a path for the water to go around the outside of the check dam. The stakes, or rebar, should be driven into the ground 1.5 to 2 feet and the bales should be set at least 4 inches into the ground.

- **Strawbale or straw wattle waterbars** - Strawbales can also be used to create temporary waterbars across a road, a temporary sediment barrier to protect a waterway, a drop inlet from siltation, or contain sediment along a vineyard edge. A series of strawbale checkdams, or waterbars, may be needed for a long slope. They should cross the entire width of the slope and be spaced to allow for sediment accumulation. The rebar should be driven into the ground 1.5 to 2.0 feet and the strawbales should be trenched at least 4 inches into the ground and set tightly together. There are also erosion control products such as sediment logs, or straw wattles, which can be used in the same way as the strawbales. Straw wattles can be carried to locations where strawbales cannot. The wattles are staked into a trench and can be stacked 2 wattles high. The length of slope, or area above each waterbar, should not exceed 100 ft. or one acre.

- **Waterbars for vineyard roads** – Waterbars consist of a berm and ditch to collect and direct water off the road surface before concentrated flow can cause erosion. Waterbars should be installed on all steep (>10% slope) seasonal vineyard roads as part of the winterization process. Waterbars are placed across the road at a 30-40 degree angle oriented downgrade to the road centerline. The waterbars should be oriented to direct the stormwater into the vineyard drainage system, or into vegetation. If a swale or creek is used, a vegetated area, or filterstrip, should exist between the road and the creek channel and an energy dissipater of gravel should be placed at the outlet of the waterbar. Waterbars should be installed at a greater frequency on steeper roads (see Table VG in Element V).

  The waterbar should extend from the inboard road cut to the outer edge of the road. The waterbar consists of a berm and a ditch. The edges of the berm should be 4-6 inches above the roadbed and the ditch should be 4-6 inches deep. The ditch and berm should be approximately 3-6 feet in width along the longitudinal direction of the road.

- **Temporary sediment basin or barrier** – A temporary sediment basin is used to catch and settle out sediment before it can enter a waterway. These are usually placed at the base of a slope, or drainage area. Sediment basins are designed for small watershed areas (no greater than 5 acres) and small storm sizes (10-year recurrence interval). A small basin can be created from compacted soil, rocks or strawbales. The basin embankment should not exceed four feet in height. A drain or outlet is used to restrict flow from the basin to allow for sediment to be trapped. A small berm, or square, of strawbales can be created around the drop inlet of the vineyard drainage system to reduce siltation. A strawbale sediment barrier can be placed along the vineyard/waterway edge prior to the rainy season to protect water quality and should be

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installed if harvest if later than Oct. 15, and cover crop seeding will be delayed. Be sure that the strawbales are securely anchored with stakes or rebar.

- **Plastic-lined ditch** - When a vineyard field road, or road ditch, begins to erode, plastic can be placed over the eroding site to reduce soil loss temporarily. Strong plastic should be used to avoid puncture by rocks and sticks. The plastic sheets should be anchored so that surface runoff, or wind, cannot move the plastic. Rebar is preferable for staking the plastic. Placing rocks on top of the plastic is not sufficient. Sheets of plastic should be overlapped a minimum of 12 inches and tightly staked at the overlap. The maximum length for use of plastic lining is 400 feet.

There are many other erosion control products on the market. Always use them for the situations the manufacturer recommends and install them according to the directions.

11. EROSION SITE REPAIRS

Background: Erosion Repairs

Erosion of soil is a serious problem. Soil erosion is caused by the ability of rainfall, flowing water and wind to move soil particles. Although erosion is natural, human uses of land often increase the rate of soil erosion and increase the amount of sediment moving into creek and river channels. Hillside vineyards, vineyard roads, and ephemeral creeks can be the sites of erosion due to concentrated flows and soil disturbance.

Rill and gull erosion are easy to observe and represent the loss of soil in one location, not layer by layer as in sheet erosion. Rills and gullies usually occur due to concentration of water flow onto soil. Flows become concentrated through changes made to drainage patterns on a hillside such as roads, soil compaction, and vegetation removal. This type of erosion is prevalent when swales and ephemeral streams are cleared and are then subject to concentrated flows as a part of the natural drainage system but without the protective vegetation.

Slope has an enormous effect on soil erosion. Slope magnifies the effects of rainwater runoff and its ability to carry soil, as well as increasing the likelihood of hillside slippage and mass movements.

A lack of an energy dissipater at a culvert or drainage outlet can start rills and gullies as can a lack of waterbars on vineyard roads. Prior land uses that left old logging skid roads, overgrazed hills, or denuded swales can get a gully started and require major repair. Careful consideration before vegetation clearing or road construction is the best way to avoid creating these problems. Rapid response to gully formation can repair small problems before they get huge.

Mass movements of soil and rock such as slope failures, debris flows and landslides involve the downhill flow of water and soil. The causes of mass movement are complex and can involve natural geologic instability or the exacerbation of an unstable situation through road

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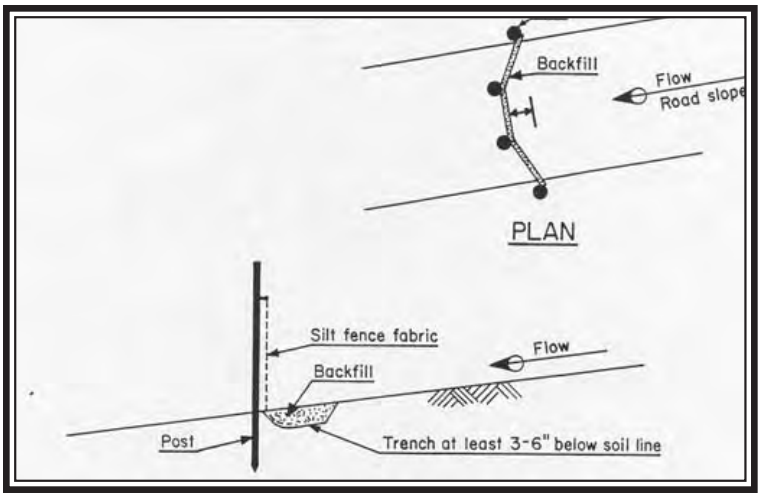

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL SILT FENCE

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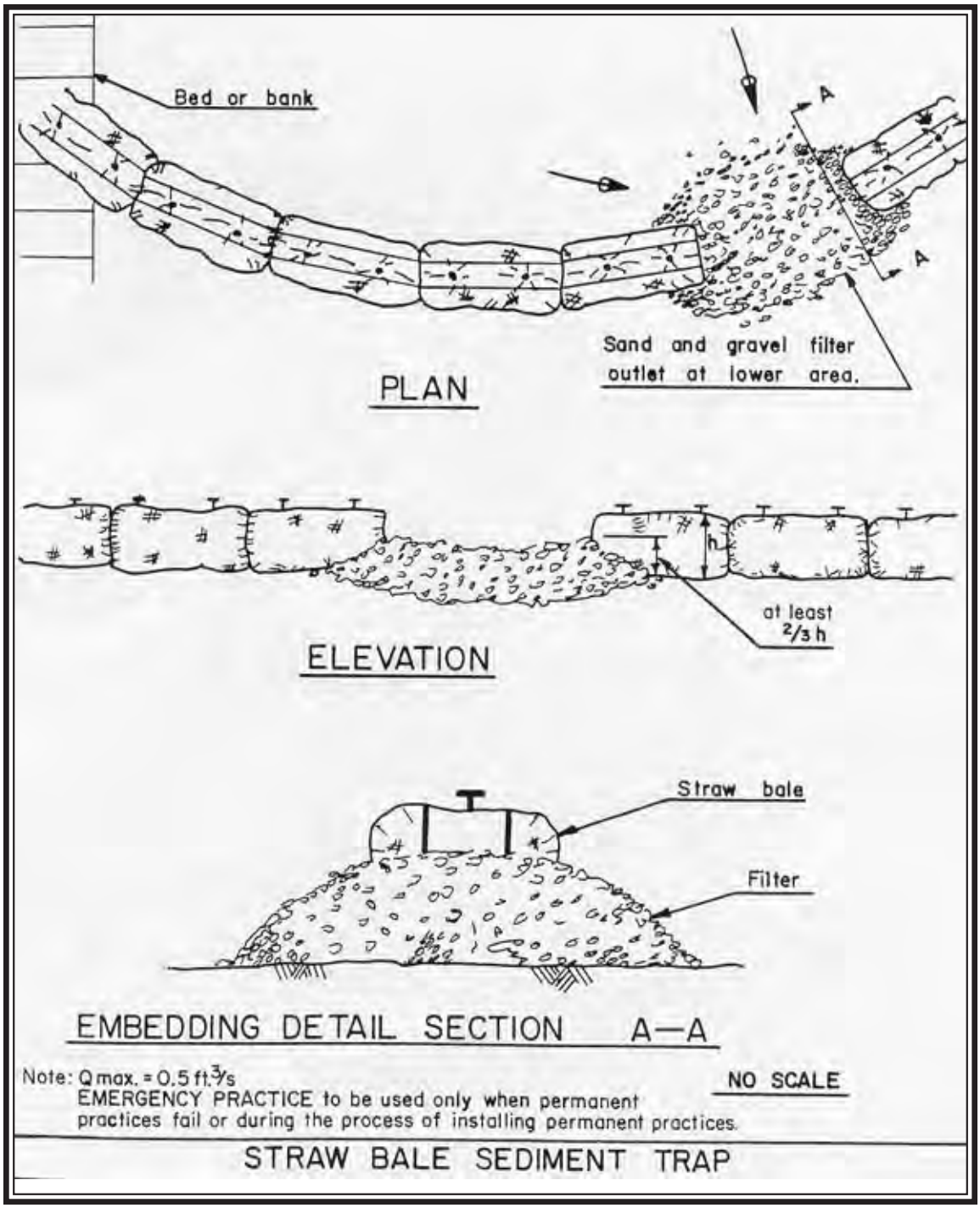

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE SEDIMENT TRAP

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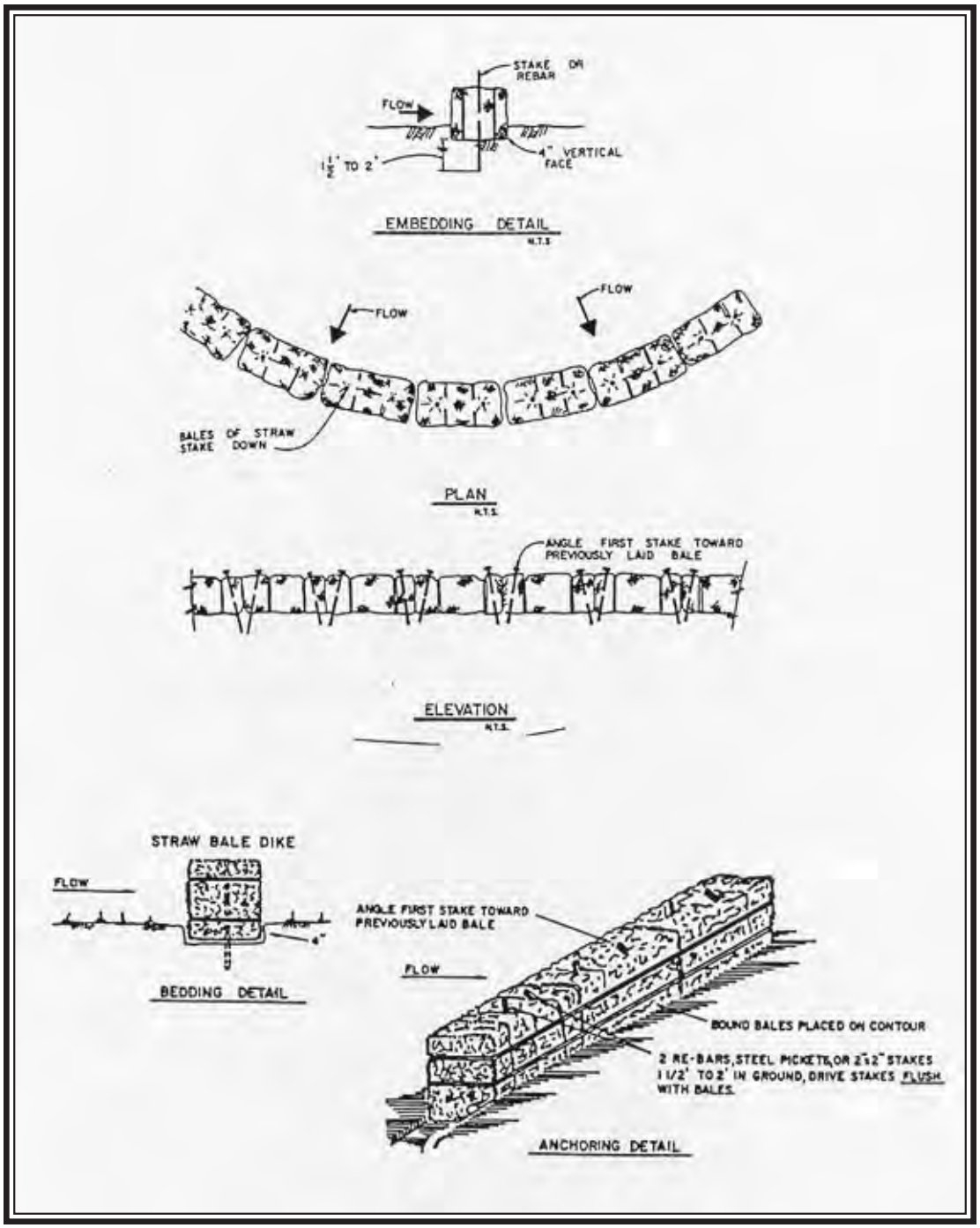

Fish Friendly Farming Environmental Certification Program	EMERGENCY EROSION CONTROL STRAWBALE BERM

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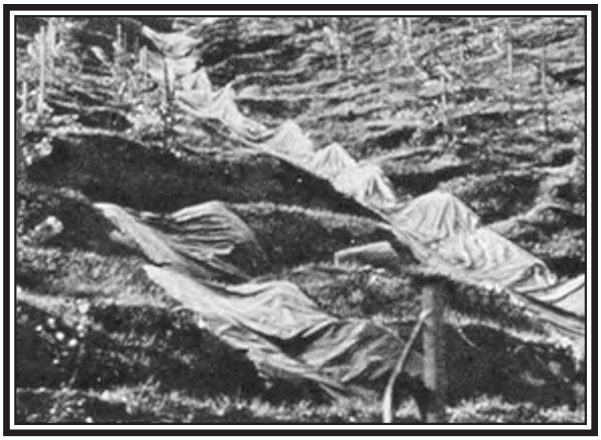
INSTALLING EROSION BLANKET - A TEMPORARY FORM OF EROSION CONTROL. BLANKET MUST OVERLAP AND AND BE INSTALLED WITH STAPLES OR STAKES.

PLASTIC SHEETING CAN PROVIDE SOME EMERGENCY EROSION CONTROL FOR ONE STORM, BUT MUST BE CHECKED FREQUENTLY AND REPLACED.

STRAW WATTLE STAKED IN EROSION SITE.



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building, vegetation removal or drainage changes. It is never wise to build anything on an unstable slope without expert advice from a geologist or engineer.

Assessment: Erosion Repairs

On the Farm Conservation Plan template:

- ❑ Describe existing erosion problems in vineyards, or vineyard roads including gullies, rilling, and hillside slippage.

- ❑ Describe any erosion problems (gullies, rilling, hillside slippage, or failures) on other areas of the property.
- ❑ Describe repairs made and success of repairs to any erosion problem.

APPLYING VINEYARD MANAGEMENT BMPs: EROSION PROBLEMS AND REPAIRS

- ❑ Cover crops, winterization of field roads and turnarounds and use of filter strips are highly effective ways to reduce sheet erosion and intercept soil before it enters waterways (see Sections 5-7).

- ❑ If a rill, or gully, develops during a storm either in the vineyard, on a vineyard field road, or another area of the property, use emergency erosion control measures (Section 10) to stabilize the problem as soon as possible. Apply the emergency erosion control measures both to the erosion site, and if possible, identify the cause and try to correct it, even temporarily, during the wet season.

- ❑ Once winter ends, address the problem as soon as you can. If you have a large problem you may need a few months to get the equipment or materials to repair the cause of the problem and stabilize the erosion site before October 15. If you have a landslide, seek professional assistance as soon as possible from an engineering geologist, geologist or civil engineer.

- ❑ For gully and other erosion repairs, contact the NRCS, a civil engineer or other professional to get assistance in evaluation and repair design. Have a qualified contractor install the project, or do it yourself with careful and detailed guidance. The FFF program can assist with major erosion control projects.

- ❑ Evaluate the cause(s) of the erosion problem. Some examples include:

    - ❑ Drainage from a culvert or a drain outlet.

    - ❑ Vegetation removal in an ephemeral stream and gullying of the stream from storm flows.

    - ❑ The diversion of storm flows from one area into another and resulting erosion.

    - ❑ Compaction of soil surfaces, or new pavement and increased volumes of runoff

    - ❑ Saturation due to springs.

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TOP PHOTO SHOWS GULLY HEADCUT FROM CONCENTRATED DRAINAGE. BOTTOM PHOTO SHOWS PLACED ROCK WITH VEGETATION REPAIR.

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CHECK DAMS CAN BE MADE OF ROCK, REDWOOD OR OTHER MATERIALS. THEY STABLILIZE THE GRADE AND MUST BE INSTALLED PROPERLY. CONTACT THE NRCS FOR DETAILS.

Fish Friendly Farming Environmental Certification Program	CHECK DAMS ARE USED TO STABLILIZE GULLIES AND REDUCE SOIL EROSION

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- Failure of a drainage inlet due to clogging from debris, or overtopping and undersized inlet.
- Water flow around instead of through an underground pipe system due to incorrect installation.

- Correct the cause of the erosion problem first.
- If the erosion site is in the vineyard, repair will mean grading and reinstalling a portion of the vineyard. Complete this repair in the dry season using all the erosion control BMPs for a new vineyard installation (see page 37).
- If the problem is gullying, or rilling, along field roads, evaluate the drainage on the road and install waterbars, rolling dips and additional drainage to reduce the length of flow down the road (see Element V – Roads and Section 10 of Element III).
- If the problem involves an ephemeral waterway, consider stabilizing structures such as checkdams and restoring it to a fully vegetated condition with native plants such as oak, toyon, manzanita, ceanothus and other appropriate species.
- Gullies move upslope and the headcut should be stabilized first after the cause is addressed. Depending on the situation there are vegetative techniques and structural solutions:
  - Vegetative techniques are most applicable to gullies with a headcut of less than three feet that is not getting rapidly larger. Willows and grasses can be sprigged and seeded after the headcut is reshaped to a flatter slope. Vegetation must be planted at the proper time of year to ensure growth without irrigation. Structural solutions include riprap placed on the headcut after it is reshaped and filter fabric is installed. Rock needs to be properly sized and placed. Willow can sometimes be sprigged in conjunction with the use of rock. With both techniques apply the following guidelines:
    - Reshape the head cut to a 2:1 or lower slope.
    - Apply a temporary cover crop by seeding if vegetation only repair is used.
    - Plant willow springs no smaller than one-half inch in diameter, (one inch to one and one half inches is preferred) and three to four feet long planted right side up (oriented as the stems were growing when pruned) driven into the soil 75 to 80% of their length and spaced 12 to 18 inches apart over the ground surface.
- For structural solutions use filter fabric properly installed under rock riprap. Use angular dense riprap rock sized to the expected storm flows for the site and installed in a matrix of large and small rocks to create a solid flat rock surface. Dumping surplus concrete, or other materials in the gully often hides the erosion underneath.
- Once the headcut is stabilized the rest of the gully can be stabilized. Checkdams, or grade stabilization structures, keep the gully from deepening and widening and further eroding. For installation of checkdams use the following guidelines:

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- ❑ There are many types of checkdams, choose one that fits your site.
- ❑ The toe of the uphill checkdam must be even, or level, with the spillway of the next downhill checkdam.
- ❑ More small checkdams are preferable to a few large checkdams.
- ❑ Install an energy dissipater at the downstream overflow for each checkdam.
- ❑ Some types of checkdams such as loose rock, cement and wood require spillways sized to the average storm.
- ❑ Key each checkdam into the sides of the gully several feet so no water can flow around the edges and erode soil.
- ❑ The checkdams must be installed perpendicular to the flow of the water wherever the checkdam is located even if the gully meanders in course.
- ❑ Revegetate the gully walls.

12. DUST CONTROL

Background: Dust Control

Dust is created by the fine-grained layer of topsoil being blown by the wind. Dust can have several effects including increasing the fine sediment in waterways and the loss of topsoil and increasing the number of spider mites in the vineyard. Dust levels are increased by exposing the vineyard floor to wind with a full tillage management system, operating machinery in windy conditions and driving too fast along dirt field roads.

Assessment: Summer Dust Control

On the Farm Conservation Plan template, describe your current dust control practices for each vineyard area, including:

- ❑ Whether you maintain perennial cover crops on the vineyard floor
- ❑ If using a tillage system, whether you spray a dust control compound in the summer
- ❑ Whether you avoid tilling on windy (>5mph) days
- ❑ Whether you have posted speed limits on you main field access roads
- ❑ Whether you gravel or asphalt your primary roads

APPLYING VINEYARD MANAGEMENT BMPs: DUST CONTROL

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- ❑ Apply an organic dust control compound to reduce the susceptibility of the soil surface to wind erosion. Check with the Agricultural Commissioner for the recommended compounds.

- ❑ Do not till field roads and turnarounds

- ❑ Practice no-till management if the vineyard is located in a windy area.

- ❑ Gravel or asphalt your primary field roads and reduce speed for small trucks and vehicles.

13. PEST AND DISEASE CONTROL PRACTICES

Background: Pest and Disease Control Methods

Managing for various pests, fungus, bacteria and other problems is part of all farming operations. Each crop has specific pest and disease problems. Many agricultural products such as fruits and vegetables are also judged by their cosmetic appearance. Wine grapes are unique in not being judged by appearance and therefore fewer chemicals can be used. In addition, grapevines are particularly suitable for floodplain areas as they are dormant during the winter flood periods and can endure water inundation during dormancy. Grapevines are also suitable for hillside areas where soils may be thin and moisture levels low. However, in both locales pests and diseases can significantly reduce production and in some instances kill the vine.

There are different approaches to addressing pests and diseases. These approaches include: eradication with chemical applications, control with biological methods, monitoring and limited chemical use, and all sorts of variations. The activities the vineyard manager undertakes to control insect infestations, or outbreaks of disease, may not pose significant risk to water quality or the fish and their habitat. However, some activities can pose risks, or significantly alter habitat areas.

Many growers carry out IPM, or Integrated Pest Management, a strategy to reduce the use of chemicals and integrate natural pest control methods into agriculture. For example in winegrapes cultural methods such as canopy management, dust control, irrigation management and uses of cover crops to support beneficial insects are part of a successful IPM program. Some levels of pest insects have to be present and tolerated to serve as prey to support healthy populations of beneficial insects. An economic threshold for damage by pests needs to be set and the pests should be tolerated until the threshold is exceeded and then chemical control should be planned. A control method should be used that targets the problem pest or disease, rather than a broad-spectrum chemical that kills both beneficial insects and the pest insect.

Toxicity and Exposure Pathways

For a pesticide, or herbicide, to have an effect on water quality, fish or wildlife, the material must have a pathway of exposure to waterways, animals and their habitats. The material must also be bio-available at concentrations that affect the animals. Effects vary from acute toxicity that leads to rapid die-off, to sub-lethal effects derived from prolonged exposure to bioaccumulation of the chemical in the animal and its environment. In addition, for most

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bioaccumulation effects, the material must have low solubility in water, as highly soluble materials wash out of the system relatively rapidly.

When a chemical is sprayed near a riparian corridor, or creek, the spray, or dust, may drift. Chemicals may also runoff in rainfall, soak into porous soil layers with rainfall or irrigation, or become attached to soil particles, particularly clays, and reach the aquatic system through soil erosion. Some chemicals break down very quickly when exposed to sunlight, or water.

Chemicals can spill or runoff from mixing and loading areas into surface water or seep into groundwater through unprotected well heads or irrigation systems. Through these pathways fish and wildlife may become exposed to the chemical.
If fish are exposed to chemicals in the aquatic system, it does not mean that a toxic effect will result. Some chemicals persist for a long time. Some chemicals become more bio-available in water while others do not. Persistent chemicals are the most likely to cause bioaccumulation effects and have been associated with environmental problems. Many of these, such as DDT, are no longer in use.

The toxicity of agricultural chemicals most commonly used in vineyards and some orchard crops was evaluated as part of this program. Table IIID lists the acute toxicity of these chemicals to wildlife. Acute toxicity is measured by exposure to a large single dose of the chemical for a 96-hour period and is usually listed by the LC_{50} (lethal concentration 50) or LD_{50} (lethal dose 50). This is the concentration of a chemical that will kill 50% of the group of test animals. The more toxic a substance, the lower the amount listed as the LC_{50} or LD_{50}. The LC_{50} values are derived from studies on rainbow trout primarily, but if such information was not available, then data for bluegill are listed. The databases and references used are listed in this table.

For all farm chemicals the label directions are very specific about application rates and restrictions on conditions for use. For environmental concerns one of the most important restrictions is wind direction and speed. Spraying, or dusting, in high wind conditions is inviting drift and potential problems. Consult with the County Agricultural Commissioner or the manufacturer for additional information on a specific product.

Assessment: Pest and Disease Control

Answer the questions and fill out the table in the Farm Conservation Plan template for your current control practices for each of the diseases/pests listed.

- ❑ Answer the questions regarding the chemical storage and mixing areas on the site and indicate these areas on a site map.

- ❑ List both the control methods typically used including the exact chemical name; formulation used; and typical number of applications, and any other methods you've tried. Indicate for the methods used occasionally if they were effective or not.

- ❑ List any variations in the way you apply control materials next to riparian corridors, waterways, drainage ditches, swales and ephemeral streams. Describe control methods including:
  - ❑ Whether insects are monitored before chemical controls are applied
  - ❑ Whether the least toxic methods has been evaluated

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- ❑ If an IPM (integrated pest management) program is in use
- ❑ What cultural methods are used for pest or disease control

- ❑ Answer the questions regarding application methods for chemicals.

- ❑ Groundwater Protection Areas (GWPAs) are defined in each county by the Department of Pesticide Regulations. Each GWPA is defined as a leaching or a runoff area. In these GWPAs, use of a number or pre-emergent herbicides are restricted up to 100 ft of unprotected wellheads. More information on GPAs can be found on the Department of Pesticide Regulations website: http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpamaps.htm

The restricted herbicides include, Atrazine, Simazine, Bromacil, Diuron, Noraflurazon, Alachor (Lasso), Bensulide (Betasan, Pre-san, Prefar), Butylate (Sutan), Chlorsulfuron (Glean, Telar, Corsair), Cynazine (Bladex), Cycloate (Ro-neet), Dazomet (Busan, Basamid), 2, 4-D, dimethylamine salt, Dichlobenil (Casoron), Diquat dibromide, EPTC (Eptam), Ethofumesate (Norton, Prograss), Hexazinone (Velpar, Pronone), Imazethapyr (Pursuit), Isoxaben (Gallery), Linuron (Lorox, Linex), Metribuzin (Lexone, Sencor), Molinate (Ordam), Napropamide (Devrinol), Oryzalin (Surflan, Rout, Oryza Ag), Pebulate (Tillam), Prometryn (Caparol), Propyzamide (Kerb, Pronamide), Pyrazon (Pyramin), Rimsulfuron, Sulfometuron-methyl (Oust), Tebuthiuron (Spike)

- ❑ Fill out the table on Weed Control strategies list both mechanical and chemical control measures.

- ❑ Answer the questions on fertilizer use and wellhead protection.

The summary allows for a short description of the biggest pest problems and what control approaches are used, what has worked and what hasn't, and any other information.

APPLYING VINEYARD MANAGEMENT BMPS: PEST AND DISEASE CONTROL METHODS

Chemical Storage Mixing and Equipment Cleaning

The areas where agricultural chemicals are stored and mixed and where spray equipment is cleaned can be sources of contaminants into creeks and stormwater. The following practices are recommended by the Agricultural Commissioner:

- ❑ Make sure that the storage site is not in a flood area, near a water way or wellhead. Put your pesticide storage structure down slope and away from a wellhead or any surface water area

- ❑ Cut back on the amounts and types of pesticides stored. If that's not practical, consider how you can protect the pesticides you keep in storage. Sound containers are your first defense against a spill or leak.

- ❑ Keep pesticide containers away from activities that might knock over a jug or rip open a bag.

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- ❑ Keep pesticide containers in a secured and locked enclosure when not in use. Post the enclosure with signs that are visible from all directions, so that it can be readily identified as a pesticide storage area.

- ❑ Store pesticide containers above the floor or ground level (where possible) in the storage enclosure. Store dust on palettes off the floor.

- ❑ Evaluate the design of your pesticide storage area and pesticide mixing and equipment cleanup areas. Each enclosure should have a solid floor and a curb, or berm, to contain liquid pesticides and wash water and simplify cleanup if there is a spill.

- ❑ Make sure any drains in each enclosure do not outlet to a waterway but flow into a closed system such as a wastewater system.

- ❑ Ensure that pesticide containers are properly identified, either with the pesticide registrant's product label or with a "service container label." Service container labeling will help emergency responders identify the container's contents in an emergency.

- ❑ Keep your inventory list current. The listing should include any unrinsed containers on the property; identity of the pesticide; and amount in the container.

- ❑ Triple rinse pesticide containers and put rinse water into spray container. As soon as practical, dispose of properly rinsed pesticide containers and properly emptied pesticide bags according to product labeling directions or in an approved landfill.

- ❑ Contact your local county agricultural commissioner's office to report any hazardous situation involving pesticides. The commissioner's office can also answer questions about safe storage and handling of pesticides.

- ❑ If you have old or unlabeled pesticide containers dispose of them through the County Hazardous Disposal program.

Integrated Pest Management

- ❑ Cultural and vineyard management measures combined with an integrated pest management (IPM) program that utilizes the least toxic approach wherever possible should be the primary focus of pest and disease control.

- ❑ The choice of rootstock and plant material for a new vineyard, or replant, should include a thorough analysis of all site conditions to avoid the development of insect and disease problems. The agricultural history of the site, likely existing soil-borne disease and insect problems, should also be considered and the most resistant rootstock and plant materials used.

- ❑ For insect pests, always monitor both the pest and the beneficial insects before spraying to make sure you need to spray and set a tolerance level or economic threshold for the insect. Do not use chemical controls until the economic threshold is surpassed. This approach will avoid creating an imbalance in pest and predator populations.

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- IPM programs require management of all aspects of the vineyard including cover crop mixes, insectary plants, mowing heights and timing to create and maintain a habitat for beneficial insects. Many beneficials must complete a significant portion of their life cycle before the "beneficial" stage, such as a larval form, is reached. The grower needs to establish a clear strategy to manage the vineyard to support beneficial insects to have them supply pest control functions.

- Use a targeted chemical if infestation levels became too high rather than a broad spectrum chemical.

- Some chemicals have a closure period for entry after application to protect human health. Do not allow entry to the vineyard before the closure period has passed.

    - Review the chemicals you are using in the toxicity table. Consider whether you can use another chemical that has a lower toxicity level for wildlife. If you can, make a point of changing your practices and indicate this change on your Farm Conservation Plan.

    - Review the use of persistent pesticides such as organophosphates and pre-emergent herbicides such as Simazine that can leach into groundwater and change your practices to less persistent chemicals. If a persistent or high toxicity chemical must be used consult with your County Agricultural Commissioner and incorporate mitigation measures such as filter or buffer strips. Riparian corridors are not buffer strips.

    - Make sure to use the formulation that is safe for aquatic areas if there is any potential for drift. For example, always use the Rodeo formulation of glyphosate if there is any chance the material will be used near to water. Round up can be toxic to fish, while Rodeo is not.

As of October 2006, a lawsuit restricted chemicals in order to protect the threatened Red Legged Frog (*Rana Aurora draytonii)* from 66 pesticides authorized for use in California. The list is as follows:

Azinphos-Methyl (i):walnuts, pears, Bromacil(herbicide), Captan (fungicide): prune/grape Carbaryl (insecticide): grape, plum, Chlorpyrifos (insecticide): grape, walnut, plum, 2,4-D (herbicide): grape, rangeland, Diazinon (insecticide): all 1,3-Dichlorpropene (fumigant): grape. Walnut, plum, Dicofol (acaricide): grape, walnut, prune, Dimethoate (insecticide): grape, Diuron (herbicide): grape, walnut, Esfenvalerate (insecticide): walnut, prune, Fenamiphos (insecticide): grape, Glysophate (herbicide): grape, walnut, prune, Imazapyr (herbicide), Iprodione (fungicide):grape, Malathion (insecticide), Mancozeb (fungicide): grape, Maneb (fungicide): walnut, Metam Sodium (biocide): grape, Methomyl (insecticide/acaricide): grape

Methyl Parathion (insecticide/acaricide): walnut, Myclobutanil (fungicide): grape, Norflurazon (herbicide): grape, Oryzalin (herbicide): grape, Oxyfluoren (herbicide): grape Paraquat Dichloride (herbicide): grape, Pendimethalin (herbicide): grape, Propargite (insecticide): grape, Simazine (herbicide/algicide):all, Strychnine (rodenticide): grape, walnut, Trifluralin(herbicide):grape, walnut, Ziram (fungicide): grape

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- ❑ **Specific Habitat Information:**
  Red Legged Frogs require 11-20 weeks of permanent water for larval development. If you have these types of conditions on your property and you use the restricted chemicals listed above, you should follow these practices:

- ❑ Do not apply these pesticides 100 ft from possible Red Legged Frog habitat.

Application Methods

- ❑ Always apply chemicals according to label directions and follow the restrictions regarding wind speed and direction and the use of the chemical near water. It is illegal to spray chemicals when winds are less than 4 mph or more than 12 mph. Follow directions regarding applications under high temperatures or other conditions. Understand the potential toxicity of the materials you use both to the environment and workers. For example, wettable sulphur can be applied in vineyards near streams to reduce any chance of drift.

- ❑ Make sure your spray equipment is calibrated regularly to assure that the appropriate amount of chemical is applied. If you have old equipment, consider replacing it with modern equipment so that the volume and location of chemical applications can be controlled and less chemical can be used.

- ❑ Follow precautions in disposing of excess pesticides, washing equipment and pouring out rinse water away from streams, waterways and wellheads.

Protecting Surface and Groundwater

- ❑ Do not transport chemicals across at-grade stream crossings where a spray rig could topple and spill into a creek.

- ❑ Reduce spray or dust near to riparian corridors and creeks even on windless days. Turn off the duster or spray rig as you make the turnaround to avoid all potential for drift into the water, the trees, and the wildlife habitat.

- ❑ Review your wellhead locations and conditions to avoid contaminating wells with chemicals.

- ❑ Review irrigation systems for back flow prevention to avoid contaminating water supplies.

- ❑ If you have residences or other “sensitive receptors” (such as schools, retirement homes etc.) near the vineyard meet with your neighbors and let them know about the chemicals you use. Inform them of when you are likely to be spraying. These steps can alleviate misunderstandings about the toxicity of the chemicals used.

  - ❑ Use ground-based application methods rather than aerial applications unless soil erosion would result from ground-based equipment under early season conditions.

  - ❑ If you have vineyard or orchard heaters, move them away from creeks and rivers to avoid contaminating surface water.

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- ❑ If you store more than 55 gallons of diesel on site, or large amounts of chemicals or fertilizers, you may need to have a Hazardous Materials plan filed with your county.

The most common diseases and pests of winegrapes are described below and beneficial management practices are suggested for each.

Diseases

Powdery mildew is a fungal disease that damages grapes and can affect wine flavor. Mildew thrives under warm moist conditions at temperatures in the high 70s and low 80s. Very high temperatures do not favor this fungus. Application of wettable sulphur, micronized wettable sulphur, and sulphur dust is the most common prevention measure. Application is by tractor with spraying or dusting.

- ❑ Sulphur can drift if applied under even slightly windy conditions. Application should not be made near riparian corridors, creeks, or waterways when drift can occur. Shut off the duster as you make the turnaround next to a waterway or use wettable sulphur. Sulphur is often applied in the early morning hours when the wind is low and the best results can be gained as temperatures rise and mildew begins to grow. Unnecessary fungicide applications may be eliminated through application of risk assessment models to site-specific weather data. Aerial application of sulphur is recommended only as a last resort.

- ❑ Sulphur is one of the most used chemicals in grape growing. It does not have a high level of toxicity for fish and wildlife unless it drifts in large amounts into streams or habitats. Wettable sulphur does not drift like dry sulphur and should be used in areas near streams. However, wettable sulphur has limited use late in the season due to its effects on wine quality.

- ❑ There are a number of other materials used to control powdery mildew. These include the sterol inhibitors – Procure, Rally, Elite, Abound, Flint, Serenade, and Elevate. Copper sulfate is used as an early season application, but its use near waterways should be limited as copper is very toxic to fish. It is important to understand potential resistance of powdery mildew to these materials that can result in the use of additional applications and crop loss.

- ❑ Compost tea has been applied to control powdery mildew. Information on this technique is available at the University of Oregon website (www.uoregon.edu).

- ❑ Stylet, Neem and horticultural oils may also be used for powdery mildew control. However, the timing of oil applications combined with any sulphur applications should be carefully monitored. Oil applications should not be used during high temperatures.

Eutypa dieback is a fungal disease that kills grapevines.

- ❑ Prune late in the season to avoid spread.

- ❑ Management of this disease involves removal of infected wood, spraying of antifungal materials. Both of these materials should be limited in use near waterways. Check with the Agricultural Commissioner for other measures.

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Young Esca also called measles, young vine decline, and black goo is a fungus infection that currently has no chemical control.

- ❑ Use only certified plant materials, carefully handle new vines when planting, care for and manage new vines to reduce all stress factors and therefore reduce the likelihood of infection.

Botrytis bunchrot is another fungal disease that infects grape clusters causing rot and making infected grapes unsuitable for wine. Most botrytis starts in clusters that are touching. This is also called "balls of clusters" or "clusters on clusters." When clusters are pressed together, the likelihood of botrytis is higher. The fungus thrives in prolonged wet conditions.

- ❑ Management measures include appropriate trellising systems and orientation of vine rows to take advantage of prevailing winds to dry the vines. Other methods of control include canopy management, removal of excess leaf growth and excess crop. Remove these "clusters on clusters" preferentially when doing cluster thinning. Frequently, excess vegetative growth may be controlled through judicious irrigation and fertilization.

- ❑ The timing of applications of control material has a great effect on controlling this fungus. Some of the materials used are biofungicides such as Serenade that must be applied at specific times during the development of the grape clusters.

- ❑ Flint, Elevate, Abound, Vanguard, Rovral and copper sulfate are used.

- ❑ Some fungicides are highly to very highly toxic to fish. All fungicides should be kept out of the riparian area and not be applied when drift or runoff would create a pathway for the fungicide to reach the water.

Oak root fungus parasitizes the roots of oaks and many woody plants. Native oaks and trees coexist with the fungus, but grapevines can be adversely affected. Symptoms include yellow leaves, stunted canes and vine die-off. The fungus thrives in continually damp soils where a host plant is available.

- ❑ Prevention involves removing infected grapevines and root debris. Evaluating the extent of the disease in a potential vineyard site prior to development may be worthwhile to avoid planting in highly infected areas.

- ❑ There are many indications that removing oaks when developing a vineyard causes the disease to spread. Retaining the oaks may keep the disease within the area of the oak roots as long as the root zone of the oaks is not actively irrigated causing the fungus to spread.

- ❑ Management can involve extensive fumigation in fall with tarping for one week. Tarped fumigation for soil fungus does not generally provide an exposure pathway for fish and wildlife. However, methyl bromide, the primary fumigant used may not be available in the future. Field trials of methyl iodine are ongoing.

- ❑ Field trials have found that changing soil pH can control oak root fungus. The fungus thrives in the slightly acidic soil conditions created by oak leaves. The addition of oyster shell during the replanting/planting process changes the soil pH and kills off the fungus.

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- ❑ Another potential control mechanism is the addition of microbes (Vesta) to the soil at planting and maintenance of high microbial activity levels through the use of compost and organic farming measures.

- ❑ Reducing irrigation or dry farming may also limit the movement of the fungus.

Pierce's disease is a bacterial disease that is fatal to grapevines. The bacteria are spread through certain insect vectors that feed from the xylem of the grapevine and inject the bacteria into the plant. The disease often results in vine death. The most common insect host in Northern California is the blue-green sharpshooter. The BMPs in this workbook only address control of blue-green sharpshooter and the Pierce's disease bacteria.

Recently a non-native insect vector, the glassy-winged sharpshooter has damaged vineyards in southern California. In response the northern California region has instituted inspections for the glassy-winged adults and egg cases on ornamental or other plant materials from the infested area. So far this effort has worked to control an infestation in Napa, Sonoma, Mendocino Counties and other wine-growing areas. However, should the glassy-winged sharpshooter be inadvertently released, the Agricultural Commissioners in these counties have established control plans. For more information see the Sonoma County Agricultural Commissioners website (http://www.sonoma-county.org/agcomm/).

While there is much that is not understood about the disease, Pierce's disease is most prevalent in areas with mild winters. The bacteria naturally occur in certain native and non-native riparian and ornamental plant species. The sharpshooter serves as a carrier of the bacteria from the host species into the vineyard. Research continues to evaluate many factors that affect the sharpshooter and the disease and its spread. There is a web site for information on this disease at www.cnr.berkeley.edu/xylella and a recent publication - Information Manual: Riparian Vegetation Management for Pierce's Disease in North Coast Vineyards.

The most recent research shows the plants which **host** the bacteria and/or the blue-green sharpshooter include: non-native Himalayan blackberry, non-native blue periwinkle and native species: California blackberry, blue elderberry, wild grape, mugwort, stinging nettle, and mulefat. Many ornamental plants also host the disease.

Riparian plant species that **do not host** the bacteria include: alder, cottonwood, willow, spicebush, snowberry, California walnut, Oregon ash, buckeye, live oak, valley oak, wild rose, maple, poison oak and others.

All of these species are interspersed with other plant species and selective removal of the host vs. non-host plants is very difficult. Identifying the host and non-host plants is also problematic. For this reason, removal of riparian vegetation to reduce Pierce's disease problems often leads to overclearing of the riparian corridor. Once cleared the site will often revegetate with the species most likely to host the disease making for a potentially worse infection the next season. In Element VI of the Farm Conservation Plan the creek and river corridor evaluation includes detailed information on the removal methods for Pierce's disease host species and revegetation. As part of the farm plan workshops assistance from a qualified restoration ecologist in creating and implementing a riparian revegetation and invasive plant removal plan will be provided.

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- ❑ The recommendation to spray Dimethoate on riparian vegetation to eliminate sharpshooters is not a preferred practice. The Department of Fish and Game recommends avoiding exposing wildlife to this insecticide due to its toxicity.

- ❑ Survey the vineyard to determine if Pierce's disease is present and to what extent. A laboratory test of plant issues should be done to confirm the presence of the bacteria, but the test is not always accurate in determining that there are no bacteria.

- ❑ Pruning or removal of infected vines can slow or halt the spread of Pierce's disease in a vineyard.

- ❑ Create a buffer between the edge of the corridor and the vineyard. Plant the buffer with non-host and non-invasive species.

- ❑ Avoid planting ornamental landscape species near the vineyard.

- ❑ Monitor sharpshooter populations using yellow sticky traps along the vineyard/riparian corridor edge during the spring from early February.

- ❑ Consider increasing corridor and buffer areas and restoring mature riparian habitat along the corridor edge. Mature tree species such as bay laurel and oak do not host either the disease or the sharpshooter.

- ❑ Do not spray insecticides into the riparian corridor; this practice affects wildlife. Sharpshooters can be controlled at the edge of the vineyard through use of Provado or Admire in the drip system.

- ❑ As part of Element VI of the Farm Conservation Plan a restoration ecologist will assist with the preparation of a plan for the removal of host plant species and revegetation with natives. The removal of non-native species is an enhancement of the riparian corridor, if non-host native species are replanted. However, it is likely you will need help to correctly identify all the plants and not make mistakes in the removal process. Implement your plan by having a professional qualified in the identification of the plants supervise the removal and the revegetation. Do not send uninformed work crews to pull out plants.

- ❑ Any use of herbicides to kill host plants should use Rodeo, not Roundup if there is a possibility of drift into water. Careful methods of hand application and paint on measures have the least likelihood of affecting other plants or waterways. Additional BMPs for the removal of non-native species is included in Element VI. When you are completing this type of plant removal, evaluate creating a corridor wide enough to plant high terrace species that are mostly non-host plants along the outside edge of the corridor.

- ❑ Removal of riparian vegetation will require a stream alteration permit (1603) from the Department of Fish and Game and a plan for revegetation. The FFF program will assist with these permits.

Fanleaf virus is carried in the soil by a nematode vector and while not lethal, can reduce yield. The virus is transmitted by nematodes in the soil.

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- ❑ Prevent the disease by using certified virus free propagation materials and resistant rootstock. The main form of eradication is removal of crop residue and soil fumigation with methyl bromide. Tarped fumigation offers few pathways for effects on fish. However this fumigant is being phased out of use.

- ❑ Control nematodes in the soil using Telone or Ditera.

Insects

Grape leafhopper can become a major pest in vineyards. The leafhopper is a sucking insect and can weaken the vine. Species of parasitic wasps are a natural predator of the leafhopper laying their eggs on the eggs of the leafhopper, but establishing large enough wasp populations to control leafhoppers is difficult.

- ❑ Monitor leafhopper populations to determine if chemical treatment is needed. The vineyard can often tolerate more leafhoppers than expected with little damage.

- ❑ Establish a threshold of tolerance for leafhoppers that addresses the effects on workers during harvest.

- ❑ Be aware of over irrigation and fertilization of vines. Prune, thin and remove leaves to create a balanced vine. Leafhoppers are attracted to vines with high nitrogen levels, therefore limit fertilization.

- ❑ Choose cover crops that support beneficial insects that will prey on leafhoppers.

- ❑ No till practices using a cover crop with clovers and other insectary plants (see Table IIIABC) allow beneficial insect populations to be sustained over their life cycle. The timing of mowing of insectary plants must be carefully managed to allow the beneficials to pupate and produce the life stage that controls pests. Late May is suggested. Mowing also needs to be timed prior to seedset to control grasses that can overwhelm insectary plants and reduce the beneficial insect populations. Use of a mower set high enough to reduce grass growth but not affect clovers and other insectary plants is the best option.

- ❑ Monitor before spraying to see if beneficials are controlling leafhopper populations. Beneficials need some pest insects in the vineyard to feed on and need to have management measures and habitat in the vineyard that support their life cycle year-round.

- ❑ If treatment is needed, insecticide soap, horticultural and Stylet oil sprays as well as Provado and pyrethrins are used. These materials should be applied at the time in their life cycle when leafhoppers are most affected. The use of these materials should be limited near waterways where drift could occur.

Spider mites are serious pests that destroy the lower surface of the leaf. Hot temperatures lead to greater spider mite populations. Water stressed vines and high dust levels increase infestation. Zinfandel and Chardonnay are especially prone to spider mites.

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The predaceous mite can keep spider mite populations in check, but overuse of pesticides to control leafhoppers is believed to reduce predaceous mite populations allowing the spider mite to thrive.

- ❑ Maintain soil moisture; avoid severe water stress for the vines.
- ❑ Reduce excessive dust; consider no-till practices. Establish a speed limit for dirt roads in the vineyard.
- ❑ Use insectary plants such as poppies or mustard in the cover crop to support predaceous mites.
- ❑ Late season sulphur applications can reduce the numbers of predaceous mites.
- ❑ Reduce use of broad-spectrum insecticides. Targeted miticides include Acramite, Agri-mek, Nexter and Omite.
- ❑ Multiple applications of Neem oil early in the season can reduce spider mites.
- ❑ Reintroduce predaceous mites if insecticides have been used. This practice is sometimes difficult.

Grape phylloxera is an aphid-like insect that feeds on the roots of grapevines. Phylloxera can cause severe damage and death of grapevines. This insect decimated the wine industry in the early 1900s in California and has caused significant damage more recently in the 1980's and 1990's. To combat phylloxera:

- ❑ Replant with resistant rootstocks.
- ❑ Remove infested vines and roots and plant site with vegetated cover for 2-7 years.
- ❑ Replanting may allow for a reconfiguration of the vineyard and restoration of riparian corridor and vegetated buffer.

Vine mealybug is a sucking insect that has recently become a problem in vineyards. Unlike the grape and obscure mealybugs which are limited by high summer temperatures, vine mealybugs tolerate heat. Ants farm the mealybugs on the vine and protect the mealybugs from predators.

- ❑ Control ants in a targeted area of the vineyard by strip-spraying Lorsban in the vine row or spraying directly onto mealybugs when vines are dormant. This is an organophosphate pesticide that should be carefully applied to avoid all drift into waterways.
- ❑ Use Admire in the drip system to provide a systemic control of mealybugs. Another method is to spray Provado onto the vines to control mealybugs.
- ❑ Dormant spray with lime sulphur or horticultural oil. Horticultural oil may also be applied on the green plant.

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- ❑ When a VMB infestation is confirmed in vineyard, notify neighbors, the Ag Commissioner, your PCA, and any winery that buys your fruit.

Nematodes are microscopic roundworms that live in the soil and feed on roots reducing the plants ability to uptake water and nutrients.

- ❑ Soil fumigation may be done when replanting, but sometimes has limited effectiveness and methyl bromide the most common fumigant is being phased out.

- ❑ Other materials include Dithera (Ditera) a microbial suspension applied to the soil as well as Enzone, Telone, and Nemacur.

- ❑ Addition of iron sulfate prior to planting may reduce nematodes.

- ❑ Use of some plants in the mustard family such as black mustard and radishes as well as rape seed is believed to repel nematodes in the vineyard.

European grapevine moth (*Lobesia botrana)* was first reported in the United States from Napa County vineyards in October 2009. In May and June, first-generation larvae web and feed on the flower clusters. Second-generation larvae (July-August) feed on green berries. Young larvae penetrate the berry and hollow them out, leaving the skin and seeds. Third-generation larvae (August-September) cause the greatest damage by webbing and feeding inside berries and within bunches, which become contaminated with frass (excrement). Additionally, feeding damage to berries after veraison exposes them to infection by *Botrytis* and other secondary fungi.

- ❑ Sex pheromone attracts males and is used to monitor male flights. Continue monitoring with traps until the peak of the third flight.

- ❑ Insecticide applications should be timed for larval emergence, requiring monitoring of egg hatch.

- ❑ Begin monitoring for second- and third-generation eggs on berries one week after the first moths are caught in traps. Continue monitoring for eggs weekly until one week after peak flight. Inspect 100 bunches, selecting one per vine. Continue monitoring bunches for feeding damage (holes or hollow berries), webbing, and presence of larvae.

- ❑ Control measures are targeted at the second generation. This is due in part to the prolonged emergence of the first generation and because of possible reinfestation from untreated neighboring vineyards. However, treatment of the first generation is recommended if populations are high or if treatments are conducted on an area-wide basis. Under California conditions, control of both first and second generations may be warranted, given that this is a newly introduced pest.

- ❑ Several reduced-risk insecticides are registered for use in grapes to control grapevine larvae. These include insect growth regulators, spinosad (Entrust), chlorantraniliprole (Altacor) and *Bacillus thuringiensis* (Bt) (Dipel, Biobit). Another commonly used chemical is methoxyfenozide (Intrepid).

- ❑ Mating disruption has been studied in Europe for several years. It has proven most effective when grapevine moth populations are low and when applied to large areas of

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over 10 acres or areaqide. Since this is a newly reported pest, no *L. botrana* pheromone mating disruption products are currently registered in the United States.

Weed Control

The use of cover crops in vineyards achieves protection of soil and may support beneficial insects. However, there are often difficult weeds that may also grow in the vineyard and if not controlled can spread and overwhelm cover crop plants. Additionally, dense growth in the vine row can compete with the vines, particularly young vines, use additional water and need control.

There are a variety of approaches to weed control. Each site is different and conditions may vary from year to year. Weed control should be reviewed every year and the following questions evaluated by the grower:

- ❑ What is the tolerable level of weeds in various areas of the vineyard?
- ❑ What measures can be used to achieve this tolerable level and how do they compare for environmental effects?

Herbicides are used to kill unwanted plants in the vineyard. There are pre- and post-emergent herbicides that have varying degrees of toxicity for fish and wildlife. Some herbicides such as Simazine have been identified as leaching into groundwater and affecting fish and water supplies and for this reason this chemical should not be used.

Other herbicides can be used in a limited direct application to control infestations of difficult weeds and reduce the need for greater herbicide use in the future. However, broad use of pre-emergent herbicides may leave inadequate cover in the vine row to prevent soil erosion.

Many formulations of herbicides are safe for use near water while others are not. For example, the aquatic formulation of glyphosate, a post emergent herbicide, is safe for use near water.

- ❑ Some of the common herbicides used are Roundup, Goal, Scythe, Devrinol and Surflan.
- ❑ Consult the Table IIID regarding the toxicity of a particular herbicide to wildlife or ask the County Agricultural Commissioner.
- ❑ Use herbicides only where needed for vine health and to control noxious weeds from spreading. Limit the use of herbicide for cosmetic or aesthetic reasons.
- ❑ Contact (post-emergent) herbicides may be preferable to treat problem plants rather than the widespread use of pre-emergent herbicides to remove all weeds. Some post-emergents have low environmental effects and for particular weeds are the primary effective materials. The choice of herbicide should strive for the lowest environmental effect, least erosion effect, and greatest control efficiency.
- ❑ Mechanical measures to control weeds in the vineyard are also available. These include gas burners that singe weeds in the vine row early in the season. Various types of

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machinery such as French ploughs remove weeds in the vine row without damaging the vine. However, these methods may not work at all times in hillside vineyards due to erosion and fire hazard issues.

Fertilizers

Fertilizers such as nitrogen and phosphorous are used in agriculture to provide additional nutrients to plants. Grapevines are not given large amounts of nitrogen as it does not lead to the best quality winegrapes. Unless carried off by rainfall shortly after being applied, these materials do not normally end up in the aquatic system. However, if fertilizers do reach the water they have the potential to cause algae blooms and fish die offs from the oxygen depletion created when the algae dies back.

- ❑ Use a schedule, visual assessment of the vines to determine the need for the major nutrients. Have a petiole analysis done to determine the need for micronutrients.

- ❑ If using fertigation methods install a backflow prevention system to assure that the water with the fertilizer will not backflow into water sources. Check that the system is working prior to fertigation.

- ❑ Compost and solid time-release fertilizers are less prone to runoff into waterways. Recent field trials with compost mulch have also established its use as an erosion control measure.

- ❑ Compost increases microbial activity in the soil. These bacteria make phosphate already present in the soil more available for uptake by vines thus reducing the need for the addition of fertilizer.

- ❑ Cover crops that include legumes can be disked into the soil to increase nitrogen levels.

Wellhead Protection

All active and abandoned wells on the property should be protected from inflow of chemicals and fertilizers during mixing, loading and storage of pesticides as well as from rinsing and cleaning of spray equipment or pesticide containers.

- ❑ Site chemical storage, loading and rinsing areas a minimum of 100 ft away from wells

- ❑ Place a berm around the wellhead to protect against movement of surface water into well.

- ❑ Do not spray restricted pre-emergent herbicides (Atrazine, Simazine, Bromacil, Diuron, Prometon, Bentazon, Norflurazon, Alachor (Lasso), Bensulide (Betasan, Pre-san, Prefar), Butylate (Sutan), Chlorsulfuron (Glean, Telar, Corsair), Cynazine (Bladex), Cycloate (Ro-neet), Dazomet (Busan, Basamid), 2, 4-D, dimethylamine salt, Dichlobenil (Casoron), Diquat dibromide, EPTC (Eptam), Ethofumesate (Norton, Prograss), Hexazinone (Velpar, Pronone), Imazethapyr (Pursuit), Isoxaben (Gallery), Linuron (Lorox, Linex), Metribuzin (Lexone, Sencor), Molinate (Ordam), Napropamide (Devrinol), Oryzalin (Surflan, Rout, Oryza Ag), Pebulate (Tillam), Prometryn (Caparol), Propyzamide (Kerb, Pronamide), Pyrazon (Pyramin), Rimsulfuron, Sulfometuron-methyl

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(Oust), Tebuthiuron (Spike) within the bermed area or within 100 ft of an unbermed wellhead.

Backflow Protection

If you use the vineyard drip irrigation system to apply pesticides or fertilizer, there needs to be a number of safeguards in the system to prevent the backflow of chemicals into groundwater. The California State Department of Pesticide Regulation recommends the following components:

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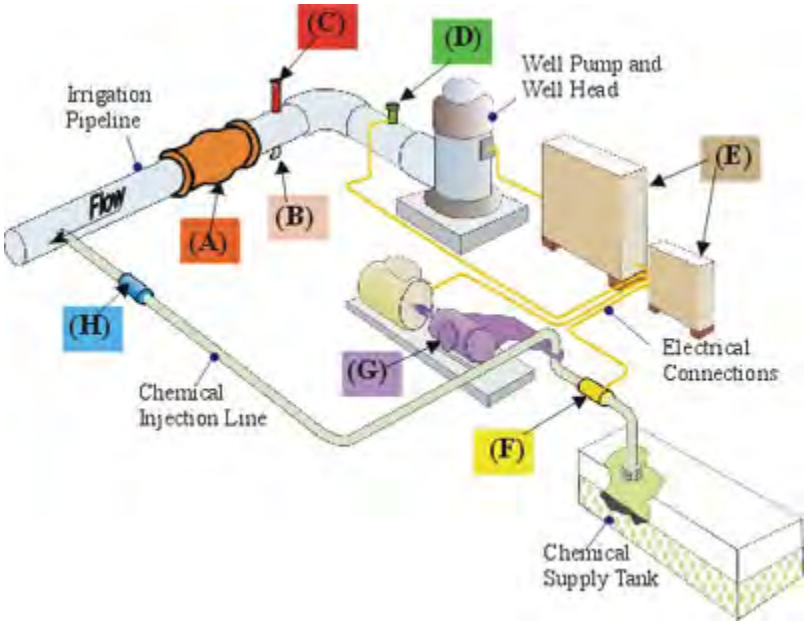
Required Chemigation Components:

[(A) Mainline Single Check Valve](#)
[(B) Low Pressure Drain](#)
[(C) Air/Vacuum Relief Valve](#)
[(D) Pressure Switch](#)
[(E) Interlocking System Controls](#)
[(F) Solenoid Operated Valve](#)
[(G) Chemical Injection Pump](#)
[(H) Injection Line Check Valve](#)



Component Descriptions

(A) Mainline Single Check Valve:

- Prevents backflow to well
- Spring-loaded, positive closing action
- Watertight seal (not metal to metal)
- Install between well & chemical injection line

(B) Low Pressure Drain:

- Drains minor check valve leakage away from well
- Install at bottom side of irrigation pipeline, upstream of mainline check valve

(C) Air/Vacuum Relief Valve:

- Prevents backsiphonage
- Can be combined with inspection port
- Install upsteam of mainline check valve

(D) Pressure Switch:

- Stops well pump when water pressure decreases
- Install in irrigation pipeline or well pump

(E) Interlocking System Controls:

- Automatically shuts off chemical injection pump when well pump stops
- Solenoid valve & chemical injection pump interlocked with well pump

- Install between chemical injection pump and well pump

(F) Solenoid Operated Valve:

- Prevents chemical withdrawal when irrigation system shuts down
- Install on intake side of chemical injection pump & connect to interlocking system controls

(G) Chemical Injection Pump:

- Assures proper chemical injection rate
- Constructed of chemically resistant materials
- Connect to interlocking system controls

(H) Injection Line Check Valve:

- Prevents flow of fluid back towards chemical injection pump
- Automatic, quick-closing check valve
- Constructed of chemically resistant materials
- Install between irrigation pipeline & chemical injection pump

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TABLE IIID PESTICIDE TOXICITIES FOR FISH AND BIRDS*
F = fungicide, H = herbicide, I = insecticide, N = nematocide

Trade Name (Product Name)	Common Name (Chemical Name)	Use	Fish LC_{50} (mg/L) for rainbow trout	Bird LD_{50} (mg/kg)	Soil Half-life (days)	Pathway/Movement into water or groundwater	Notes
Abound	Azoxystrobin	F	Moderate fish toxicity - 1.1 for bluegill	No information found	65	High absorption to soil particles, low leaching	Powdery mildew, botrytis bunchrot control. Inhibits fungal respiration.
Acramite	Bifenazate	I	High fish toxicity - 0.76	Low bird toxicity - 1142	5	No information found	Miticide
Agri-mek	Abamectin Abarnectin	I	High fish toxicity - 0.003	Low bird toxicity - >2000	7	Unlikely to leach or contaminate groundwater	Abamectin is used to control insect and mite pests.
Altacor	Chlorantraniliprole	I	Moderate fish toxicity 75.8	Low bird toxicity >2,000	>100 days	Persistent and mobile in terrestrial and aquatic habitats.	Controls European Grapevine Moth.
Armicarb, Remedy	Potassium bicarbonate	F	No information found	No information found	No information found	No information found	Fungicide for the control of powdery mildew.
Aquashade	Erioglaucine, Tartrazine	Algae cide	Slightly toxic > .01	Low bird toxicity <5620 ppm	N/A	N/A	Other active ingredients are F.D.&C. Blue No. 1 and Yellow No. 5. Do not bioaccumulate in fish
Auxigro	Glutamic acid	F	No information found	No information found	No information found	Degrades rapidly in the environment	Glutamic acid is an amino acid found in nature. It is used as a fungicide and acts as a growth inhibitor.
Bayleton	Triadimefon	F	Moderate fish toxicity - 14	Low bird toxicity - >4000	26	Moderate	Triadimefon is used for control of powdery mildew and bunch rot. Prevents synthesis of ergosterol – a sterol that is needed by fungi to grow.

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Benlate	Benomyl	F	High to moderate fish toxicity - 0.05 to 14	Low bird toxicity - 10,000	(67) When applied to turf, it has a half-life of 3 to 6 months and, when applied to bare soil the half-life is 6 to 12 months	Low	Benomyl is a systemic, benzimidazole fungicide that is selectively toxic to microorganisms and to invertebrates, especially earthworms.
Champ	Copper hydroxide	F	High fish toxicity - 0.023	Moderate bird toxicity - 686	Copper will persist indefinitely and is bound to organic materials and clay.	Copper absorbed to clay will reach waterways through soil erosion	Powdery mildew, botrytis control.
Chateau	Flumioxazin	H	Should not be applied near water. Moderate fish toxicity - 23	Low bird toxicity >2250	No information found	Does not leach	Pre-emergent herbicide
Copper Sulfate (Bordeaux mix)	Copper sulfate	F	High fish toxicity - 0.13	Low bird toxicity >2000	Copper will persist indefinitely and is bound to organic materials and clay.	Copper absorbed to clay will reach waterways through soil erosion	Eutypa treatment, powdery mildew, botrytis control.
Cygon	Dimethoate	I	Moderate fish toxicity - 6.2	High bird toxicity - 41.7 to 63.5	4 to 16	low persistence in the soil	Dimethoate is an organophosphate insecticide.
Devrinol	Napropamide	H	Moderate fish toxicity - 9 to 16	Low bird toxicity - 5600	56 to 84	Moderate	Napropamide is a selective systemic amide herbicide used to control a number of annual grasses and broad-leaved weeds.
Dipel, Abel, Biobit, Foray, Javelin, Thuricide	Bacillus thuringiensis	I	Low fish toxicity	Low bird toxicity >10,000	A naturally occurring soil bacteria that readily breaks down	Adheres to organic matter	A naturally occurring soil bacterium that produces a poison which causes disease in insects, especially caterpillars of moths and butterflies.

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Dithera (Ditera)	Myrothecium verrucaria	N	Should not be applied near water	No information found	No information found	No information found	Microbial suspension applied to soil for nematode control.
Dithane	Maneb/Mancozeb	F	Moderate fish toxicity - 2.2	Low bird toxicity - >10,000	1 to 7	Low	Mancozeb is used for botrytis.
Elevate	Fenhexamid	F	Moderate fish toxicity - 2.66	Low bird toxicity - >2,000	No information found	Very soluble in water	Used for botrytis.
Elite	Tebuconazole	F	No information found	No information found	No information found	Low	Powdery mildew control. Prevents synthesis of ergosterol – a sterol that is needed by fungi to grow.
Entrust, Conserve SC, Success	Spinosad	I	Moderate fish toxicity 30.0	Low bird toxicity >2,000	9-10	Very low leaching potential due to a moderate soil sorption coefficient, low to moderate water solubility and short residual time in the environment	Controls European Grapevine moth
Enzone	Sodium tetrathiocarbonate	F, I, N	21 – in bluegill	No information found	Low	Low	Applied to soil for nematode, oakroot fungus and phylloxera control.
Flint	Trifloxystrobin	F	High fish toxicity		5	High absorption rate, low leaching	Powdery mildew botrytis control. Inhibits fungal respiration.

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Goal Tender	Oxyflourfen	H	High fish toxicity - 0.41	Low bird toxicity - >4000	35	Extremely Low	Herbicide, can be used as a pre-emergent.
Habitat	Imazopyr	H	Low fish toxicity 11,000 mg/l	No information found	90 days	Low	Aquatic herbicide, can be applied to water, targets waterweeds
Horticultural oil, Stylet oil	Refined petroleum distillates	I, F	Low fish toxicity - >25,000	No information found	21	No information found	Used as dormant and green oil for control of leafhoppers, spider mites and mealybugs.
Intrepid 2F, Intrepid 80 WSP	Methoxyfenozide	I	Moderate fish toxicity 4.2	Low bird toxicity >5,620	336-1,100	Highly persistent, likely to be transported in solution to surface waters and leach into groundwater	Insect growth regulator that controls codling moth, leafroller and European Grapevine Moth.
Lime Sulphur	Lime Sulphur	I	Range from High to Moderate toxicity - 0.003 - 8.8	No information found	No information found	No information found	Dormant spray for control of mealybugs.
Lorsban, Dursban	Chlorpyrifos	I	Very high fish toxicity - 0.009	High bird toxicity - 112	60 to 120	Very low; immobile in soils unlikely to leach	Chlorpyrifos is a broad-spectrum organophosphate insecticide used for spot control of ants and mealybugs.
Malathion: Celthion, Cythion, Dielathion	Malathion	I	Highly toxic to fish 200	Moderately toxic to birds 400	biodegrades quickly	Drift and runoff likely	Highly toxic to bees, broad spectrum organophosphate

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Neem oil, Trilogy	Clarified hydrophobic extract of neem oil	F, I	Should not be applied near water	No information found	No information found	Dispersible in water	Used for control of spider mites.
Nemacur	Fenamiphos	N	High fish toxicity - 0.11	Very high bird toxicity - 1.0 to 2.4	50	Not strongly adsorbed to soils, disappears quickly from water	Fenamiphos is an organophosphate nematicide.
Nexter, Nester	Pyridaben	I	Very high fish toxicity	Low bird toxicity - 2,250	86	High absorption, low leaching	Used for control of spider mites.
Omite	Propargite	P	Low fish toxicity – 118 - 445	No information found	56	Very Low	Used for control of spider mites.
Pristine	Pyraclostrobin, Boscalid	F	Moderate fish toxicity – 3.9	No information available	No information found	Potential for groundwater contamination from poorly drained soils- a vegetative buffer strip is recommended	Botrytis control, controls powdery mildew.
Provado, Admire, Marathon, Premier, Pro-Rate Merit	Imidacloprid	I	Low fish toxicity - 211 (high shrimp toxicity)	High bird toxicity - 152	48-190	Breaks down very fast in heat and light. In alkaline soils, Imidacloprid can easily permeate into groundwater.	Imidacloprid is a systemic, chloro-nicotinyl insecticide with soil, seed and foliar uses for the control of sucking insects such as leafhopper, mealybugs and spider mites.
Procure	Triflumizole	F	High fish toxicity - 0.58	Low bird toxicity - >2,510	14	Moderate	Powdery mildew control. Prevents synthesis of ergosterol – a sterol that is needed by fungi to grow.

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Trade Name (Product Name)	Common Name (Chemical Name)	Use	Fish LC_{50} (mg/L) for rainbow trout	Bird LD_{50} (mg/kg)	Soil Half-life (days)	Pathway/Movement into water or groundwater	Notes
Pyganic	Pyrethrins	I	Moderate fish toxicity - 3.4;	Low bird toxicity >10,000	No information found	Little residual effect. Breaks down in water	Pyrethrins are natural insecticides derived from certain species of chrysanthemum plants and also made synthetically.
Quintec	Quinoxyten	F	Should not be applied near water. High fish toxicity- 0.1 - 1.0	Low bird toxicity > 2000	3-17 days	Low persistence in soil	Powdery mildew control, dangerous to bats.
Rally, Systhane	Myclobutanil	F	Moderate fish toxicity - 4.2	Moderate bird toxicity - 510	66	Moderate	Powdery mildew control. Prevents synthesis of ergosterol – a sterol that is needed by fungi to grow.
Rubigan	Fenarimol	F	Low fish toxicity	No information found	360	Moderate absorption, high leaching	Powdery mildew control. Prevents synthesis of ergosterol – a sterol that is needed by fungi to grow.
Roundup (upland formulation), Rodeo (formulation near water)	Glyphosate	H	Moderate fish toxicity - 86 (130) 69**	Low bird toxicity - >4500	47 - half life is shorter in lower pH soil	Extremely Low	Herbicide
Rovral	Iprodione	F	Moderate fish toxicity - 6.7	Low bird toxicity - >2,000	14	Low	Botrytis control
Scythe	Nonanoic acid (fatty acid)	H	Do not apply near water	No information found	No information found	Emulsifiable in water	Broad-spectrum foliar herbicide
Serenade	Strain of dried Bacillus subtilis	F	No information found	No information found	No information found	Dispersible in water	Powdery mildew, Botrytis biofungicide. Fermentation product of a bacterium that inhibits cell growth of fungi and bacteria.

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Sevin	Carbaryl	I	Moderate fish toxicity - 1.3	Low bird toxicity - >2,000	7 to 14	Low	Carbaryl is a wide-spectrum carbamate insecticide.
Sovran	Kresoxin-methyl	F	0.5 mg/L High fish toxicity	Low bird toxicity	No information found	Easily permeates alkaline soils to groundwater.	Suppresses Botrytis
Sonata	Strain of dried Bacillus pumilus	F	No information found	No information found	No information found	Dispersible in water	Biofungicide for powdery mildew
Sulphur (powder)	Sulphur	F	Low fish toxicity >5,000	Low bird toxicity - 2250	No information found	Powder can drift into waterways	Powdery mildew control. Interferes with fungal cellular respiration.
Wettable sulphur and micronized wettable sulphur	Sulphur	F	No specific information found, likely same as powdered sulphur	No specific information found likely same as powdered sulphur	No information found	Low	Powdery mildew control
Surflan	Oryzalin	H	Moderate fish toxicity - 3.26	Moderate bird toxicity- >500	20	Low	Oryzalin is a selective pre-emergent surface-applied herbicide.
Topsin	Thiophanate	F	Should not be applied near water. Moderate fish toxicity 2.2	No information available	No information found	No information found	Powdery mildew control
Telone, Inline	1, 3 – Dichloropropene	N	Low fish toxicity - 470	High bird toxicity - 152	10	Moderate	Applied to soil for nematode control. Inline and Telone have 2 active ingredients 1,3- Dichloropropene and Chloropicrin.
Telone, Inline	Chloropicrin	N	High fish toxicity - 0.0165		4.5 hours	Moderate	

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TABLE IIID PESTICIDE TOXICITIES FOR FISH AND BIRDS*
F = fungicide, H = herbicide, I = insecticide, N = nematocide

Trade Name (Product Name)	Common Name (Chemical Name)	Use	Fish LC_{50} (mg/L) for rainbow trout	Bird LD_{50} (mg/kg)	Soil Half-life (days)	Pathway/Movement into water or groundwater	Notes
Valero	Cinnamaldehyde	I, F	May be toxic to fish	No information found	No information found	No information found	Miticide
Vanguard, Vangard	Cyprodinil	F	Low fish toxicity	No information found	50	Low leaching	Botrytis control

*Toxicity level based on bobwhite quail or mallard, Numbers in ( ) are from 1996 data.

Toxicity Rating
Toxicity to fish (LC_{50}): less than 1 mg/L = High, 1-100 mg/L = Moderate, and greater than 100 mg/L = Low.
Toxicity to birds (LD_{50}): less than 200 mg/kg = High, 200-1,000 mg/kg = Moderate, and greater than 1,000 mg/kg = Low.

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REFERENCES FOR TABLE IIID PESTICIDE TOXICITIES FOR FISH AND BIRDS

Websites and publications used:

California Department of Fish and Game. 1996. California Wildlife and Pesticides: A guide to using pesticides in and near fish and wildlife habitat.

EXTOXNET

http://ace.orst.edu/info/extoxnet

The EXTOXNET InfoBase provides a variety of information about pesticides. The Pesticide Information Profiles (PIPs) (http://ace.orst.edu/info/extoxnet/pips/pips.html) contain specific information on pesticides. Information in these topic areas primarily has been developed by toxicologists and chemists within the Extension Service of the land-grant universities University of California-Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho.

Environmental Protection Agency

http://www.epa.gov/docs/envirofw/html/emci/chemref/index.html

US EPA Envirofacts Master Chemical Integrator (EMCI) – Searches the EMCI Chemical References Web Pages.

http://www.epa.gov/opppmsd1/PPISdata/ppisdata.htm

The Pesticide Product Information System (PPIS) contains information concerning all pesticide products registered in the United States. It includes registrant name and address, chemical ingredients, toxicity category, product names, distributor brand names, site/pest uses, pesticide type, formulation code, and registration status.

http://www.epa.gov/pesticides/

US EPA Office of Pesticide Programs

CDMS – Ag Chem Information Services

www.cdms.net

CDMS, Inc. is a privately held corporation located in Marysville, CA. Founded in 1983, the company provides America's premier software service to access crop protection product label, MSDS, WPS and DOT information.

National Pesticide Information Center (NPIC)

http://npic.orst.edu/tech.htm#ecpd

The NPIC is a cooperative effort of Oregon State University and the U.S. Environmental Protection Agency. It provides objective, science-based information about a wide variety of pesticide-related subjects, including: pesticide products, recognition and management of pesticide poisoning, toxicology, and environmental chemistry.

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Natural Resources Conservation Service (NRCS)
http://www.wcc.nrcs.usda.gov/water/quality/common/pestmgt/winpst.htm#ppd
Windows Pesticide Screening Tool (WIN-PST) is a pesticide environmental risk screening tool that NRCS field office conservationists, extension agents, crop consultants, pesticide dealers and producers can use to evaluate the potential for pesticides to move with water and eroded soil/organic matter and affect non-target organisms.

California Department of Pesticide Regulation
http://www.cdpr.ca.gov/docs/label/prodnam.htm – Search page.
Product specific inquiries (product and use data)

Pesticide Wise – University of California, Riverside Cooperative Extension Water Quality Program
http://www.pw.ucr.edu/WQ_Homep.asp
Pesticide Wise searches through a comprehensive EPA-USDA database and presents critical information on a pesticide's properties and water quality risks.

Scorecard
www.scorecard.org/chemical-profiles
Scorecard provides detailed information on more than 6,900 chemicals, including all the chemicals used in large amounts in the United States and all the chemicals regulated under major environmental laws. You can search for information by typing in the chemical's name (or any common synonym) or the chemical's standard identification number (Chemical Abstracts Service or CAS registry number).

Pesticide Action Network Pesticide Database
www.pesticideinfo.org
Lists regulatory status of agricultural chemicals. Research based on EPA's PPIS and CDPR list of active ingredients.

Various websites of pesticide manufacturers were used as well.

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14. WATER SUPPLY AND CONSERVATION

Background: Water Supply and Conservation

Water Conservation: Irrigation

Vineyards use low amounts of irrigation water ranging from one-third to one-acre foot of water per acre per year. Winegrape quality can be reduced by over watering so grapegrowers are typically very careful about irrigation practices. By comparison suburban landscaping can consume 6-10 acre-feet of irrigation water per acre per year.

Most vineyards use drip irrigation systems that are highly efficient in conserving water. However, there may be additional measures that can be used to further reduce water use, particularly in dry years. An important element of water conservation is to irrigate only when necessary, rather than on a schedule. Water use and need by grapevines depends upon the microclimate of the vineyard site, summer temperatures and conditions, overall rainfall for the year and the time period since the last rainfall, the soil type and slope of the site and the variety and age of the grapevines. To further evaluate soil moisture conditions simply dig a hole for each soil type and pickup a handful of soil at the depth of the root zone. Use the following table to evaluate soil moisture:

WHEN IRRIGATION IS NEEDED, SOIL WILL FEEL AND ACT THIS WAY:

SOIL TEXTURE	A HANDFUL OF SOIL WILL:
Coarse	*Tend to stick together slightly, but will not form a ball.*
Medium	*Be crumbly, but will form a ball.*
Fine	*Be pliable, and will form a ball.*

Another method is to use neutron probes distributed over the vineyard to measure soil moisture in the various soil types. The probes should be placed to 12 ft. depths and be read weekly. This information is used with California Irrigation Management Information System (CIMIS) information from the nearest station. Based upon weather data collected at the station, the CIMIS information estimates the amount of water evaporated from the soil and the amount used by irrigated grass at the station site. The CIMIS ET (evapo-transpiration) numbers for grass can be converted to other crops using site-specific information from the neutron probes in your vineyard. CIMIS data is available by subscription and over the internet (www.cimis.water.ca.gov). Some large grapegrowers have their own weather stations and complete a similar estimate based upon site-specific data.

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Measurements of leaf turgidity, or water content, using a pressure bomb can also be used to determine if vines need irrigation. The neutron probe/CIMIS information, leaf turgidity and soil moisture data help to more precisely determine how many hours to irrigate.

Irrigation Systems

Irrigation systems are made up of a main waterline from the source of water (well, reservoir, canal, or riparian diversion) to the vineyard. Described simply the water is pumped from storage through a mainline to smaller pipes and blocks of vineyard with drip irrigation lines and emitters. There are also other parts of the system that regulate pressure and boost water up slope. The emitters drip water to each vine, and for most vineyards, release between one half to one gallon of water per hour.

Dry Farming

There are locations, particularly in valley areas, where vineyards are dry farmed, or not irrigated. The vines may be irrigated just after planting, but once established, are not regularly irrigated. Grapevines have deep roots and will seek out groundwater. Dry farmed vineyards must be managed to reduce competition from grasses and cover crops, but due to the lack of irrigation, may have fewer weeds and undergrowth. The vine may also not produce as extensive of foliage or amount of grapes as an irrigated vineyard. There are some locations amenable to dry farming due to groundwater availability and others, such as rocky, well-drained hillsides, where this practice may not be possible. Dry farming near native trees such as valley oaks may be difficult as native plants can out-compete the vines.

Water Conservation: Frost Control

In certain areas, spring can bring freezing temperatures after grapevines have budded out. These frosts will burn tender vegetation and damage the plant if no measures are taken. Frost conditions come from two different types of climatic events. Advection frost occurs when a large mass of arctic air occupies a valley, creating frost conditions on both the valley floor and hillsides. The frost season of 2008 included an advection frost event on April 20-21.

More common are radiation frost events. In these events, cold air pools at the lowest points in a river valley, along tributary creeks, and in hollows. Above this layer of cold air, a warmer air mass may be present, creating a strong inversion layer. If the difference in air temperature between the valley floor and upper layers is small, this is a weak inversion layer. Radiation frost events are also marked by clear skies and calm winds. Radiation frost events occur in the valleys and low hollows of the Russian River watershed on a frequent basis. Only frost events that occur during and after grape bud break are of concern to farmers. This is usually the March 15 to May 15 period. Typically vineyards and orchards on the valley floor and in hollows or low spots in the hilly areas require frost protection. Most hillside vineyards do not need frost protection due to the infrequent occurrence of advection frost.

In order to understand frost control measures, it is essential to understand the physical processes that occur during a radiation frost event. During a radiation frost event, more energy is lost to clear, cold skies from the vines than is gained. Cloudy or windy conditions may have adequate energy transfer to avoid energy loss from the vines. Typically there are several types of energy transfer:

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- **Conduction** is the transfer of energy through objects that don't move. Soil heat moves through conduction.
- **Convection** is the transfer of heat in moving air.
- **Radiation** is the transfer of electromagnetic energy such as sunlight. Crops radiate energy as does the atmosphere.
- **Latent heat** is the energy stored in the bonds that join water molecules together. For example, when water changes form from a liquid to a solid state, the environment around the water changes temperature due to the change of the latent heat in the water to sensible heat. Sensible heat is measured with a thermometer and is "sensed" by us. When water changes from liquid to a solid, the localized air temperature rises. When water changes from a liquid to a vapor state, the localized air temperature falls. This cooling effect of evaporating water is the principle used by swamp coolers. Similarly, there is a warming effect of freezing water.

One of the physical factors besides air temperature that determines frost effects is humidity. Humidity plays a major role in frost events. Humid air or air with a high water vapor content has a higher energy content than dry air, due to the increase in air temperature produced when vapor condenses or changes to a liquid form.

The severity and timing of a frost event is affected by both the air temperature and the timing of freezing temperatures (32°F or 0°C), as well as the dew point or temperature (DPT) at which water vapor condenses to liquid or dew. The wet bulb temperature (WBT) is another important

measure and is the evaporatively cooled temperature of a moist surface in a given air mass. WBT is approximately halfway between ambient air temperature and dew point temperature.

During very low humidity conditions, damage to vines may occur before freezing temperatures (32°F or 0°C) occur. For this reason, air temperatures, dew point, and wet bulb temperature must be monitored to determine when to begin frost prevention measures.

Water freezes onto plants more readily if ice-nucleating bacteria are present. The bacteria act as surface particles that make it easier for ice crystals to form. These bacteria have the greatest effect in the range between 23°F to 32°F (-5°C and 0°C). Spraying anti-bacterial copper or introducing competing bacteria that do not nucleate ice can reduce the ice-nucleating bacteria.

For most of the valleys where grapes are grown, frost control is essential to avoid major damage and loss of both a year's crop and sometimes the vines themselves. Vineyards on hillsides or near the coast or San Francisco Bay typically do not have frost problems or require frost protection most of the time.

In the Upper Russian River and Navarro River drainages, springtime temperatures can become very cold (27°F or -3.9°C wet bulb temperature) and these areas are in a severe frost zone. Portions of the Sonoma County area of the Russian River watershed, Alexander Valley, Knights Valley, and many small valleys and hollows are also severe frost zones. Upper Napa River watershed, Pope Valley, Wooden Valley, and Upper Sonoma Creek watershed are severe frost zones. Other parts of these watersheds are moderate frost zones (28-30°F or -2.2°C wet bulb temperature). Lower Napa River watershed, lower Sonoma Creek watershed, and Suisun Valley have mild frost events (31-32°F or -0.5 – 0.0°C wet bulb temperature) due to the moderating effect of San Francisco Bay.

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Small topographic changes between the low-lying areas of a valley and adjoining lands can create different levels of severity in frost events and allow for different frost prevention methods.

Temperature monitoring in the vineyard is the only way to determine what frost prevention methods can be used. Detailed weather forecasts, particular for local areas, can provide important information on whether freezing air temperatures and low dew point temperatures will occur, where they will occur on a local basis, and what time of day or night critical temperatures will occur. But site specific air temperature and wet bulb temperature monitoring are needed to determine when frost prevention measures should begin for a particular location.

Passive Frost Control Measures
There are a number of passive measures that can be implemented to reduce frost damage in vineyards. These are cultural measures which can allow for lower temperatures to occur without damaging vines. These measures used alone can be adequate in areas with very little frost risk. They can also be incorporated into a program which includes active measures.

Passive Frost Control Measures include:

- **Site selection**. Some varieties of grape vines bud later in spring and will require less frost protection. Chardonnay is an early budding variety, while Cabernet is not. If the soil and climate are appropriate, the lowest-lying valley areas can be planted or replanted to the later-budding grape variety to reduce water use.

TABLE IIIE SEASONAL BUD BREAK BY GRAPE VARIETY

Grape variety	Seasonal date of budbreak
Chardonnay	Early
Pinot noir	Early
Gewürztraminer	Early
Pinot gris	Early
Petite Sirah	Middle
Merlot	Middle
Zinfandel	Middle
Syrah	Middle
Viognier	Middle
Sauvignon blanc	Middle/Late
Cabernet Sauvignon	Late

- **Increase cold air drainage** out of the vineyard. The row orientation and location of ornamental vegetation around the vineyard may be modified to allow for cold air moving to lower areas to drain rather than pool in the vineyard.

- **Restrict cold air movement** into the vineyard. For low-lying sites, row orientation and bordering vegetation can be used to block cold air moving into the vineyard, thereby limiting damage or active control measures to the outer vineyard edge.

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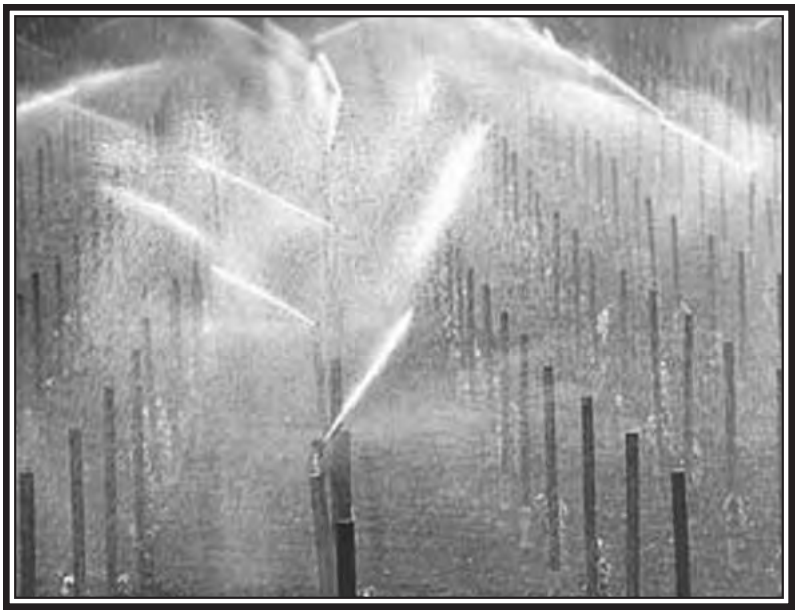

STANDARD SPRINKLER

LOW-FLOW SPRINKLER

WATER IS USED FOR FROST CONTROL IN AREAS WITH SEVERE AND MODERATE FROST TERMPERATURES

MICROSPRINKLER

VINE BURNED BY FROST WILL NOT PRODUCE A CROP

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WIND MACHINES CAN PROVIDE FROST CONTROL IN MODERATE TO MILD FROST ZONES BY STIRRING COLD LOW-LYING AIR LAYERS WITH OVERLYING WARMER AIR LAYERS. WiND MACHIENS DO NOT WORK IN SEVERE FROST ZONES

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Fish Friendly Farming
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ON-CHANNEL RESERVOIRS

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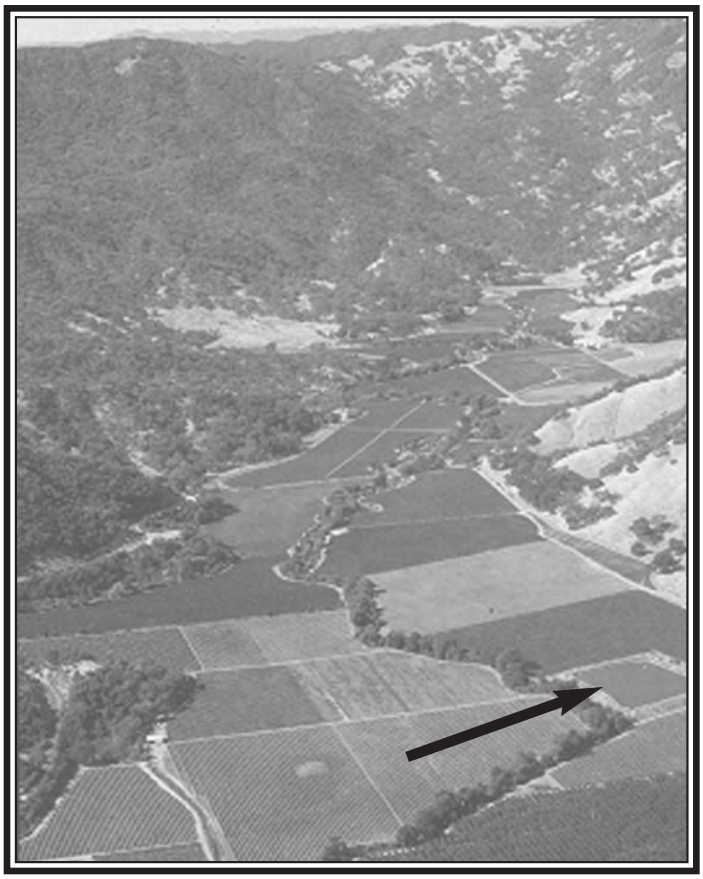

TWO AERIAL PHOTOGRAPHS SHOWING OFF-CHANNEL RESERVOIRS

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- **Late pruning**. By pruning grapevines later (early March), the onset of budding can be delayed and the need for frost control can be delayed.

- **Cover crop and vineyard floor management**. Cover crops are a required BMP during the rainy season, but they need to be managed to reduce frost problems. Decisions on what type of vineyard floor management is needed should consider if a drought is occurring and the level of frost risk for a particular site. Cover crops reduce the amount of heat absorbed by the soil. Cover crops also host ice-nucleating bacteria, which can increase frost damage. Mowing cover crops and strip-spraying with herbicides can reduce some of the negative effects of cover crops during frost events. Disking and rolling the soil surface is also suggested by some experts to increase solar radiation inputs into the soil, which will then radiate heat into the crop during nighttime hours. This practice can result in soil erosion and should only be used in dry years when water supplies are low. Vineyards with cover crops can be 1 to 3°F (0.5 to 2.0°C) colder than vineyards with mowed and disked cover crops.

- **Copper applications**. Copper sulfate is a commonly used, organically-certified fungicide. Copper applications can kill ice-nucleating bacteria and therefore reduce frost damage in marginally frost-prone areas and on nights with low, but not extremely low temperatures. Care in the application process is needed to avoid any drift of copper spray, any rinse-off, and any soil erosion as copper binds to soil particles. Copper is acutely toxic to aquatic organisms. Copper applications are known to allow for 1-1.5°F (0.5 to 1.0 °C) colder conditions without damage than on vines without copper.

- **Frost Gard, Frost Shield Sprays.** These sprays claim to provide protection to vegetation down to -2°F (28.4°F) but must be applied 24 to 10 hours before frost event and must completely coat the vegetation. The Frost Shield spray is a micro-thin protein pro-polymer and Frost Gard is a systemic/contact nutritional spray.

- **Risk management**. The risk of frost damage in marginally frost-prone areas may be low enough that only passive BMPs are needed.

Active Frost Control Measures
There are a few active frost control techniques currently in use – wind machines, diesel heaters, and water.

Wind machines have a limited application, depending upon the vineyard location. Most wind machines are a large horizontal fan that stirs up air masses, mixing the cold air near the ground with warmer layers above. In areas with marine influence, or certain microclimates, wind machines can work to prevent frost damage. However, in many interior valleys, the air layers above the ground are also at freezing temperatures, so mixing the air masses is not effective. Another type of wind machine is a Selective Inverted Sink (SIS), which is a fan oriented parallel to the ground and housed in a small tower. The fan, which is close to ground level, shoots cold air upward and draws warm air to the ground. Generally wind machines can provide frost protection down to 29°F (-1.6°C) and can only work where an inversion layer occurs at 6 to 50 feet above the ground and is at least 2.7°F (1.5°C) warmer than the ground layer air.

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Vineyard Heaters. Diesel fuel heaters were once in common use for frost protection. In a few areas, diesel vineyard heaters may still be used, but most growers stopped using them in the 1970s due to the air pollution problems they create.

Water. In colder areas with moderate to severe frost conditions, water is the only frost control measure. The concept behind this technique is based on the latent heat released as water moves from a liquid to solid state. By continuously applying water to the vineyard, the water changing from a liquid to a solid state on the vines creates heat and protects the vegetation from frost damage. Use of water can protect against temperatures of 27°F (-2.7°C) but will not work at 23°F (-5.0°C).

There are several different types of sprinklers in use for frost control in vineyards:

- **Standard size overhead sprinkler system** emit 50 gallons/minute/acre or 3,000 gallons/hour/acre. These are rotating head sprinklers, which wet the entire vineyard canopy and vineyard floor. They typically rotate every 30-60 seconds and 25-30 sprinklers are needed per acre regardless of the vine spacing or trellis type. A minimum of 0.1 inches of water must be applied per hour. Within the vineyard, these sprinklers have a separate system of water pipes than the drip-irrigation system.

- **Low-flow overhead sprinklers** emit 35-40 gallons/minute/acre or 2,400 gallons/hour/acre. These are also rotating head sprinklers, but wet a smaller area. These sprinklers are used at the same density as the standard overhead sprinklers. In vineyards with dense spacing standard sprinklers should be used. These sprinklers also run off a different set of waterlines than the irrigation system. If water availability is a limiting feature spacing the vines to be able to use these sprinklers may be advantageous.

- **Micro-sprinklers** are of two types: pulsating and constant. Both types operate as part of the drip-irrigation system. The micro-sprinklers are placed in the vine canopy and have a localized effect. To provide adequate frost protection there needs to be 280-400 micro-sprinklers/acre. Pulsating micro-sprinkler systems use 12-20 gallons/minute/acre or up to 1,200 gallons/hour/acre. Micro-sprinklers with constant water output use 25-35 gallons/minute/acre or up to 2,100 gallons/hour/acre. Micro-sprinklers do not work in divided canopy trellis systems; they work only in single canopy systems.

There are several considerations in choosing one type of sprinkler over another. Areas with severe frost events, such as Ukiah Valley, Upper Napa Valley or Pope Valley, can theoretically use micro-sprinklers as long as the system is turned on several hours earlier than standard set systems. However, there are many growers who have had problems with the small water lines of micro-sprinklers freezing in severe frost zones. It is not clear why these problems have occurred and if improved management with the micro-sprinklers would prevent frost damage in these vineyards. Another consideration is the vine-row spacing. In densely planted vineyards, the number of micro-sprinklers needed and the water use can exceed standard set sprinklers.

A final consideration is the method of harvest used. Machine harvesters are often used on flat ground in valley areas also typically frost-prone. Prior to harvest, all types of sprinklers have to be removed and then reinstalled prior to spring. Micro-sprinklers can be very labor intensive to remove and re-install due to their numbers in the vineyard.

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TABLE IIIF FROST ZONES AND AVERAGE ANNUAL HOURS OF FROST CONTROL

Severe	hours	Moderate	hours	Mild	hours
Redwood Valley	100	Upper Napa Valley		Lower Napa Valley	
Potter Valley	150	Dry Creek Valley		Coastal areas	
Ukiah Valley	80	Alexander Valley		Lower Sonoma Valley	
Hopland Valley	80	Petaluma Valley		Suisun Valley	
Anderson Valley					
Knights Valley					
Upper Sonoma Valley					
Green Valley					
Russian River Valley					

When to turn on the sprinklers

Determining when to turn on the sprinklers on a frost night will partially depend on the type of sprinklers used. For all systems, several types of temperature monitoring in the vineyard are needed.

Even if accurate localized weather forecasts are available, conditions in the vineyard's most frost-prone areas have to be monitored. Standard set sprinklers need to be turned on when the wet bulb temperature is above the critical damage temperature for the crop. For grape vines, the critical damage temperature is 31.5°F for 30 minutes. Micro-frost systems need to be turned on several hours earlier that standard sprinklers. Under low dew point temperatures (a very dry cold), sprinklers need to be turned on earlier than under higher dew point temperatures for the same air temperature. Under low dew point temperatures the wet bulb temperature is lower than the air temperature and, when the sprinklers are turned on the water reduces air temperatures to the wet bulb temperature and frost damage can occur. For this reason, sprinklers must be turned on early.

Wet bulb temperatures can be measured directly or determined from measurements of the dew point or relative humidity and air temperature. A wet bulb temperature above 31.5°F, the critical damage temperature for grapes is selected. Using Table IIIG the selected wet bulb temperature, and measured/predicted dew point can be selected and the air temperature for standard sprinklers turn-on can be read. If relative humidity and temperature are known, Table IIIH can be used to determine dew point temperature for use in Table IIIG. Direct measurements of wet bulb temperature in the vineyard allow for different types of sprinklers to be turned on at the needed time before the critical damage temperature will occur.

Wet bulb and dry bulb temperature can be measured in the vineyard with a manual instrument called a sling psychrometer or a digital version. The digital version, if fixed to a location in the canopy of the low part of the vineyard, often has the ability to be read remotely by a computer or

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cell phone. A network of instruments can give the greatest coverage and determine the need to turn on the sprinklers most accurately.

Water is continuously applied to the vines during frost events. As the water is applied and it freezes, it releases heat, warms the leaves, but then the temperature drops to the wet bulb temperature as evaporation occurs. If the leaves are not wetted again immediately, frost damage will occur. Therefore, the interval between water applications is critical to avoiding damage. This interval is the sprinkler rotation rate, which for standard overhead sprinklers is typically 30 seconds, but may be as long as 60 seconds. The entire bud/leaf/stem area needs to be covered on each rotation. Table IIII lists the water volumes applied for 30 or 60 second rotation sprinklers at various temperatures and wind speeds. The water is turned off when the air temperature and the wet bulb temperature are above 32°F (0°C). It is not necessary to wait for all the ice to melt.

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TABLE IIIG MINIMUM TURN-ON AND TURN-OFF AIR TEMPERATURES (^{O}F) FOR SPRINKLER FROST PROTECTION FOR A RANGE OF WET-BULB AND DEW-POINT TEMPERATURES (^{O}F)*

Dew-point Temperature	Wet-bulb Temperature (^{o}F)										
^{o}F	22	23	24	25	26	27	28	29	30	31	32
32											32.0
31										31.0	32.7
30									30.0	31.7	33.3
29								29.0	30.6	32.3	34.0
28							28.0	29.6	31.2	32.9	34.6
27						27.0	28.6	30.2	31.8	33.5	35.2
26					26.0	27.6	29.2	30.8	32.4	34.0	35.7
25				25.0	26.5	28.1	29.7	31.3	32.9	34.6	36.3
24			24.0	25.5	27.1	28.6	30.2	31.8	33.5	35.1	36.8
23		23.0	24.5	26.0	27.6	29.1	30.7	32.3	34.0	35.6	37.3
22	22.0	23.5	25.0	26.5	28.1	29.6	31.2	32.8	34.5	36.1	37.8
21	22.5	24.0	25.5	27.0	28.5	30.1	31.7	33.3	34.9	36.6	38.2
20	22.9	24.4	25.9	27.4	29.0	30.6	32.1	33.7	35.4	37.0	38.7
19	23.4	24.9	26.4	27.9	29.4	31.0	32.6	34.2	35.8	37.5	39.1
18	23.8	25.3	26.8	28.3	29.8	31.4	33.0	34.6	36.2	37.9	39.5
17	24.2	25.7	27.2	28.7	30.2	31.8	33.4	35.0	36.6	38.3	39.9
16	24.6	26.1	27.6	29.1	30.6	32.2	33.8	35.4	37.0	38.7	40.3
15	25.0	26.4	27.9	29.5	31.0	32.6	34.2	35.8	37.4	39.0	40.7

***Select a wet-bulb temperature that is at or above the critical damage temperature for your crop and locate the appropriate column. Then choose the row with the correct dew-point temperature and read the corresponding air temperature from the table to turn your sprinklers on or off. This table assumes a barometric pressure of 1013 millibars (101.3 kPa).**

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TABLE IIIH DEW-POINT TEMPERATURES (^{O}F) FOR A RANGE OF AIR TEMPERATURE AND RELATIVE HUMIDITY*.

Relative humidity	Temperature (ºF)					
%	32	36	40	44	48	52
	32	36	40	44	48	52
90	29	33	37	41	45	49
80	27	30	34	38	42	46
70	23	27	31	35	39	43
60	20	23	27	31	35	39
50	16	19	23	27	30	34
40	10	14	18	21	25	28
30	4	8	11	15	18	22
20	-4	-1	2	6	9	12
10	-18	-15	-12	-9	-6	-3

***Select a relative humidity in the left column and an air temperature from the top row. Then find the corresponding dew point in the table.**

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TABLE III I APPLICATION RATES FOR OVERHEAD SPRINKLERS FOR FROST PROTECTION OF GRAPEVINES

Temperature	Wind Speed	30 second rotation	60 second rotation	30 second rotation	60 second rotation
^{o}F	Mph	in/hr	in/hr	gpm/acre	gpm/acre
29	0.0-1.1	0.08	0.10	36	45
26	0.0-1.1	0.11	0.13	50	59
23	0.0-1.1	0.15	0.17	68	77
29	2.0-3.0	0.10	0.12	45	54
26	2.0-3.0	0.13	0.15	59	68
23	2.0-3.0	0.18	0.20	81	90

Tables 1-3 from: Snyder, Richard and J. Paulo de Melo-Abreu. 2005. Frost Protection: fundamentals, practice and economics. Food and Agriculture Organization of the United Nations Rome; Snyder, Richard L. 2001. Principles of Frost Protection FP005 Quick Answer. University of California, Davis.; Snyder, R. L., 2000. Sprinkler Application Rates for Freeze Protection FP004 Quick Answer. Department of Land, Air and Water Resources, University of California, Davis.

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Water Sources

Sources of water for the vineyard may be reservoirs, diversions from the river or wells. Each type of water supply has different permit and license requirements and potential effects on fish and wildlife habitats.

Salmon and steelhead trout require adequate amounts of cold water to spawn, incubate, rear and migrate successfully. In the winter, stream flows need to be adequate to attract adult fish. In the winter season, flood flows need to be adequate to clean and replenish gravel and supply clean, cold, oxygenated water to developing eggs. In summer and fall, rearing habitat requires enough water, typically provided by groundwater sources, to sustain cold-water conditions until winter rains arrive.

Reservoirs

There are numerous reservoirs in the Napa River and Suisun Creek watersheds. The largest is Conn Dam, creating Lake Hennessey along with Bell Canyon Reservoir, Rector Reservoir, Lake Madigan, Milliken Reservoir and Lake Curry, these reservoirs are for municipal water supply for cities.

In addition to these large reservoirs, there are small reservoirs throughout most watersheds. These reservoirs typically impound winter runoff for use in frost control and summer irrigation. Sometimes there are separate sources of water for irrigation and frost control. These small reservoirs are of several types:

- On-channel reservoirs consist of a permanent dam across a creek channel. The dam may impound a year round, intermittent or ephemeral creek. Typically for older reservoirs, water fills the impoundment and then water flows over a spillway, or an outlet is opened. These reservoirs also collect sediment from the in-flowing waterway.

- Off-channel reservoirs consist of a berm-enclosed storage reservoir filled by pumping or diverting from a creek, river, groundwater sources, or direct rainfall, but does not impound a stream.

- Seasonal reservoirs created by placing a small flashboard dam across a channel to impound flow.

The types of effects smaller reservoirs, as well as the large municipal reservoirs, can have in fish habitats include:

- The reservoir blocks a creek and the habitat above it from fish use.

- The reservoir impounds sediment as well as water, potentially causing channel incision downstream and a reduction in habitat.

- The flashboard dam may be placed too early in the year, blocking the movement of adult steelhead, or smolts, out of the system.

- Pumping from a creek, or river, to fill the reservoir in the late spring or summer can reduce water for rearing habitat.

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- The reservoir is stocked with warm water predatory fish such as small-mouthed bass and these fish are distributed into the creek system when the reservoir spills. Bullfrogs may also be distributed and both of these creatures can eat many small salmon, or steelhead, fry.

Direct Diversion

Another method involves direct diversion of water from creeks and rivers and may or may not involve a regulatory pond, or off-stream storage reservoir. This method may affect fish habitats in a number of ways:

- The pump can suck up small fish if not fitted with a functional fish screen.

- Direct pumping in the summer season can reduce flows, directly affecting rearing habitats and water temperatures.

- Diversions for frost protection may occur in early spring and can reduce water flows.

- All direct diversions for frost should have an off-stream storage pond to provide water for frost control and reduce the instantaneous diversion rate. Refilling the pond should be done at a rate and time that doesn't affect creek flows.

Collection of Subsurface Vineyard Drainage

Many vineyards have perforated pipe or French drain systems, which collect water below the vineyard surface and transmit it to sumps or cisterns. The sumps typically have pumps, which move water to off-stream reservoirs.

Purchased water

In the Suisun Valley and other areas of Solano County, farmers can purchase water from State and Federal sources. The Putah South Canal provides water from Lake Berryessa to irrigators and a number of cities. The Bureau of Reclamation manages Lake Berryessa and the Putah South Canal with the Solano Irrigation District as the local sponsor.

Wells

Use of groundwater is a common form of water supply for both agricultural and residential uses. Each well draws water from the groundwater basin around it and may or may not have any affect on the surface flow in a creek or the overall amount of summer groundwater for rearing habitat. The depth of the first perforation or screen should be investigated. If the well is near a stream, it may need to have a sleeve or liner installed to move the level of pumping to a greater depth.

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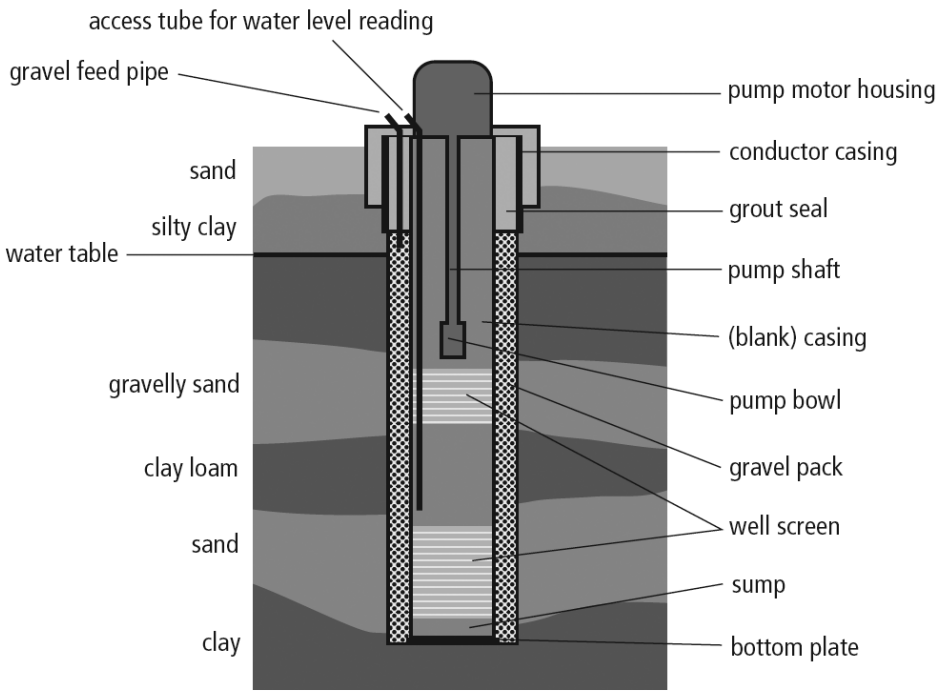

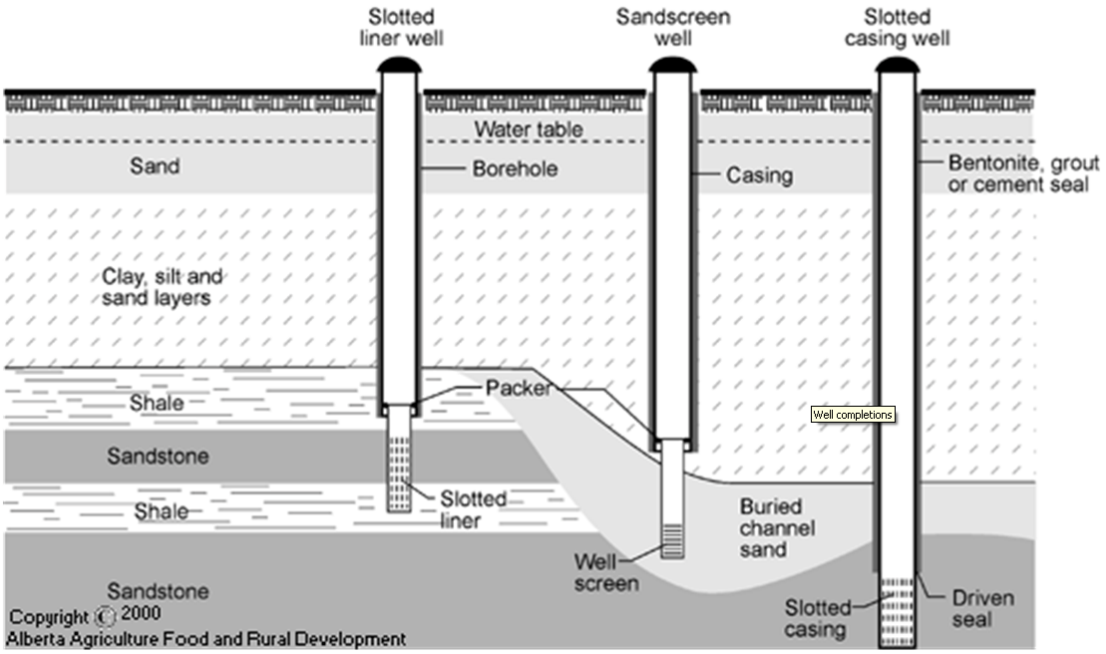

Drawings of wells illustrating the varied locations of well screen and seal/casing.

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Wastewater Re-use
In some locations, treated wastewater or recycled water from cities, or wastewater from a winery may be available for use in irrigation. These operations typically reduce dependence on other sources of water, but do require careful control and storage of the wastewater.

Water Rights

Water rights are fairly complex and cannot be fully explained in this document. The following is a brief review of the types of water rights and the permit and license requirements of each. For more information, contact the Division of Water Rights, State Water Resources Control Board in Sacramento (www.waterrights.ca.gov).

Riparian water rights are the right to divert water from creeks and rivers where the property is adjacent to the channel and the water is used only on the adjacent property. Water obtained through riparian diversion can be stored for 30 days only in a regulatory pond. Riparian diverters should file notices of their water use with the State Water Resources Control Board on an annual basis.

Appropriative water rights are issued by the State Water Resources Control Board, in accordance with the California Water Code and other state laws, through a permit and license process. Appropriative rights provide for longer-term (greater that 30 days) storage of a certain amount of water diverted at a defined location for certain beneficial purposes. Diversion periods and volumes are typically defined as part of the water right. Appropriative water rights usually take several steps –completion of an application, issuance of a permit to install the storage facility and divert water into it and issuance of the water right, or license, after it is demonstrated that all the stored water is being put to beneficial use in the irrigation of crops. Many existing storage reservoirs have a permit, but not a license. Some reservoirs and diversions may not have a permit and are still in the permit application process.

If you have a reservoir and have applied for, but not yet received your permit, license, or water right, new requirements may apply to your existing reservoir. For new applications, only off-channel reservoirs filled through diversions between December 15 and March 31 will receive appropriative water rights permits and licenses. Off-channel is defined as a reservoir that does not impound natural runoff of any type, but must be filled through a diversion from a water source or by direct rainfall. Reservoirs on ephemeral creeks are considered on-channel.

Assessment: Water Supply and Conservation in Irrigation Practices

- ❑ On the aerial photos/map indicate the location of the water sources, storage sites, wells and diversions.

- ❑ On the Farm Conservation Plan template, describe the features of the water supply system including:

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- ❑ The sources of irrigation water, storage sites, diversion sites, and type of water rights - appropriative or riparian, and any restrictions on the timing, flow levels, or volume of the use of the water right.
- ❑ Describe the operation of the reservoirs – when filled and from where, when flash boards are installed and other operational features.
- ❑ Describe the sources of frost control water and the features of the system.
- ❑ List the numbers of your appropriative water rights application, permit and license on the farm plan template.
- ❑ Describe the size of your irrigation blocks and average annual water use.
- ❑ Describe your method for determining when to irrigate - soil moisture, neutron probe, leaf turgidity (pressure bomb), CIMIS (California Irrigation Management Information System) data, or schedule.

❑ Answer the questions regarding the potential for changes to the water supply system.

❑ Do you use fertigation and does this require additional water over regular irrigation

❑ Do you have a backflow prevention valve to stop fertilizer from entering the water supply or groundwater

Assessment: Conservation in Frost Control Practices

❑ On the aerial photos/maps:

- ❑ Indicate those vineyard areas with frost control.
- ❑ Indicate vineyards as early, mid or late budding varieties.
- ❑ Indicate the locations of main water lines used in frost control operation, secondary and lateral water lines, water source, pumps, and any valves in the pipe system.
- ❑ Indicate any areas where water pressure can be a problem during frost events.
- ❑ Determine whether the site is in a severe, moderate or mild frost zone.

❑ On the Farm Plan Template, describe the features of the frost control system, including:

- ❑ Identify sources of weather data used for frost forecasts.
- ❑ Describe the number of locations in the vineyards regularly monitored and the frequency of monitoring during frost events.

❑ Do you monitor:

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- ❑ Air temperature
- ❑ Humidity
- ❑ Dew point
- ❑ Wet bulb temperature

- ❑ Indicate the type of sprinklers in each vineyard area.

- ❑ Indicate the water use per hour per acre for frost.

- ❑ Indicate the diversion rate of the pump if direct diversion from streams and river methods are used. Also indicate if the pump has variable speeds.

- ❑ Indicate diversion rate and refill timing if a reservoir is used for frost water supply.

- ❑ Indicate is a sump system is in place to re-capture applied water.

- ❑ Fill out tables and review potential for changes.

- ❑ Fill out the list of BMPs which will be used or are already in use on the site.

APPLYING VINEYARD MANAGEMENT BMPs: WATER SUPPLY AND CONSERVATION

Given the complexity of water supply, stream flows, individual watershed conditions and water rights, it is not possible to be completely comprehensive on this subject. However, we recommend several general BMPs:

General

- ❑ Make conservation of water in all uses on the farm a primary goal; regardless of the amount of water the property owner has rights to.

- ❑ Assess the type and timing of diversions and filling of reservoirs for effects on fish and habitat and retrofit and change facilities as needed.

- ❑ Evaluate alternative water sources such as waste or recycled water if such measures will relieve use of creek water during the times and in locations needed to benefit the fish.

- ❑ The period of irrigation can be more precisely determined for each site by using tools such as neutron probes and soil moisture measurements, CIMIS data and leaf turgidity measurements to reduce the hours of irrigation to minimum required.

Frost Control

Frost control operations require a large amount of water over a short period of time. If direct diversions are used, water levels can drop quickly in creeks and rivers, causing small salmonids to be stranded and die. This part of the template allows a grower to calculate the

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water use for each vineyard with no BMPs applied and then select BMPs that will work for the site and calculate both the cost and the potential water savings. If these BMPs are already being applied then this section can validate the water savings occurring and determine if additional BMPs are feasible. In addition, the template identifies vineyards with direct diversions as water sources which pose a potentially high impact to fish in order to prioritize sites for off-stream pond construction.

- ❑ Check your frost control system for leaks on a regular basis and fix them to reduce losses of water.
- ❑ Using the farmplan template and spreadsheets, determine your frost water demand with no BMPs.
- ❑ Document the BMPs currently used or evaluate all that could be applied.
- ❑ Calculate the potential water savings and costs for implementation of BMPs
- ❑ The conservation goal is 15% of the total water demand without BMPs. Determine the best mix of BMPs for the site and determine the total water savings.
- ❑ Determine if the site has a direct diversion from a creek and needs an off-stream pond.

Irrigation

- ❑ Review how you determine when the vineyard needs irrigation. Do you monitor soil moisture and plant turgidity (wilt) to determine irrigation needs?
- ❑ Review your irrigation methods to assure water conservation is maximized and no unnecessary irrigation is done.
- ❑ Check your irrigation systems for leaks on a regular basis and fix them to reduce losses of water.
- ❑ Replace higher volume emitters with lower volume emitters for more precise water control if feasible.

Riparian Diversions

- ❑ Place screens on all direct diversions according to the NMFS criteria in Appendix 5.
- ❑ Evaluate developing an off-channel reservoir with winter diversions for winter frost and summer irrigation needs.
- ❑ Evaluate how to change your irrigation blocks and size to reduce the volume of water diverted at one time and extend the time period for irrigating the vineyards over a longer time frame.
- ❑ For riparian frost control diversions on creeks, you will need an off-stream regulatory pond to impound water in spring (30 days maximum) for frost control. Diversions to fill the pond should be made only during high water periods.

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Reservoirs

On-channel reservoirs

- ❑ Determine if the reservoir blocks fish passage to upstream habitat. Evaluate if the reservoir can be retrofitted to allow fish passage with a ladder.

- ❑ If the reservoir has a major effect on fish habitat it may need to be replaced by an off-channel reservoir and the stream restored. If it has filled-in significantly with sediment this may be a good idea anyway. There are funds available for construction of small reservoirs through various sources.

- ❑ Evaluate if the reservoir can be operated to allow for bypass flows during the early fall and only be filled in the December 15- March 31 period.

Filling reservoirs: On and off channel

- ❑ Limit the time of pumping out of the creek to fill the reservoir to the December 15 to March 31 period to reduce effects on the fish.

- ❑ Flashboard dams may need to be put in later in the season than April 15 to allow spawning adult steelhead to escape out to the ocean. Consider constructing an off-channel reservoir if the flashboard dam affects a salmon or steelhead rearing area.

Waste or Recycled Water Use

- ❑ If wastewater is available and a grower wishes to use it freshwater can be conserved by using this replacement supply. However the grower may want to file paperwork with the Division of Water Rights in Sacramento to preserve riparian and appropriative water rights.

15. REPLANTING

This section is used if the replanting program will not involve grading or extensive earthwork, no expansion of the vineyard is planned, and each replanting area uses the same footprint as the previous vineyard. If re-contouring or grading the vineyard area, complete Element IV. If expanding the vineyard area, complete Element II. Replanting offers the opportunity to upgrade drainage systems, repair and reduce erosion problems.

Assessment: Replanting

On the Farm Conservation Plan template:

- ❑ Describe the area that would be replanted and the timing, soil conservation measures, drainage improvements, changes to fencing and changes to the irrigation system.

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Soil Conservation

- ❑ Plan the replant such that activities do not start prior to April 15 and that all ground preparation drainage or irrigation system changes and trellis /vine installation is done and all erosion control measures are installed by October 15.
  - ❑ Incorporate filter strips into the replanting program at the bottom of each vineyard slope and between all vineyards and waterways. These can be seasonal vineyard field roads and turnarounds winterized as filter strips.

  - ❑ Relocate access roads away from creek corridors and edges of swales.

Fencing

- ❑ Outline the current fencing alignment

- ❑ Replanting offers an opportunity to enhance wildlife migration corridors. Deer, for example, move from canyon bottom to the ridgetop and from the very upper areas of a creek watershed to its outlet. Evaluate how an animal can cross through the site with the vineyard fencing and incorporate vegetated migration corridors in the design. Well-vegetated creek corridors without cross fencing, or an adequate area of natural vegetation for the animals to easily go around the vineyard site should be included in the replant design. Appendix 3 includes some considerations for wildlife friendly fencing.

Drainage

- ❑ Install drainage facilities in vineyards that have had recurring erosion problems. Review BMPs in Element II for design guidelines.

- ❑ Indicate these areas and the drainage plan on the aerial, or map, and include it in the Farm Conservation Plan.

- ❑ Replace drainage facilities that are undersized or have failed in the past. Have your engineer use the 50- to 100-year frequency, 24-hour duration rainfall event. The system should include:
  - ❑ numerous inlets and outlets rather than fewer

  - ❑ adequate energy dissipaters to reduce erosion at all the outlets

- ❑ To the degree practicable, install stilling or detention basins to reduce stormwater volumes to total no more than a 10-15% increase over the natural volume from the site.

- ❑ To the extent possible revegetate natural swales and ephemeral streams and remove cultivation from these unstable areas. Create a 25-foot buffer between the edge of ephemeral creek corridor and the vineyard roads or turnarounds.

Water Conservation/Supply

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- ❑ If you are on a riparian diversion, change the irrigation system to use small blocks of 5 acres so that lower volumes of water can be diverted at one time.

- ❑ If you are increasing the number of vines per acre and will need additional irrigation or frost control water, determine the source of this additional water and apply for the required permits and licenses.

- ❑ Review the water conservation measures in section 14 and incorporate them into the replant design.

16. ADDITIONAL ACTIVITIES

Outline other practices you implement that benefit the environment. Include tree planting, wildlife watering troughs, native grass plantings, wildlife-friendly fencing and other upland practices. Outline creek improvements in Element VI.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds.

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ELEMENT IV - MAJOR REPLANT OF EXISTING VINEYARD: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

Replanting refers to the removal of all the vines in a vineyard and the replacement with new vines. Inter-planting of vines or replacement of a few vines is not considered a replanting program. This element is for existing vineyards that are undergoing a replanting program that includes one or more of the following:

- ❑ Major grading or re-contouring
- ❑ Change in the vineyard footprint
- ❑ Removal of vegetation, other than vines
- ❑ If none of the above conditions apply to the replanting, use Element III that includes a simple replanting section
- ❑ If expanding the vineyard footprint, complete Element II for the new vineyard areas
- ❑ All sites whether new, or existing and undergoing replanting need to complete Element III - Managing the Vineyard

SITE INVENTORY

Replanting over a large scale with revision of the vineyard footprint, or extensive earthwork is similar to a new vineyard development. Replanting offers an opportunity to improve on the vineyard layout and reduce soil erosion through improvements to drainage and installation of erosion control measures. Fill out the farm plan template for replanting sites planned for the next 5 years.

1. FEATURES OF THE REPLANT SITES

Make copies of your aerial photograph and topo map and outline different features on each copy such as the property boundary, replant areas, natural drainage features (creeks), roads, buildings and water sources. You may want to create an enlarged copy of digital blow-up of each replant area to indicate existing features such as drainage and irrigation systems and proposed new features. On the copies indicate:

- ❑ Outline each replant area on the aerial/topo map and give each a name or number.
- ❑ All existing vineyards that will not be replanted.
- ❑ Indicate the primary access roads and vineyard field roads.
- ❑ Existing water sources and all proposed new water developments
- ❑ Farm buildings
- ❑ Vineyard fencing

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- ❑ Adjacent land uses

- ❑ Take photographs of each site

2. ACREAGE

On the Farm Conservation Plan template, fill in the information for each replant site including:

- ❑ Indicate the acreage of each replant site.

- ❑ The year proposed for each replant site

3. SOIL TYPES (see Element II for background information)

- ❑ As part of the replant erosion control plan, soil types will be evaluated. Fill in the soil types for your site in your Farm Conservation Plan. Fill in the soils table in the farm plan for each proposed replant area using Tables IIA, IIB, IIC and Appendix 1. Detailed site evaluation of soils should be included.

4. SLOPES (see Element II for background information)

- ❑ Using a detailed topographic map record the slopes of each replant area on the farm plan template. Areas of greater slope within the replant area should be delineated if greater than one acre. These areas may require greater erosion control.

- ❑ Record slope lengths for each replant area.

5. NATURAL DRAINAGE FEATURES (see Element II for background information)

- ❑ On a map and aerial photo indicate natural drainage features including: ephemeral streams/swales, intermittent or seasonal streams and year round streams. Include any springs or other features. Use your delineation from Element III if possible.

- ❑ On the farm plan template indicate the amount of vegetation and erosion for each creek.

- ❑ Take photographs of each creek.

- ❑ List the distance from the edge of the replant area to the edge of the creek corridor.

6. EROSION SITES (see Element II for background information)

- ❑ Look over the aerial photo for indications of landslides on the property. Are there hillside slips or lumpy looking, unstable ground? Are there large cracks in the ground indicating movement? Element III may also have this information. If these features occur near the replant/expansion area a geologist or civil engineer should be consulted prior to any project work.

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- ❑ Indicate any erosion sites, gullies, hills, slips, and landslides on the aerial photo/map. Fill in the Farm Conservation Plan template.

- ❑ Take photos of each erosion site.

7. FEATURES OF THE EXISTING VINEYARD DRAINAGE SYSTEM IN REPLANT AREAS

- ❑ On a copy of the aerial (you may need to make an enlargement) delineate the drainage system for each replant area. Indicate an **O** for each inlet, ***//*** for underground pipes, **X** for outlets, **D** for energy dissipaters at outlets or for stilling basins, **==** for aboveground diversions including diversion ditches, grassed or lined waterways and pipe drops (elephant trunks). Indicate any permanent sediment basins. You may have an engineering plan for the vineyard drainage system, which will fulfill this step.

- ❑ On a separate copy of the aerial outline the area that each drainage system serves and its outlets.

- ❑ On the Farm Conservation Plan template describe the type of drainage system currently installed in each replant area.

- ❑ If available include the plans and specifications for the drainage system and indicate the design criteria (storm size event) for the system on the Farm Conservation Plan template.

- ❑ On the Farm Conservation Plan template indicate the locations of erosion problems and major repairs. This information is used to determine where replacement or upgrades in the drainage system are needed or installation of additional drainage is needed.

Your erosion control plan should have above items 1-7 documented on a detailed map. You can use your erosion control plan and map to fill out the Farm Conservation Plan template.

8. SUMMARY OF CONDITIONS: REPLANTING SITES

- ❑ Fill in the table in the Farm Conservation Plan template summarizing conditions on each replant area. This information in conjunction with the maps and aerials will be used in the design for the replant or expansion project.

9. EVALUATION OF THE REPLANTING AREAS: REVISING THE FOOTPRINT

- ❑ Using the summary table evaluate each replant area. Use the following BMPs to refine the replant area footprint to reduce erosion and drainage problems.

Acreage

- ❑ Revise the schedule for each replant area so that all grading, site preparation, installation of drainage systems and other site improvements can be completed by

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September 30 and each area can be planted with cover crops and fully winterized by October 15.

Slope

- ❑ Delineate the areas of each replant area over 30% slope. Slopes over 30% are likely to pose significant erosion hazards. Small areas (less than 2 acres) over 30% slope within less steep areas may not pose a problem. Although the slope limitations of the County ordinance do not apply to replants, areas in the 30-50% slope classification pose a high erosion hazard. An evaluation of cost and revenues from the replant areas over 30% slope over a 10-year period should be done. The high cost of maintaining a steep slope vineyard should be included in the evaluation. Costs should include all site work and infrastructure as well as all erosion control requirements. Revenues should include those expected from equal numbers of years of high and low grape prices. The steeper areas of a replant site may not be profitable and could become an expense if erosion problems become great.

Ephemeral Creeks

- ❑ Creeks in or adjacent to each replant area should be evaluated carefully. For year round and seasonal creeks Element VI addresses management and restoration of creek corridors. Ephemeral creeks are typical of hillside areas and can be the site of landslides, debris flows and erosion if not well vegetated and managed carefully to avoid problems. When a major erosion problem occurs, the vineyard will be affected if close to the creek. When a vineyard is replanted there is an opportunity to move back from the creek edge and reduce the likelihood of the creek damaging the replanted vineyard. The replant footprint should have a minimum of a 25 ft. setback from the topographic edge of the swale or ephemeral creek to the outer edge of the vineyard turnaround, road or headland. For some ephemeral creeks the top of bank may be the topographic edge. For others especially in steep hillsides, the swale may contain the creek and the swale edge will have a distinct change in topography from the adjacent hillside. The farm plan workshops will assist in the delineation of these areas. In this setback area the focus of activities should be revegetation, management as a filter strip and erosion control. Winterization measures should also include installation of erosion measures such as strawbale sediment barriers.

- ❑ If the evaluation of creeks shows excessive erosion, lack of vegetation or erosion at drainage outlets, stabilization and revegetation should be part of the replanting design.

Erosion

- ❑ Erosion associated with drainage system outlets, diversion ditches, reservoirs and other facilities should be addressed as part of the replanting design or as part of Element III.

Wildlife

- ❑ Replanting allows for changes in fencing and the removal of cross fencing which can restrict the movement of wildlife along creek corridors or through hillside and valley areas.

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APPLYING BMPS: DESIGN AND INSTALLATION OF VINEYARD REPLANT

10. DESIGNING FOR SOIL CONSERVATION AND EROSION CONTROL

- ❑ The Sonoma County Hillside Vineyard Ordinance regulates certain replant activities:
  "Level 1 replanting has either highly erodible soils and an average slope of not more than fifteen percent (15%), or less erodible soils and an average slope of not more than thirty percent (30%)."

  "Level 2 replanting has either highly erodible soils and an average slope of more than fifteen percent (15%), or less erodible soils with an average slope of more than thirty percent (30%) to not more than fifty percent (50%)."

Level 2 sites require an Erosion and Sediment Control Plan prepared by an approved civil engineer and approved by the agricultural commissioner.

The Fish Friendly Farming program encourages a more expansive review of potential erosion problems to comply with state and federal regulations and avoid fines.

- ❑ An erosion control plan should be prepared for all replant sites with recurring erosion problems as identified in the inventory.

- ❑ The erosion control plan should be prepared by the NRCS, civil engineer or a certified professional soil erosion and sediment control specialist.

The erosion control plan should include:

- ❑ Narrative and graphic information describing the project

- ❑ The name of the preparer or civil engineer

- ❑ A description of the site including topography, soil types, vegetation, streams, lakes, reservoirs, roads, homes and existing drainage improvements. Identification of areas on the vineyard site that may have significantly more or less potential for erosion

- ❑ A summary of temporary and permanent measures to protect disturbed areas and manage stormwater runoff on the vineyard site and minimize the discharge of sediment from the vineyard site. A schedule for implementation, maintenance and upkeep of the temporary and permanent measures and provisions for responsibility of maintenance

- ❑ A location map of the vineyard site

- ❑ A topographic map of the site at a scale of 1''=200' showing all the details of the project including vineyard layout and boundaries, existing and finished contours, soil types, stormwater flow lines, creeks and setbacks, vegetation, buildings, wells and utilities, proposed soil protection measures, proposed stormwater management and sediment control measures and calculations for each measure, construction details, drainage area of the stormwater management system

- ❑ An analysis of sheet erosion from the proposed vineyard using the Universal Soil Loss Equation (USLE) included in Appendix 1 should be completed if not done as part of the Erosion Control Plan. The USLE evaluates the potential for sheet erosion of a particular

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site with a set of proposed practices. The USLE predicts soil loss over a relatively small area such as a vineyard site by evaluation of rainfall conditions (R), the susceptibility of soil to erosion (K), the length and steepness of slope (LS), the erodibility of soil under various cover cropping scenarios (C), and the effectiveness of the vineyard layout (on-contour, for example) on erosion control (P).

The predicted sheet erosion or soil loss is then compared to the T value or soil loss tolerance for specific soil types. Acceptable T values are relatively low at 2 to 4 tons per acre per year. Erosion Control Plans are reviewed to assure they include a variety of practices such as row alignment, drainage improvements, cover crops and tillage, sediment basins and grassed waterways to attain the acceptable soil loss tolerance for sheet erosion.

The Erosion Control Plan should also review the potential for concentrated flows and rill and gully erosion. The plan also includes temporary erosion control measures for assuring that any soil loss from the site is contained.

- ❑ Attach the Erosion Control Plan to the Farm Plan.

- ❑ Using the detailed slope measurements, evaluate revising the replant site footprint to avoid developing areas over 30% slope.

- ❑ The layout of the vineyard in relationship to slopes should provide for tractor safety, grape production and maximum soil protection.

- ❑ The vineyard may not provide the best soil conservation by cross slope or with the contour layout. In some sites, using an up and over the hill layout with frequent drainage inlets and managed with cover crops creates the best situation.

- ❑ When considering the use of terraces and benches the need for soil conservation requires cover crop on the terrace flat and the berm or face of the terrace. Additionally the terrace flats can be easily damaged if tilled when soil is wet. These ruts can create changes in drainage and localized failures in the terrace. For these reasons expect a greater degree of management and maintenance with terrace designs.

- ❑ For vineyards along river and creek channels orienting the rows parallel to river flow can reduce the amount of damage from floods and debris.

11. DESIGNING DRAINAGE IMPROVEMENTS (see Element II for more background information)

Consult with NRCS or a qualified engineer or professional to design a new or upgraded drainage system for the replant areas where ongoing erosion problems have occurred in the past or the review of the erosion potential of the site shows the need for an improvement to the drainage system.

- ❑ To the greatest degree possible do not replant areas in natural drainage channels - year round and seasonal, creeks and their riparian corridor areas and all major ephemeral streams or swales.

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- ❑ Size and design all stormwater diversions and drainage systems for the 50- to 100-year frequency, 24-hour duration rainfall event, or greater, and the soil type, slope lengths, full cover crop and vineyard land condition for the location of the site and runoff volumes.

- ❑ Use a long record of rainfall data and make sure it is close enough to the location of the site to be applicable. Review the information for the highest intensity rainfall event (the greatest amount of rainfall over the shortest period of time, typically a 100-year frequency, 6-hour duration event) and make sure that this amount does not differ a great deal from the 100-year frequency, 24-hour duration measurement. This comparison is done to assure that the system will not fail in a very intense, but short, storm event. This information is available from the National Weather Service at http://www.wrcc.dri.edu/pcpnfreq.html.

- ❑ Design the system to result in only very small increases in peak stormwater volumes. The drainage system should not increase stormwater volumes over pre-vineyard conditions by more than 10-15% for the 2-, 5-, and 10-year rainfall events. If such increases are unavoidable, then detention or water spreader facilities should be included to mitigate the increase. Reducing the volumes and the potential for erosion of creeks is in the vineyard operators' favor. Remember that incision of the creek from increased flows can create failures in the banks of ephemeral streams and damage the vineyard.

- ❑ Plans for the system should address whether the soil types on the site are subject to piping. Piping is the movement of water through porous soil types and along the edges of underground pipes. The water increases erosion and blowouts of the drainage system. Some types of soils are more inclined to undergo piping than others. Compaction of backfill and use of frequent cutoff collars reduce the effects of piping.

- ❑ Plans should address inlet clogging with installation of screens, grates or other measures.

- ❑ Design the outlets of the system to result in no erosion in the swales, streams or creeks. The drainage system should spread the flows out into several pipes rather than concentrating all the drainage into a small number of pipes and outlets. All outlets should have energy dissipaters.

- ❑ The system should address more than just the drainage produced by the vineyard. The larger upslope areas and the storm flows entering the site need to be included. .

- ❑ Winter cover crops are needed in conjunction with drainage improvements to reduce surface flows and soil erosion.

- ❑ All designs and plans need adequate detail to install the drainage system and other features very precisely. Detailed specifications can avoid problems in construction. These plans will also guide annual maintenance and management for outlets, inlets, and other features detailed in Element III.

12. LAND TREATMENT (see Element II for background)

Only fill out this section if major grading is part of the replant project. Many replant sites will not require this section.

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- ❑ Indicate the type of land treatment to be used for each replant area.

- ❑ Each area to be graded or re-contoured should be sized so that all soil grading is completed, drainage, irrigation and other improvements are installed and cover crops are seeded and irrigated to produce a dense ground cover October 15. This may require separating a large vineyard area into phases.

- ❑ The last pass or set of passes by the grading equipment must be a cross-sloped pass to avoid creating any rills up and down the hillside and increasing erosion problems.

- ❑ If the project cannot be completed and a dense cover crop established by October 15 don't start the project until next spring.

- ❑ All emergency erosion control and a winter inspection program by the farmer should be in place by October 15.

13. VINEYARD ROADS (see Element II for background)

- ❑ The replant design should avoid locating vineyard roads too close to stream channels. Floodwaters may create a waterway out of the field road and severely erode it. Field roads adjacent to swales can concentrate runoff, cause erosion in the swale and undercut the vineyard. The main roads should be located through the middle of the vineyard with turnarounds along the edge of the vineyard/creek corridor or swale. All turnarounds and field roads adjacent to creek corridors and swales should be winterized and managed as vegetated filter strips.

- ❑ Minimize creek crossings. Construct those crossings necessary for the site at right angles to the creek channel. Construct them to create the least disturbance to the natural form of the channel. One of the best ways to plan the vineyard road system is to cross above or below swale areas.

  Plan to have one, or at most two, seasonal crossings or bridges for larger creeks. Seasonal at-grade crossings can be the least impacting if the banks of the channel allow this design, and the use of the crossing will not disturb in-stream uses of the creek by the fish. Bridges are also a preferred design if they can be constructed without constricting or filling the creek channel. Culverted crossings, concrete fords and other types of crossings should be carefully evaluated with Fish and Game due to the problems that can arise.

- ❑ Indicate the locations and features of vineyard roads on the Farm Conservation Plan map and aerial.

14. VEGETATION REMOVAL (see Element II for background)

Only include this section if the project involves removal of vegetation other than grapevines in the vineyard. Many replant sites will not require this section.

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- ❑ Remove only the minimum of vegetation for the vineyard replant. Do not over clear the area, as it will require replanting to stop soil erosion. Minimize the road width around the outside perimeter to allow for vegetation retention.

- ❑ Do not clear creeks or drainageways of any type – year round, intermittent, or ephemeral, as this can cause severe erosion, sedimentation and directly impact fish habitat.

- ❑ If you have a vernal pool or wetland on your site you will need to apply for a permit to develop the area. If you have habitat that could support a listed species (see Tables IID and IIE), the Fish Friendly Farming workshop will assist in the delineation of the vineyard footprint and permit and mitigation needs.

- ❑ If you plan to remove forest you may need a permit from the California Department of Forestry.

- ❑ Replanting offers an opportunity to enhance wildlife migration corridors. Deer, for example, move from canyon bottom to the ridgetop and from the very upper areas of a creek watershed to its outlet. Evaluate how an animal can cross through the site with the vineyard fencing and incorporate vegetated migration corridors in the design. Well-vegetated creek corridors without cross fencing, or an adequate area of natural vegetation for the animals to easily go around the vineyard site should be included in the replant design. Appendix 3 includes some considerations for wildlife friendly fencing.

15. EROSION SITES (see Element II for background)

Only include this section if you have ongoing erosion problems or erosion sites. Many replants will not need this section.

- ❑ With assistance from NRCS, or a qualified engineer, certified professional in erosion and sediment control, or soil scientist, evaluate potential solutions for the erosion site(s) within the replant area. Focus on sites with ongoing, recurring erosion problems and those that have undergone major blowouts. Coordinate erosion site repair with the drainage system design. The evaluation should review the entire drainage system on the site, the erosion problem and its cause.

- ❑ If erosion sites are primarily streams and swales, be very careful to consider fish friendly restoration techniques. Excessive use of rock to line swales and streams for erosion control can cause streamflow to increase in velocity. High velocity stormflows damage creeks downstream of the rock lining. Vegetative solutions for erosion are preferred, as they will not increase velocity of stormflows in downstream areas. Severe erosion problems in streams may require both vegetative and structural components.

- ❑ Consider the entire drainage system when fixing erosion problems. Don't fix one piece only to create a bigger problem downstream. As a rule, repairs should stop the cause of the problem, not just repair the symptoms or translate the problem downstream.

16. WATER SOURCES/CONSERVATION (see Element II for background information)

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- ❑ Take photographs of all the components of your water supply system: reservoirs, pumps and diversions. In Elements II and III, the location and operation of all water sources, storage sites, wells and diversions are outlined.

- ❑ Review the water rights section of Element 3 and fill in the template with any changes made as part of the replanting program.

- ❑ On the Farm Conservation Plan template, describe the features of the water supply system including:

  - ❑ The amount of water needed per acre will likely increase if replanting involves increasing the number of vines per acre. Describe sources of additional irrigation water.

  - ❑ Review the layout of the irrigation system, the vines per acre and the size of the vineyard blocks. If you are a riparian water diverter in particular, it is advisable that the vineyard blocks be no larger than 5 acres, with 1,000 vines per acre, to allow for a lower volume of water to be taken from the creek at one time. The goal is to have more, smaller, blocks rather than a fewer, larger, blocks so that the volume of water diverted can be reduced and the time frame for irrigation over the site can be extended.

  - ❑ Consider how to change irrigation lines by using pressure reducers or inline regulators to create smaller irrigation blocks.

  - ❑ Replace higher volume emitters with lower volume emitters for more precise water control.

  - ❑ Evaluate changing frost control methods from conventional sprinklers to low flow sprinklers, misters or wind machines, if practical at the vineyard location.

  - ❑ Element III includes an evaluation of current water sources. Complete this section if developing new water sources or increasing diversions as part of the replant project. Also review Appendix 4 for more information.

16. TIMING OF VINEYARD INSTALLATION (see Element II for background information)

- ❑ All land clearing, grading, drainage system installation and construction activities including the installation of temporary and permanent erosion control for the site must be completed between April 15 (or the end of the rainy season if later) and October 15. The project development plan should include the installation of soil protection and erosion control practices within this time frame.

- ❑ Seeding of a temporary cover crop should occur in September. For steep slopes and highly erosive soils, straw mulch should also be applied and irrigation used (bring in water on a one-time basis if needed) to promote vigorous growth prior to the rains. If cover crop seeds are planted earlier than September and birds may eat them, seed can be drilled and covered with straw mulch. For terraces make sure all parts of the site are covered with erosion control including cover crops, erosion blanket and other materials.

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- ❑ The first winter season of the replant project allows the grower to watch site drainage, soil movement and install emergency erosion control as needed. These observations allow the grower to improve on the site design if needed.

17. LAND TREATMENT (see Element II for background information)

Use these BMPs if the replant site involves re-contouring, deep ripping or significant grading and ground disturbance.

- ❑ Phase the project such that all earthwork and installation of all drainage improvements are completed prior to the end of September to ensure that cover crops, filter strips and other erosion protection practices are completely installed before the rains begin.

- ❑ Make sure that final grade and equipment passage leaves cross-sloped soil contours. If equipment leaves up and down slope trenches, erosion is almost a certainly with expensive re-grading and potential siltation for creek areas and regulatory fines.

- ❑ Cover crops should be seeded at higher densities and applied with fertilizers and mulch and irrigated to assure the maximum coverage possible by October 15.

- ❑ Sites that undergo extensive soil disturbance should be carefully monitored over the rainy season with immediate attention to any small erosion problem and installation of temporary control practices before the problems become large.

18. COVER CROPS FOLLOWING INSTALLAION (see Element II for background information)

- ❑ All replant sites with grading or significant ripping should be seeded with fast growing grasses no later than September 30 to promote development of a dense cover crop prior to heavy winter rains. Apply seed in cross slope direction to avoid creating rills up and down the slope. Irrigate the site if possible and apply mulch and fertilizer as needed.

  Temporary cover crops are typically annual grasses that grow rapidly and densely and have fibrous root systems. Species often used are blando brome, cereal rye, barley and oats, which are established by seeding at 6 lbs. per acre and are adapted to many climatic conditions. These species work effectively to protect soil by rapid germination after rains and developing a dense growth habit. These species die back during summer and may require reseeding for the next winter. Legumes, such as clovers, do not develop the extensive root systems of grasses and will not provide adequate soil protection.

- ❑ Seed with fertilizer is more effective especially if the site has been terraced or graded. For the terraced site, it is important that cover crops protect all areas of the terrace both the flat and the sloped face between the benches. Add mulch or erosion blanket to protect the face of the terrace and get a cover crop established. Broadcasting seed at a higher rate with fertilizer also helps to establish cover. Both the vineyard and road areas should be seeded.

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19. DESIGN DETAILS AND INSTALLATION: THE DRAINAGE SYSTEM

The detailed BMPs for designing and installing various types of drainage systems such as diversion ditches underground pipes systems with inlets and outlets, flexible pipe drop, grassed waterway and terraces or benches are described in Element II

- ❑ The drainage system in the replant site should include the BMPs described in Element II.

21. EMERGENCY EROSION CONTROL MEASURES

All replant and expansion sites can have an erosion problem that requires immediate attention. The details for use of emergency erosion control measures such as mulching, jute netting and erosion control blankets, silt fences, strawbale and straw wattle sediment barriers and road waterbars are outlined in Element II.

- ❑ Emergency erosion control materials should be readily available on-site with crews trained in their proper use. For the first several winters the site manager should inspect the replant/expansion site after every rainstorm and install emergency erosion control as necessary without delay.

22. ADDITIONAL EROSION CONTROL (see Element II for background information)

Filter strip - A strip of dense grass or other vegetation between the vineyard site and waterway serves as an additional protection against siltation in streams. Surface flows carry soil through the filter strip before reaching the waterway. The dense grass slows the water and catches the sediment providing another protective measure. The filter strip should include these features:

- ❑ Filter strips should be planted along the waterways adjacent to the vineyard. These areas are typically the downslope edges of vineyards. Filter strips may also be used across the vineyard slope between blocks of vines as an additional practice to reduce sediment movement though sheet flow.

- ❑ The size of the filter strip varies according to the slope of the area draining to the strip. For slopes of less than 1%, the strip should be at least 10 ft. in width and increase proportionate with the increase in slope up to 25 feet in width for slopes of 30%. The 25-foot setback area between the vineyard turnaround or roads and the creek edge should be managed as a filter strip.

- ❑ Plant the filter strip in September to allow for adequate vegetative cover to develop. Plant density should be a minimum of 60% and may consist of annual grasses. Native bunchgrasses can be used if the filter strip will not be tilled. Fertilization and irrigation may be needed.

- ❑ Do not till the filter strip area until after April 30 to provide the greatest degree of protection. If frost is a concern and the strip is near to vines it can be mowed.

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- Depending on the site the filter strip area may be further enhanced as a permanently vegetated buffer. Native species should be used and chosen carefully to promote beneficial insects or block the movement of pest insects. Additional amenities such as bat boxes, raptor and owl roosts may increase wildlife values and take advantage of the benefits of these animals for control of insects and rodents.

- **Sediment basin –** Sediment basins may collect larger particle sizes such as sand and can be partially effective in collecting some fine sediment. They need to be maintained at least annually. The basin must be sized for the site to hold the maximum amount of sediment expected over one winter. Cleaning out the basin is not always possible in a wet winter. The basin must also accommodate the runoff from a 10-year 24-hr frequency rainfall event without overtopping. The basin is created by constructing an embankment, basin emergency spillway and a release structure, such as a perforated pipe riser. Sediment basins may be located at the bottom of the vineyard slope where drainage enters a swale or waterway. These basins should be designed by a civil engineer on a site-specific basis and installed using proper construction and compaction for the berm and correct sizing and construction for release structures and spillways. The basin should not be located on a stream.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds.

For Element IV the timeline for the phases of the replant, design and installation should be outlined as well as the repair and revegetation of ephemeral creeks, water rights applications, erosion sites or other sites on the property and the completion of any revegetation enhancement or habitat creation or mitigation projects.

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ELEMENT V – ROADS:
INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for roads on the entire property including year-round field roads. It includes:

- ❑ Inventory/Assessment of the features and conditions of the roads on the entire property.
- ❑ Evaluation of current road management and maintenance methods.
- ❑ Discussion of the Beneficial Management Practices (BMPs) for roads.
- ❑ Creation of a road repair and improvement program; road maintenance and winter inspection program.
- ❑ New road design/construction guidelines.

FFF program staff working with the landowner will complete the road element.

INTRODUCTION

Roads can be a major source of sediment in a watershed. A road cut through a natural hillside changes many of the processes occurring on the hillside during storm events. The road intercepts groundwater moving though the subsoil of the hillside. As groundwater reaches the road it changes into surface flow and can become a large concentrated flow. Water flowing along a road can erode the road and potentially cause the road to fail if the water destabilizes the road fill. Roads built across steep slopes and old landslides can fail if the drainage features of the road are inadequate. The soil eroded from the road surface, or from a road failure, can be discharged into a creek or river.

Another change roads make in drainage and water movement occurs when the road crosses a creek channel. Typically for small hillside creeks the channel is filled and a road is constructed on top of the fill. A culvert is placed to direct water through the road fill. In large storms, the culvert can plug with debris, or the volume of stream flow is greater than the size of the culvert, backs up and overtops the road fill eroding it away. The road is damaged and a great deal of sediment enters the stream.

Road fill and crossing structures may also interfere with sediment transport in the stream filling in the upstream area and eroding the channel downstream. Fish may be unable to swim through the culvert and reach habitat above the crossing.

While the roads on an individual ranch or property may be well designed and maintained, the road system in the larger watershed may have great impacts on fish habitat. Roads can interfere with the overall function of a watershed to infiltrate stormwater and recharge the groundwater to produce summer rearing habitat for the cold-water salmon. Because roads can intercept groundwater and change it to surface flow, the movement of water from the upper watershed into creeks can become more rapid. If the road system in a watershed is extensive or is combined with urban development and impervious surfaces, the summer water and fish rearing habitat can be diminished. Water diversions can further decrease summer water availability.

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Roads built next to creeks and rivers are particularly problematic. Road erosion can discharge directly into the creek. Additionally any erosion of streambanks may erode the road base increasing siltation and creating the need for costly repairs.

Roads are essential to most land uses. Road assessment, repair and maintenance should be part of every operation. These BMPs outline the features of roads that can increase erosion and recommend practices to reduce water quality impacts and sedimentation problems. There are many other operational and safety aspects of roads that may be of importance and should be evaluated.

One publication on road design and maintenance is particularly useful - The Handbook for Forest and Ranch Roads by William Weaver and Danny Hagans. It is available from the Mendocino Resource Conservation District by writing to the RCD at 405 Orchard Ave., Ukiah, California 95482.

It is especially important to seek the advice of an engineering geologist, or civil engineer, if road construction is going to affect highly erodible soils, steep or unstable hillslopes. New, or reconstructed, stream crossings should be approved by the Department of Fish and Game to avoid creating barriers for fish. Permits from the Department of Fish and Game may be needed for any work in, or near, the creek channel.

As the existing road system is assessed the owner needs to evaluate their needs and use them in the evaluation. Some of the pertinent questions to answer include:

- ❑ What types of equipment need to use the road system and what are the specific road sizes or gradients needed for this equipment?

- ❑ How many roads need to be available to year-round use and what roads can be seasonal use only? Year-round roads require greater maintenance and may also have different construction needs.

- ❑ How fast will vehicles need to travel, are there specific braking and sight distances and turning restrictions needed for equipment?

- ❑ Does the existing road system provide adequate access to all the needed areas of the property? Are additional roads needed? If additional access is needed can an old road be reopened to serve this need?

- ❑ How can the number and size of roads be reduced? The first priority for road closure should be roads on unstable slopes, those with large numbers of stream crossings (and thus high maintenance expense) and, roads next to creek and river corridors.

SITE INVENTORY/ROAD ASSESSMENT

The FFF program staff will complete this inventory for all existing year-round and seasonal road with the landowner/manager.

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1. GENERAL FEATURES OF THE ROAD SYSTEM

Collecting Resources

Obtain aerial photographs at a relatively large scale (1''=500' to 1"=200' is recommended and available from most counties) and topographic maps of the property. Make copies of the aerial and outline the road system on a map and aerial photos. Both those roads that are currently in use and those that have been abandoned even if severely overgrown should be included. Old skid roads should be included as well. Within the vineyard only outline the primary access roads.

- ❑ Give each road a name or number.
- ❑ Mark the locations where each road crosses a year-round, seasonal or ephemeral stream. Give each crossing a number, or use the road name with a number. This information will be used in Section 6.
- ❑ Photograph each road and photograph stream crossings. Label each photograph with the name of the road and the crossing number.
- ❑ On the Farm Conservation Plan template fill out the table with the general features for each road.

2. FIELD SURVEY OF ROAD CONDITIONS: PREPARATION

Background: Existing Roads

The best prevention for erosion from roads is to have a well designed and maintained road system. The road system needs to be evaluated for the adequacy of the roads, and the need for additional measures to reduce erosion and drainage problems and effects on the creeks. The goal of this evaluation is to create a repair and improvement plan to reduce erosion and a maintenance and winter inspection plan for on-going erosion control.

To complete this section of the template you will need to walk or drive each road with the workshop instructor and document conditions and current management practices. Because roads can be such a major source of fine sediment this work is very detailed.

- ❑ Before starting, read the background information and look at the photos and drawings so you understand what the terms mean and the items you are looking for as part of the field inventory.
- ❑ Remember to bring your camera.
- ❑ Drive slowly and stop frequently to check conditions.
- ❑ It is important to be accurate and complete.

To measure the location of features use your trip odometer. For each road start at a defined beginning point and set the odometer at 0.0. In the table note this beginning location. Then note the odometer reading for every feature in the assessment. For old roads or skid trails

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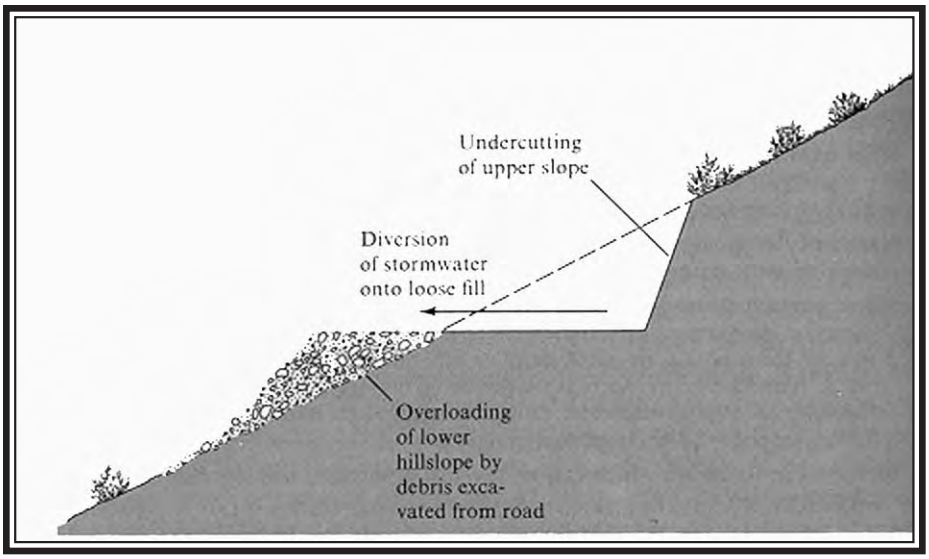

Fish Friendly Farming Environmental Certification Program	ROADS SHOULD BE CAREFULLY DESIGNED TO AVOID DRAINAGE AND EROSION PROBLEMS. THE NUMBER OF ROADS SHOULD BE MINIMIZED

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TOP RIGHT PHOTO SHOWS A DIRT DRIVEWAY ERODING FINE SEDIMENT. THE BOTTOM TWO PHOTOS SHOW RILL EROSION AND THE LOSS OF THE OUTER PORTION OF THE ROAD BED

Fish Friendly Farming
Environmental Certification Program

VARIOUS TYPES OF ROAD EROSION

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that are not drivable, measure your stride (3-5 ft. for each) and write down strides to determine distances.

3. HILLSLOPE STABILITY

Background: Hillslope Stability

Some roads cross unstable hillsides with lumpy-looking ground, gullies, slips or slowly moving ground. Other hillsides may show signs of the potential for large landslides.

Field Survey: Hillslope Stability

Look for signs of instability on the hillslope by first examining the aerial photograph and then reviewing the hillside both above and below the road. Record any of the following conditions and their locations in mileage from your starting point:

- ❑ Rolling and lumpy-looking ground which may have large cracks and slips, leaning or split trees, perched ponds or wetland plants.
- ❑ Irregular shaped slopes where the upper portion appears to have a scoop taken out of it, like a concave impression, and an accumulation of material at the lower end of the slope. This type of topography can indicate a previous landslide or slope failure.
- ❑ Fine textured grey-blue clays exposed in the road cut can indicate unstable areas. This type of clay swells with water in winter and is a sign of landslide and high erosion potential. Material above the clay layer may slip or the clay will ooze downhill inducing a slip and hillside movement.
- ❑ Record you observations on the farm plan template. FFF program staff will assist with this evaluation.

4. ROAD SURFACE

Background: Road Surface Conditions

The road surface may show conditions that indicate that water is moving down the road instead of through drainage features, such as culverts and ditches. Water will erode rills in the road surface. Other features of the road surface, such as cracks, or erosion, along the outer road edge, or ponding in the road surface are also indicative of road problems and the need for repairs and improvements.

Field Survey: Road Surface

The stability of the cut and fill bank, the sidecast fill on the outer edge of the road and the condition of the road surface are reviewed in the inventory.

- ❑ Record on the Farm Conservation Plan template:
    - ❑ Indicate the locations in mileage from your starting point of the following:

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- ❑ The sections of the road where rill erosion of the road surface is significant. Rilling appears as incised lines along the road indicating water flow. Record the mileage of the start and the end of major rills.

- ❑ Areas that regularly pond water and have tules, rushes, sedges or other wetland plants growing.

- ❑ Cracks and erosion along the outer edge or where a portion of the outer edge of the road is slipping downslope. This is most likely to occur on partial bench (cut and fill) construction.

- ❑ Locations where a berm occurs along the outer edge of the road and focuses water flow down the road causing rilling and erosion of the road surface. Record the start and end mileage of the berm.

5. ROAD SURFACE DRAINAGE

Background: Road Surface Drainage

Road drainage refers to the way the road surface slopes and thus its drainage features. There are insloped, outsloped and crowned roads. Road surfaces collect and direct runoff. Rill erosion of a road due to improper drainage can produce tons of sediment into a stream over the life of the road. Proper surface design can vastly reduce this source of siltation as well as road and hillslope failures.

Insloped roads drain water inward toward the cut bank and into an inboard ditch. The ditch directs the runoff into ditch relief culverts, or other drainage facilities installed beneath the road. The ditch relief culvert direct flows under the road and onto the hillside below the road.

Problems with insloped roads include:

- ❑ Too few, or undersized, ditch relief culverts which blow out, or plug, in storms causing runoff to flow down the road causing rill erosion or failure of the road fill and possibly the hillslope.

- ❑ Lack of energy dissipaters such as large rock at the outlets of the ditch relief culverts resulting in erosion of the hillslope with potential undermining of the road fill.

- ❑ The inboard ditch erodes significantly or undercuts the cutbank indicating there is too much flow and ditch relief culverts are not frequent enough.

- ❑ Soil eroded from the road or an upstream area of the ditch can settle out in the portions of the ditch where gradients are low and fill the ditch, causing runoff to flood over the road surface and erode it.

- ❑ Maintenance costs for insloped roads are high due to the need for maintenance of ditches and culverts and the need for continual replacement of ditch relief culverts and energy dissipaters.

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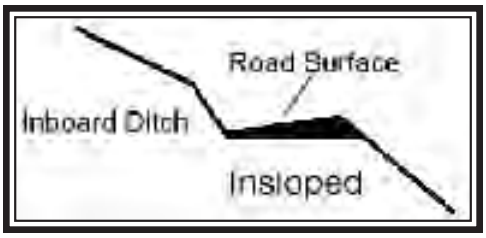

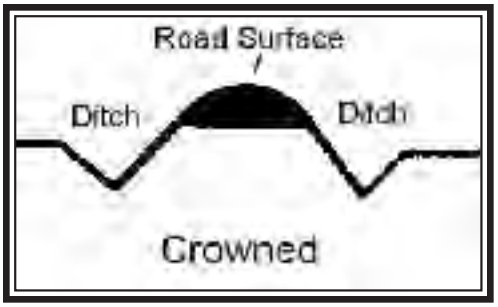

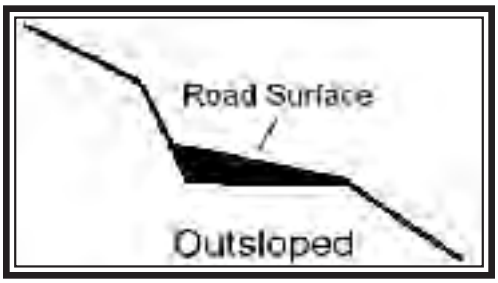

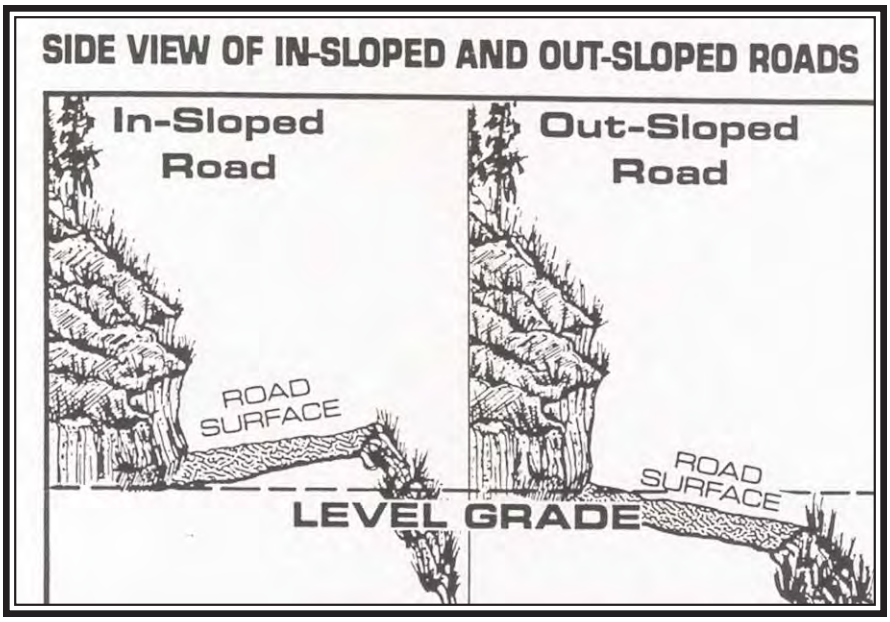

OUTSLOPED ROAD

INSLOPED ROAD WITH DITCH

Fish Friendly Farming Environmental Certification Program	TYPE OF ROAD SURFACES

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Insloped roads should include these features:

- ❑ Ditches should be designed to accommodate the flood flow from the cut bank and upslope areas intercepted by the road as well as the road surface drainage.
- ❑ The ditch should be no deeper than 12 inches below the roadway.
- ❑ The ditch should have a modest gradient of 2-6% to avoid both erosion and deposition of sediment. If the gradient must be higher, lining the ditch with rock or installing rock checkdams will reduce erosion.
- ❑ Ditch relief culverts should be installed at frequent enough intervals to drain water in the ditch to the hillside before the flow becomes greater than the ditch can hold.
- ❑ Ditch relief culverts should never directly discharge into streams and should not adversely impact downslope landowners.
- ❑ A vegetated buffer should filter road drainage before it enters all creeks including ephemeral creeks.
- ❑ Culverts should discharge onto rock, another type of energy dissipaters or an extended plastic pipe snake to reduce erosion of the lower hillside.
- ❑ If a gradient difference occurs between the ditch and the ditch relief culvert, the culvert inlet can be armored, or a drop inlet placed to reduce erosion around the inlet.
- ❑ There may be waterbars installed on the road surface to break up the road runoff and reduce the likelihood of ditch erosion and culvert blow out.
- ❑ Ditch relief culverts in most locations should be 18 inch in diameter at a minimum to avoid plugging and be adequate for drainage.
- ❑ The ditch relief culvert should be set at a grade of 2% more than the ditch gradient and at a 30 to 45° angle to the road alignment.
- ❑ Set the ditch relief culvert below the base of the road fill so that the water discharge point will not affect the road fill.
- ❑ At a minimum the ditch relief culvert should be set at least one foot below the road surface.
- ❑ A waterbar consists of a ditch with a berm on the downhill side. The ditch directs flow impounded by the berm. The ditch should be 3-6 inches deep and the berm should be 3-6 inches high.
- ❑ Waterbars can be used in certain sections of steep roads to reduce erosion.
- ❑ An energy dissipater of gravel or rock should be placed at the discharge point for the waterbar.
- ❑ Waterbars should be reconstructed at the beginning of each winter season.

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- ❑ Waterbars should be placed according to the grade of the road. As a general rule, take the road grade, divide by 1000 and the answer is the frequency for waterbar installation.

In **outsloped roads** the roadbed slants to the outer edge of the road directing storm runoff outward onto the hillslope below the road. If properly designed, water sheets off the road before it can concentrate. Generally, there is no inboard ditch or culvert system. There can still be culverted stream crossings however.

Outsloped roads are environmentally preferable, but there are sites where outsloping can pose certain problems. Steep gradient roads, dirt roads with large amounts of clay, certain types of curves and turns in the road and roads with large amounts of upslope runoff needing a ditch. Often outsloping of the majority of the road combined with insloping of small sections is the best choice.

Outsloped roads should include these features:

- ❑ Outsloped roads rolling dips to direct road drainage off the road surface before flow concentrates. Rolling dips are constructed as part of the roadbed and create a slight rise and dip in the roadbed. Rolling dips serve to segregate the road into smaller sections each of which sheet flows water from the road cutbank to the road edge.

- ❑ The dips are placed frequently enough to avoid concentrated flow down the road.

- ❑ Rolling dips are built at a 30 to 45 degree angle to the road with a gradient of 1% greater than the road gradient.

- ❑ The outlet of the dip should have an energy dissipater and vegetated filter.

- ❑ Waterbars serve much the same purpose as rolling dips. The waterbar consists of a ditch with a berm on the downhill side. The ditch directs flow impounded by the berm. However, waterbars are more abrupt, harder to drive over, and tend to break down on roads used in the winter season.

Crowned roads drain both outward and inward from a central raised crown in the middle of the road. Crowned roads spread drainage in both directions and are typically paved, all weather roads.

Crowned roads designs should include:

- ❑ Crowned roads may require either inboard ditches with ditch culverts or rolling dips depending on the site.

- ❑ Crowned roads can work well on steep ridges or for high quality, all weather roads.

- ❑ Designs should use either the features for insloped or outsloped drainage or both.

Flat roads are typical in valley areas where the land has less than a 2% slope. A flat road may simply puddle with water during large storms and then dry out and have little water flow over the road surface.

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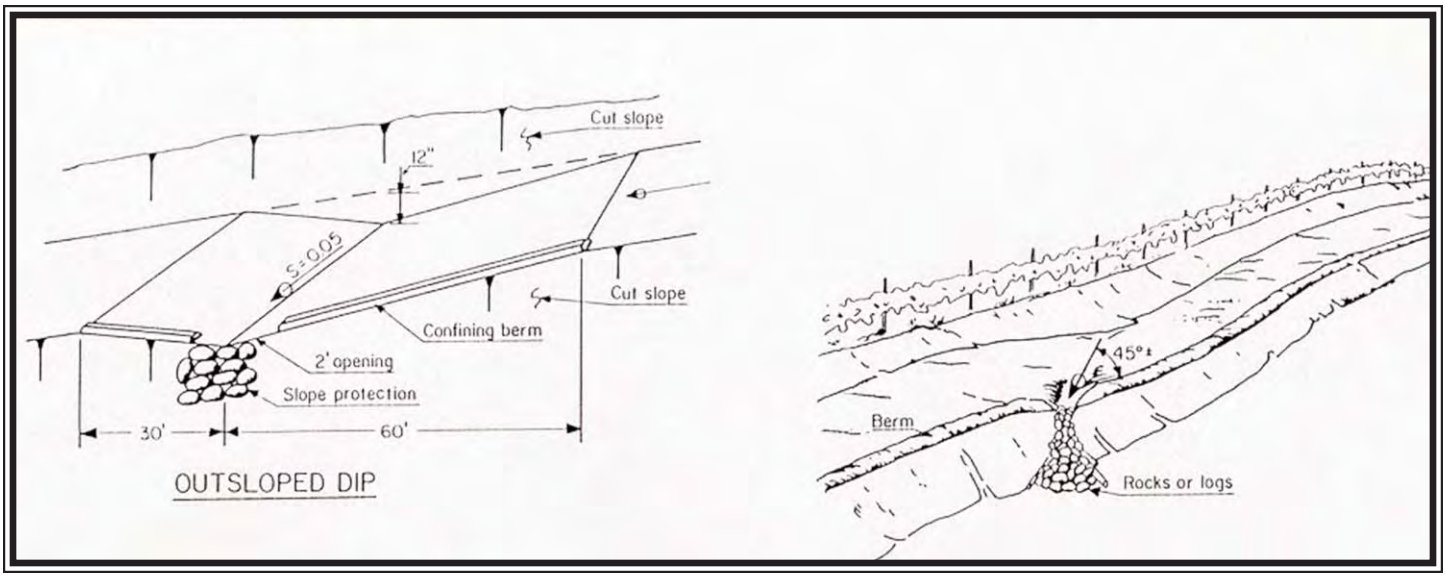

Fish Friendly Farming Environmental Certification Program	ROLLING DIP FOR OUTSLOPED ROADS

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Vineyard roads are often relatively steep, oriented to the slope differently than other ranch, or vehicle, roads, and usually dirt or gravel. Most vineyard roads or avenues (the areas between vine rows) are generally not used in the winter and are addressed in the winterization/cover crops BMPs in Element III.

Vineyard access roads should include:

- ❑ The vineyard access roads along the outside of the vineyard and some in the center may be used as year-round access roads. Winterization of these roads should also be included in your roads program.

- ❑ Vineyard access roads should have adequate drainage and features as all other year-round roads

Field Survey: Road Drainage

In conjunction with the FFF program staff complete a detailed field survey of each road using your car odometer (or measure strides if walking) to determine the location of each feature from the starting point recorded in Section 2. Since the features of insloped, outsloped and crowned roads are different, the first step in assessing a road is to figure out what type of road you are reviewing. Each road may have sections that are insloped, outsloped and crowned.

- ❑ Record the locations by mileage from the starting point for each type of road.

For insloped roads:

Ditch condition

- ❑ Record locations where there is erosion of the in-board ditch and where there is major deepening of the ditch. There may be some small erosion sites as well, but your survey should primarily document major ditch erosion where the cut bank of the road may be undercut.

- ❑ Record locations where sediment fills the ditch so the capacity of the ditch is diminished and water overflows onto the road surface.

- ❑ Record the beginning and ending mileage of the ditch erosion or filling

- ❑ Record locations where the cutbank is slumping or eroding into the ditch.

Ditch relief culverts

- ❑ Record the number of ditch relief culverts per length of road and estimate the slope of the road. Use your odometer and measure the distance between culverts. This is a very important feature to correctly inventory.

- ❑ Record locations where the ditch relief culverts are not at the intervals specified in Table VA.

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- ❑ Record the location and the condition of each ditch relief culvert. Record the diameter and type of culvert, if the culvert is crushed, plugged or rusting.

- ❑ For each culvert record if the energy dissipater at the outlet of a ditch relief culvert is adequate with no erosion or if it is missing or inadequate and erosion is evident. Check these as you check the culvert condition.

- ❑ Record locations of ditch relief culverts where water has overflowed onto the road surface. The road surface will show rill erosion. Try to determine the cause such as the small size of the culvert, if the culvert is plugged, in poor condition, or another cause.

- ❑ Record locations where ditch relief culverts discharge directly into a creek.

- ❑ Record the number of waterbars per length of road.

For outsloped roads:

- ❑ Record the number of waterbars or rolling dips per length of road and the road slope. Use your odometer and measure the distance between waterbars or rolling dips for the slope of the road as listed in Table VB and VC. This is a very important feature to correctly inventory.

- ❑ Record where waterbars or rolling dips are not at the intervals specified in Table VB and VC.

- ❑ Record locations where energy dissipaters at the outlet of waterbars or rolling dips are missing or inadequate with erosion occurring.

- ❑ Record locations where the road surface shows rill erosion.

- ❑ Record locations where the cut bank is slumping onto the road.

For **crowned roads** use all that apply to the particular features of the road:

<u>Ditch condition</u>

- ❑ Record locations of erosion of the in-board ditch and where there is major deepening of the ditch. There may be some small erosion sites as well, but your survey should primarily document major ditch erosion where the cut bank of the road may be undercut.

- ❑ Record locations where sediment fills the ditch so the capacity of the ditch is diminished and water overflows onto the road surface.

- ❑ Record locations where the cutbank is slumping or eroding into the ditch.

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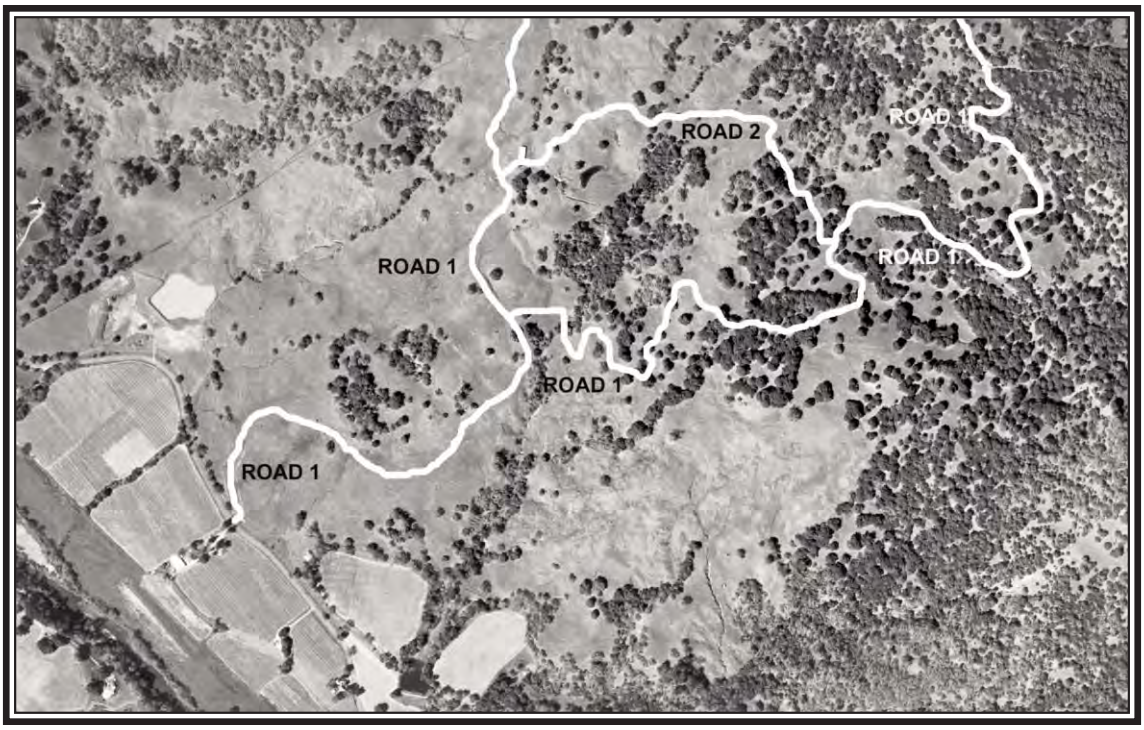

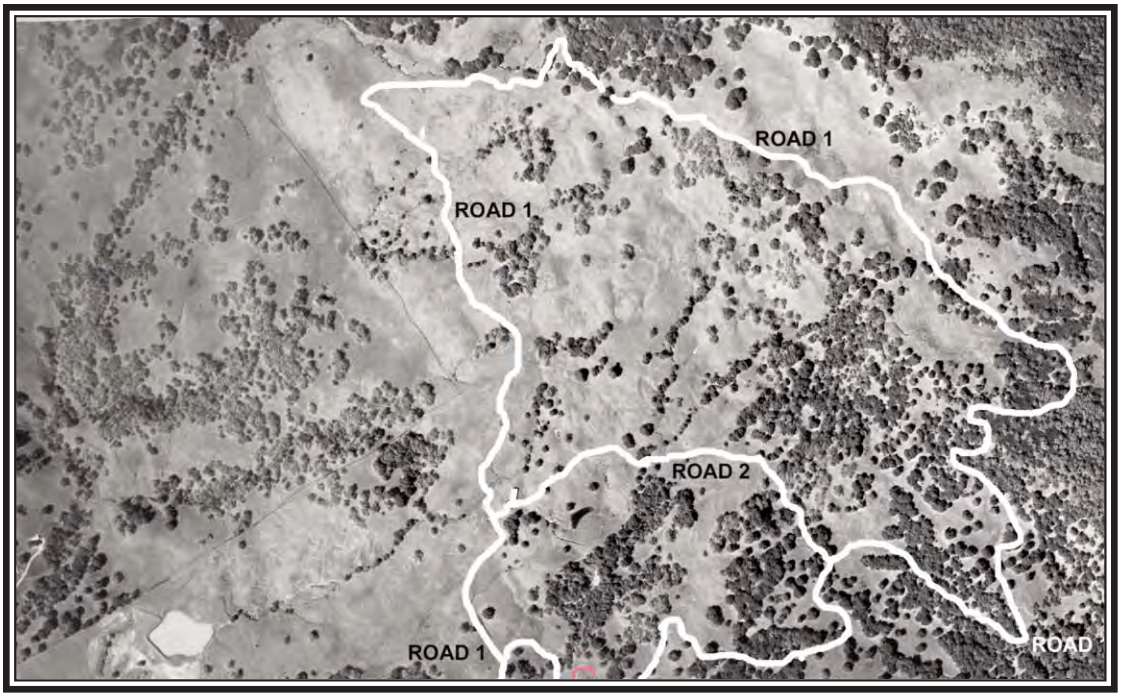

Fish Friendly Farming Environmental Certification Program	FARM PLAN ROAD ELEMENT MAPS

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TOP VIEW SHOWING PLACEMENT OF CROSS-DRAINS

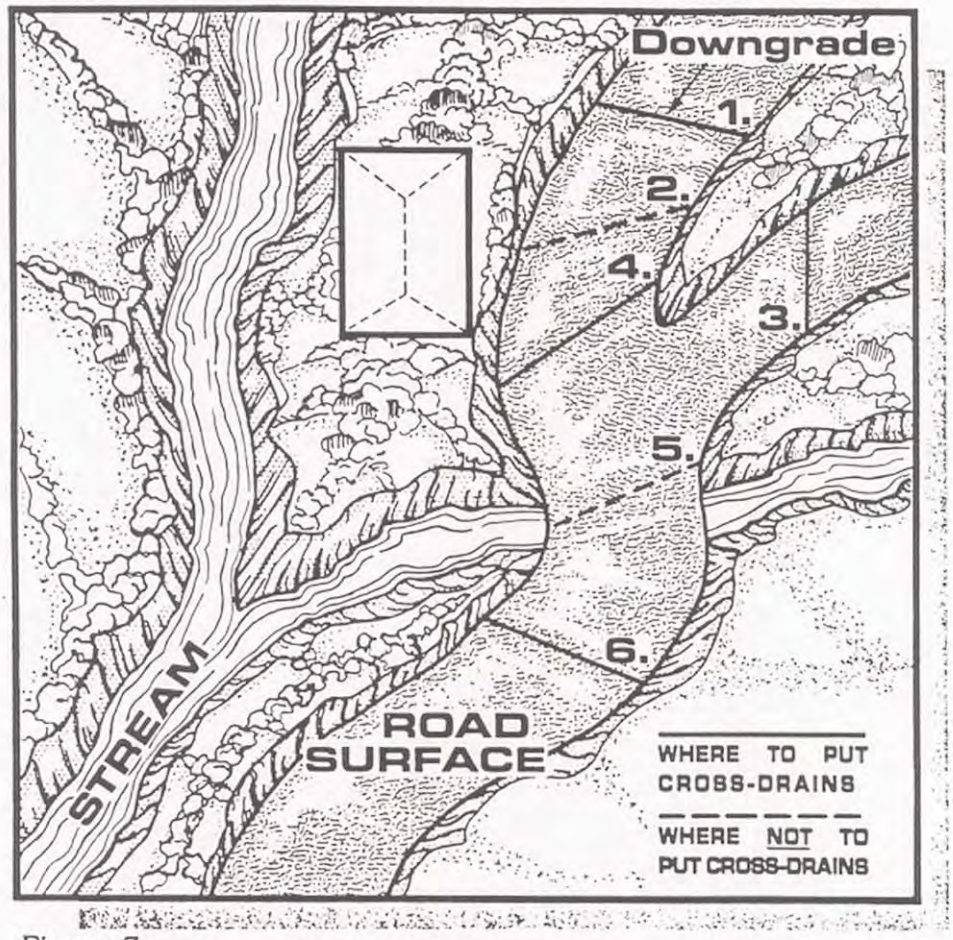

Figure 7.

WHERE TO PUT CROSS-DRAINS

1—Above curves
3, 4—Above junctions
6—At recommended spacing

WHERE *NOT* TO PUT CROSS-DRAINS

2—Pointed towards buildings
5—Directly into streams at crossings

CAUTION: Outlets should be carefully selected to avoid causing erosion on slopes below the road.

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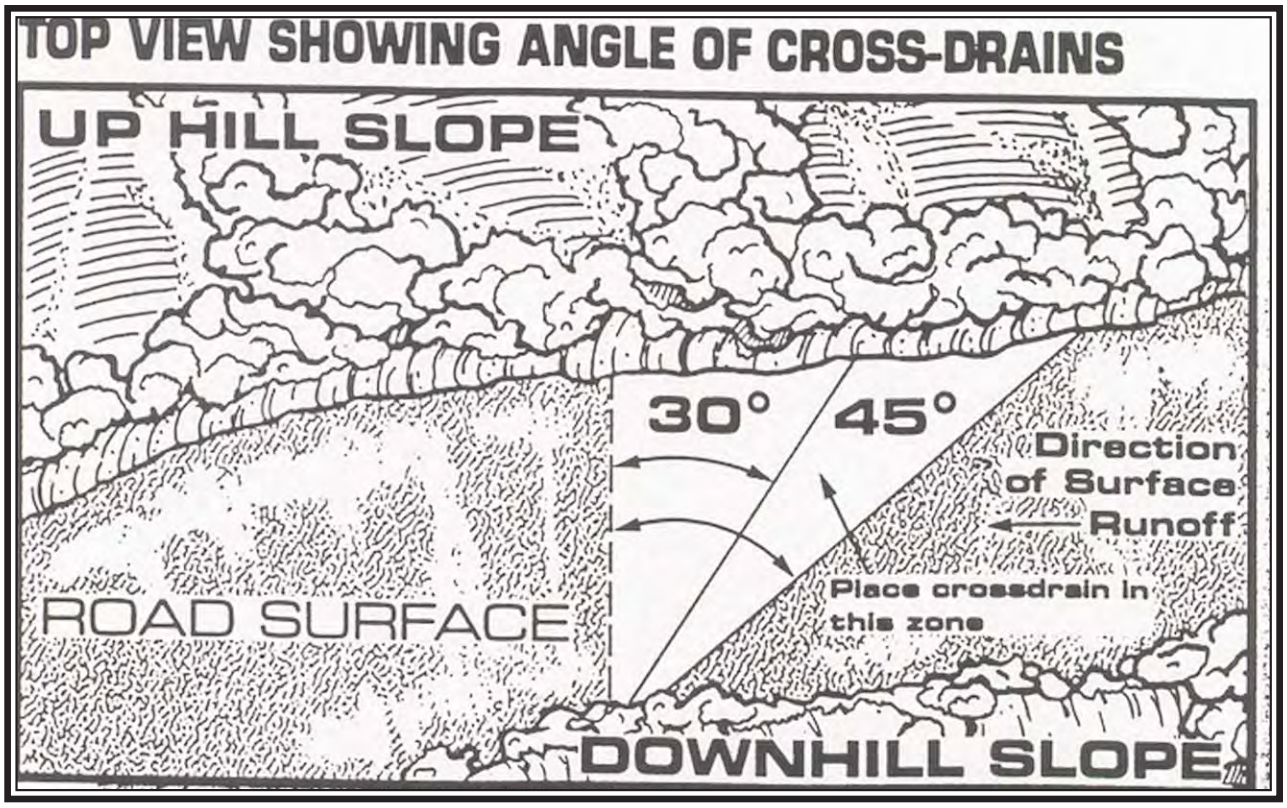

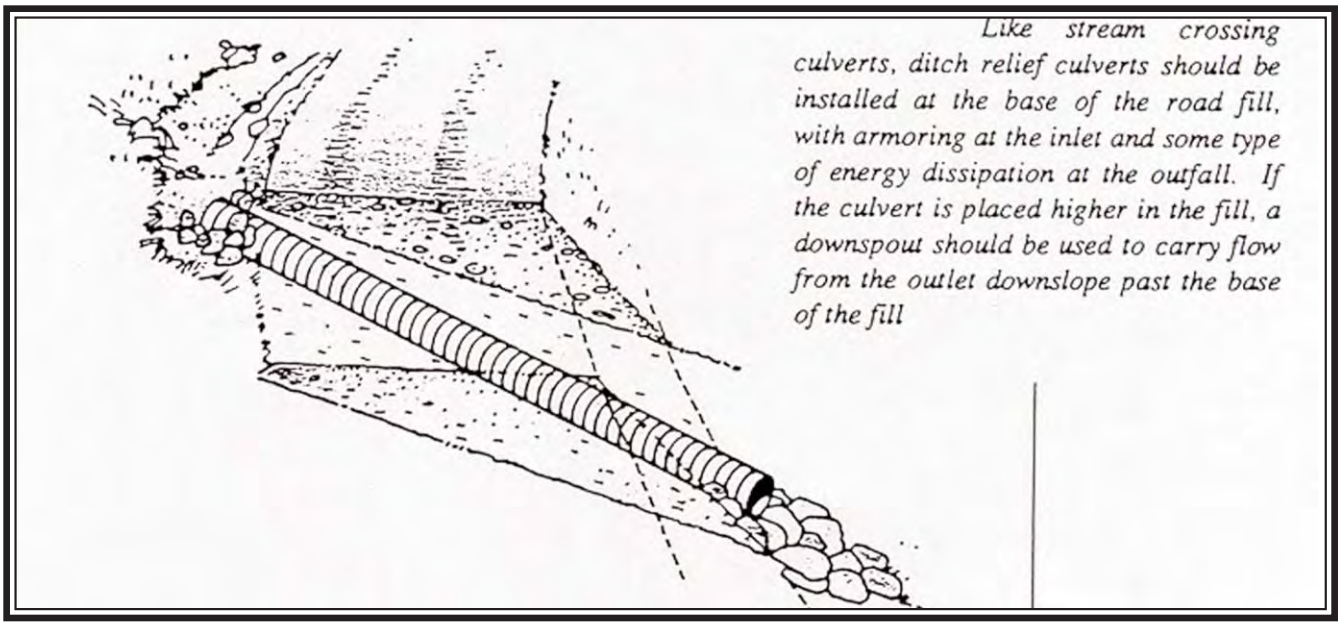

Fish Friendly Farming Environmental Certification Program	PLACEMENT AND LOCATION FOR DITCH RELIEF CULVERTS AND CROSS DRAINS

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Ditch relief culverts

- ❑ Record the number of ditch relief culverts per length of road and the slope of the road. Use your odometer and measure the distance between culverts. This is a very important feature to correctly inventory.

- ❑ Record locations where the ditch relief culverts are not at the intervals specified in Table VA.

- ❑ Record the location and the condition of each ditch relief culvert. Record the diameter and type of culvert. Record if ditch relief culverts are crushed, plugged or rusting.

- ❑ For each culvert record if the energy dissipater at the outlet of a ditch relief culvert is adequate with no erosion or if it is missing, or inadequate, and erosion is evident. Check these as you check the culvert condition.

- ❑ Record locations of ditch relief culverts where water has overflowed onto the road surface. The road surface will show rill erosion. Try to determine the cause such as small size of the culvert, the fact that it is plugged or in poor condition, or another cause.

- ❑ Record locations where ditch relief culverts discharge directly into a creek.

- ❑ Record the number of waterbars or rolling dips per length of road and the road slope. Use your odometer and measure the distance between waterbars or rolling dips for the slope of the road as listed in Table VBC. This is a very important feature to correctly inventory.

- ❑ Record where waterbars or rolling dips are not at the intervals specified in Table VBC.

- ❑ Record locations where energy dissipaters at the outlet of waterbars or rolling dips are missing or inadequate with erosion occurring.

- ❑ Record locations where the road surface shows rill erosion.

- ❑ Record locations where the cut bank is slumping onto the road.

For flat roads:

- ❑ Record the locations of flat road sections (1% or less slope) and describe the road conditions in the comment section.

For vineyard roads:

- ❑ Record the number of roads with rolling dips installed on the road, the approximate frequency and slope of road.

- ❑ Record the location of ditches that are eroding or filling.

- ❑ Record if there are energy dissipaters at the outlets of the water bars, culverts or rolling dips.

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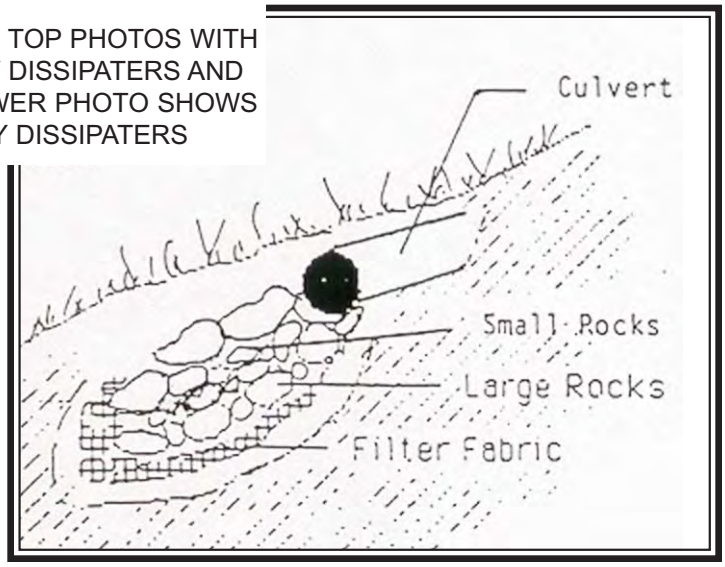
CULVERTS IN TOP PHOTOS WITH NO ENERGY DISSIPATERS AND EROSIONLOWER PHOTO SHOWS ENERGY DISSIPATERS



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DITCH RELIEF CULVERTS WITH AND WITHOUT ENERGY DISSIPATERS

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- ❑ Record if the surface of the road is covered with gravel or in cover crop in the rainy season.

- ❑ Record roads with water bars installed on a regular seasonal basis and approximate frequency of waterbars and the slope of road.

- ❑ Record if there is a filter strip between the road discharge and the creek corridor in the winter.

6. STREAM CROSSINGS

Background: Stream Crossings

Another major feature of road systems are stream crossings. These are all the locations where the road crosses an ephemeral, seasonal or year-round stream. It is important to have properly designed stream crossings. Ephemeral streams that only flow in large storms are often very steep and carry large amounts of flow over short periods. This flow must be accounted for in the road crossing structure or the road will fail, require costly repair and contribute sediment to the stream.

Fish must also be able to pass through crossing structures on permanent streams. All crossing structures should be sized for large flood events of the 100-year frequency interval. Perennial stream crossings will require approval from Fish and Game (see Appendix 5). There are several types of crossings: road fill with culverts, fords and bridges.

Road Fill with Culverts or Culverted Crossings

Road fill with culverts is the most common type of crossing structure and one of the most problematic. Culverted crossings require constant maintenance, frequent replacement and can fail if not managed frequently.

This type of road crossing involves filling the creek channel with material and installing culvert(s) to transmit water through the road fill. However, the creek transports sediment and debris as well as flood flows. If undersized, or in a creek with lots of wood, culverts can easily plug, or become overwhelmed in large floods. When flood flows come over the top of the road fill, the water may enter the inboard ditch, or flow down the road surface. The water may erode the road and possibly the road fill and culverts.

To avoid these problems the following design considerations are needed:

- ❑ Culverts must be sized for the 100-year flow as based on local rainfall records and hydrologic calculations. Stream crossing culvert sizes should account for proposed land use changes that could increase runoff (upstream urbanization, for example) in the watershed of the creek.

- ❑ Trash racks may be installed upstream of the culvert on streams with high debris levels, if the rack will not interfere with fish migration. In general, trash racks may be useful in some ephemeral creeks.

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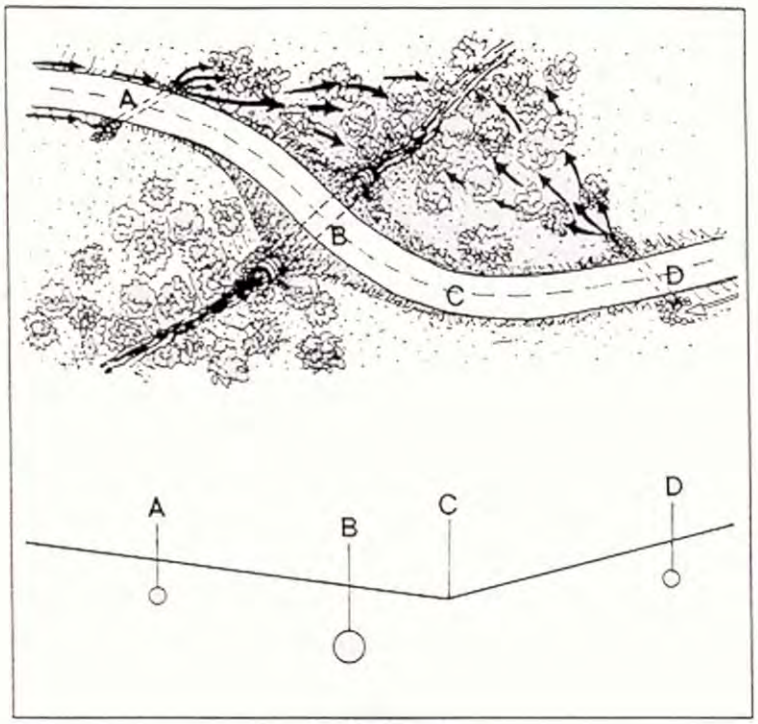
Where a road approaches a stream crossing (B), ditch flow should be culverted across the road (A, D) and discharged into a vegetative buffer that can filter the runoff before it reaches the watercourse. If the stream culvert plugs with debris or is topped by flood flows, flow will spill over the road at the change-in-grade at location "C" and back into the stream channel (modified from M.D.S.L., 1991).



Fish Friendly Farming Environmental Certification Program	DRAWING OF PROPER PLACEMENT OF DITCH RELIEF CULVERTS NEAR STREAM CROSSING

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- ❑ The culvert should be set at the same slope as the bottom of the natural stream channel to allow water and sediment to move throughout the culvert. If the culvert is set at a steeper gradient than the stream there may be erosion at the outlet. If the culvert is set at a flatter gradient than the stream, it may collect sediment. Since many culverts are steeper than the stream, an energy dissipater at the outlet is needed with eventual replacement, or re-setting of the culvert as part of the repair and management program.

- ❑ The road crossing should be oriented at a right angle to the creek with the culvert aligned with the creek channel set at the bed elevation of the channel.

- ❑ The culverted crossing should be constructed with a critical dip at a lower elevation at the edge of the road fill to direct floods over the fill and back into the creek, rather than allow flow to divert down the road and cause erosion. The dip may be filled with gravel.

- ❑ On streams where anadromous fish need to migrate through the culverted crossing there are several options for changing or retrofitting the culvert:

  - ❑ The preferred option is to replace the culverts with a bridge (see below). Larger, faster streams should use bridges.

  - ❑ Bottomless arch culverts are preferred over the standard corrugated metal pipe on streams fish migrate through. The bottom of the culvert should sit slightly below grade (embedded design) to allow the fish easy passage. Consult with the Department of Fish and Game for design assistance.

  - ❑ Non-embedded culverts must be backwatered using hydraulic controls, with the downstream end fully submerged for adult passage. If a jump into the culvert is planned, the project designers should document why the culvert cannot be designed without a jump.

  - ❑ A change in water surface elevation (a jump) of up to one foot is acceptable for adult passage conditions, provided water depth and velocity in the culvert meet all other hydraulic guidelines.

  - ❑ A jump pool must be provided that is at least 1.5 times the jump height, or a minimum of two feet deep, whichever is deeper.

  - ❑ Culverts that are too long, or too high in gradient, require resting pools, or other forms of velocity refuge, for fish of all life stages.

Bridges

Bridges can have the least impact on stream processes if they are designed to avoid filling the creek and floodplain to create a smaller crossing. However, bridges with piers in the channel can collect debris during floods. Bridges and their supports have weight limitations that should be considered. Railroad flatcars can be used as bridges.

Here are design considerations used for bridges:

- ❑ Bridges are the preferred option for road crossings on fish bearing streams where salmon, or steelhead trout, adults and juveniles must migrate up and down the stream.

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- ❑ The best bridge design allows for the supports of the bridge to be constructed out of the flood zone. However wide year-round stream channels are unlikely to accommodate this design and will need in-channel supporting piers.

- ❑ The bridge should be installed at a right angle to the creek.

- ❑ The channel should not be filled or altered to fit a bridge. The design of the bridge should span the channel as it exists.

- ❑ The road entrance on each side of the bridge should be above or level, not below, the bridge deck elevation.

Fords

A ford consists of a road crossing on the bed of the stream channel. One type of ford is called an at-grade, or Arizona crossing. This type of ford is made yearly from the compacted gravel of the streambed. Other types of fords are concrete structures that remain in the stream year-round. Since the crossing is in the streambed, it is subject to scour from winter floods.

The design and location of fords should include:

- ❑ For incised streams with steep banks, those with year-round water, or fish passage, a ford is not a good option and a bridge should be used.

- ❑ Concrete fords can make a good crossing in some ephemeral streams. The ford is designed as a dip in the road at the channel crossing and serves to transmit seasonal flows from the channel across the concrete ford and back into the channel. An energy dissipater should be installed on the downhill side. Some care should be taken to site the ford low enough in the channel bed such that sediment can move with the flood water over the concrete ford and the ford doesn't initiate incision downstream and aggradation upstream.

- ❑ Temporary culverted crossings are often used in gravel bed channels with the creation of a vehicle ramp slightly above the steam bed made out of the gravel with culverts placed to direct the water flow. During low flow periods water percolates through the ford and flows through the culverts. The ford is then removed before the winter season.

- ❑ Use of these crossings should be limited to avoid water quality effects and disturbance of the streambed. These types of crossings should never be used in salmonid spawning and rearing habitat.

Old Crossings

If you have a Humboldt crossing or earth-covered log stringer bridge on your road it needs to be replaced with bridges or culverted crossings. These crossings were constructed out of logs and covered with fill for the roadbed. The logs eventually rot and the crossings fail. Many of these crossings date to the 1800’s and can be very unstable and blow out without warning.

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Field Survey: Stream Crossings

On the Farm Conservation Plan template fill in the table for the stream crossings:

- ❑ List the road name or number, the name or number of the creek and the number of the crossing. All crossings - culvert, bridges and fords are numbered sequentially from the start location.
- ❑ Record the type of creek – ephemeral, seasonal or year-round.
- ❑ Record the location of the crossing using mileage from the starting point.

For culverted crossings:

- ❑ Record the type of culvert at each crossing.
- ❑ Record the diameter of the culvert.
- ❑ Record if the culvert is crushed, plugged or rusty.
- ❑ Record if there is a critical dip in the road surface constructed specifically to allow overflow for floodwater and direct it back into the stream and away from the road.
- ❑ Record if there is an energy dissipater below the culvert outlet.
- ❑ Record if there a trash rack at the upstream end of the culvert.
- ❑ Record if there is substantial sediment deposition on the upstream side of the culvert.
- ❑ Record if there is substantial scour on the downstream side of the culvert.
- ❑ Record any other observations regarding historic erosion or blowouts.

For bridge crossings:

- ❑ Record if the bridge deck collects debris and trash in large storms. If so it may be built too low and close to the stream.
- ❑ Record if the bridge piers are in good shape or are undercut. Are the supports located to avoid squeezing the stream through a smaller area.

For fords/at-grade crossings:

- ❑ Record if the ford is year-round or seasonal and what type of ford it is.
- ❑ Record if there is bank erosion downstream or along the edges of each concrete ford.

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- ❑ Record any other comments including if the ford has washed out, or been damaged in the past.

7. SUMMARY: EXISTING ROAD CONDITIONS

Summarize the locations of the following conditions in the table in the template.

1. Road sections with signs of unstable hillslope conditions
2. Road sections with rilling
3. Road sections with cracks
4. Road section with outer road berm causing erosion
5. Road section with wetland plants
6. Road section with significant ditch erosion
7. Road section with significant ditch filling
8. Road section with cutbank slumping
9. Road section with inadequate numbers of ditch relief culverts, undersized or numerous damaged culverts
10. Road section where ditch relief culverts overflow road surface
11. Road sections with ditch relief culverts without energy dissipaters
12. Road sections where ditch relief culverts discharge directly into creek
13. Outsloped or crowned road sections with inadequate numbers of waterbars or rolling dips
14. Outsloped or crowned road sections with waterbars/rolling dips where energy dissipaters are missing
15. Vineyard roads with rilling and a lack of waterbars or other drainage features
16. Road sections adjacent to creeks including ephemeral, seasonal, and year-round streams
17. Stream crossings with undersized culverts
18. Stream crossings without energy dissipaters
19. Stream crossings where overflows onto the road have occurred

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20. Stream crossings with erosion at the outlet

21. Stream crossings with deposition at upstream inlet

22. Stream crossings with plugged, rusty or crushed culvert

23. All stream crossings that have failed or been significantly damaged

24. Culverted crossings/permanent fords on year-round streams

25. Bridges with unstable piers, inadequate width or debris on deck

26. Ford with erosion on downstream end or sides

APPLYING THE BMPS: ROAD REPAIR AND IMPROVEMENT PROGRAM

Your road survey summary is a list of the conditions that require the application of BMPs and incorporation into the repair or improvement program. The FFF program staff will complete the field survey, summary and repair and improvement program in conjunction with the owner/operator. Funding is available from many sources for implementation.

Hillslope Stability/Road Surface Condition BMPs

- ❑ If the road has significant road surface erosion, cracks or failures along the outer edges it may need to have significant reconstruction work, or be re-located.

- ❑ Areas of a road with springs, seeps and saturated soils for most of the year should have additional subsurface drains installed including:
  - ❑ French drains or ditches at the base of the cutbank and installation of drainpipe to drain hillside seeps and springs into the ditch culvert system.

  - ❑ A gravel blanket with filter fabric can be installed beneath the roadbed to drain springs outward onto a dissipater on the hillslope below the road.

  - ❑ Surfacing perennial wet areas on a road with angular gravel can reduce erosion.

  - ❑ If the installation of additional drainage facilities will not address the instability of the road, the road should be relocated and the unstable section restored

Trying to maintain a road built across an unstable slope is very difficult. Seek expert advice from a geotechnical or civil engineer or engineering geologist to assure design, alignment, and drainage are properly addressed and the road can be maintained. If not the road needs to be closed and restored.

Road Surface Drainage BMPs

- ❑ Outsloped roads with rolling dips are the preferred option for sites where they can be used. It may be possible for much of a road system to be outsloped with certain sections insloped with ditches and culverts.

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Evaluate changing your insloped road system to an outsloped system with rolling dips.

- ❑ In areas where the gradient or use of the road does not allow for an outsloped road, insloped roads are acceptable if adequate-sized ditches, frequent ditch relief culverts of adequate size with energy dissipaters and vegetative filters are installed.

- ❑ All culverts should be designed for the 100-year storm event to assure stability and reduce erosion.

- ❑ Review the background information for each road design. These are the features your road repair and improvement plan should implement.

If you have an **insloped or crowned road**, your road repair/improvement program should address:

- ❑ Replacement of all undersized or damaged ditch relief culverts.

- ❑ Increases in the frequency of ditch relief culverts in road sections showing too few culverts and road surface erosion. Repair of ditch erosion/filling and realignment of road ditch or changes to other drainage features. Reduce cleaning of ditch if causing erosion and on steep areas install rock check dams or rock lining. Make sure there are enough culverts to relieve ditch flows in steep areas.

- ❑ Installation of energy dissipaters at outlets of ditch relief culverts, waterbars and rolling dips. Energy dissipaters need to be of adequate size to function in large storms.

- ❑ Installation of vegetative filters for culverts that discharge directly into creeks.

If you have an **outsloped or crowned road** your road repair/improvement program should address:

- ❑ Installation of additional rolling dips if needed.

- ❑ Installation of energy dissipaters at the discharge point for the waterbar or rolling dip. Energy dissipaters need to be of adequate size to function in large storm events

<u>Vineyard Road BMPs</u>

- ❑ Install waterbars as part of the winterization process on seasonal vineyard roads over 10% slope. Either direct the waterbar to drain into the vineyard drainage system or place energy dissipaters at the outlet.

- ❑ Mulch and cover crop seasonal vineyard roads. Plant seasonal filter strip along the roads on the downhill slope or next to creeks.

- ❑ Place strawbale, or straw wattle, sediment barriers along the edge of vineyard/waterway on a seasonal basis.

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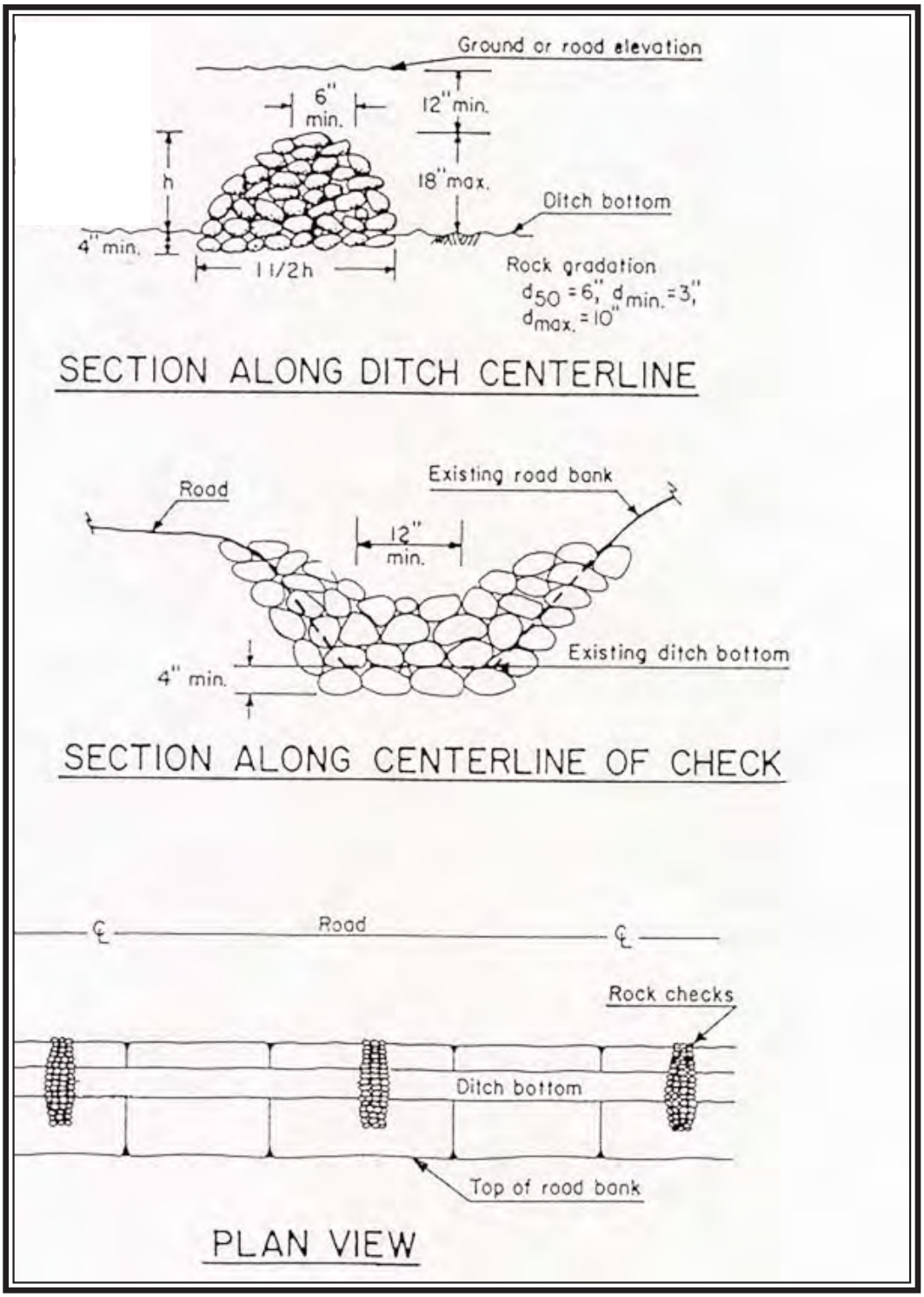

Fish Friendly Farming Environmental Certification Program	SPECIFICATIONS FOR ROCK CHECKDAMS TO REDUCE EROSION OF ROAD DRAINAGE DITCHES

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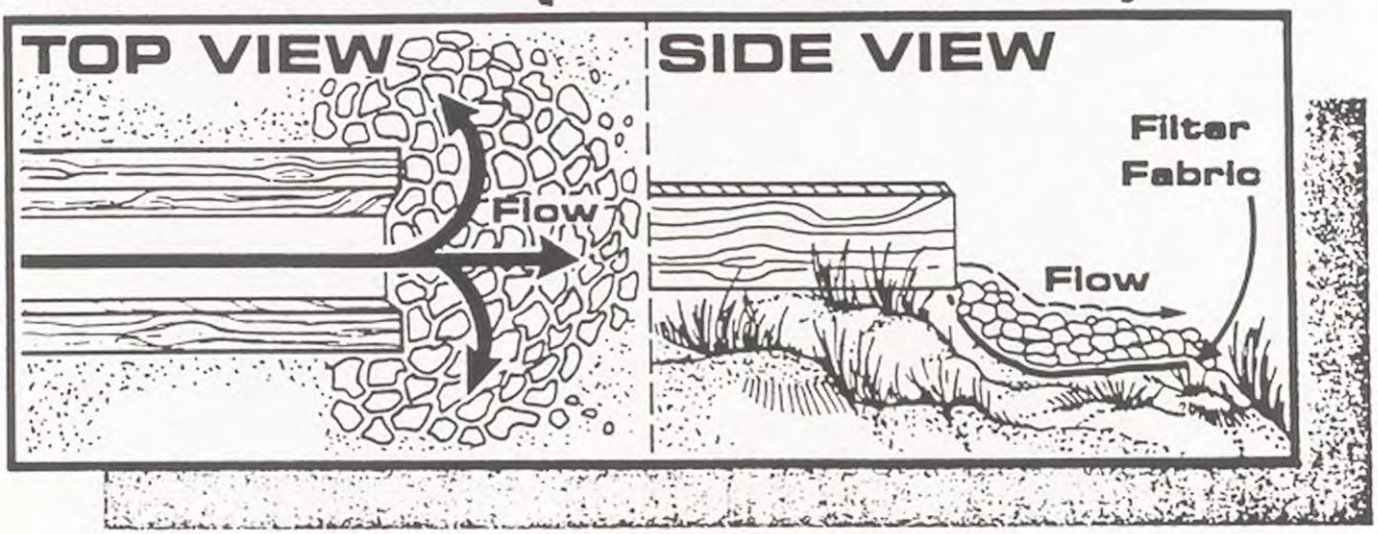
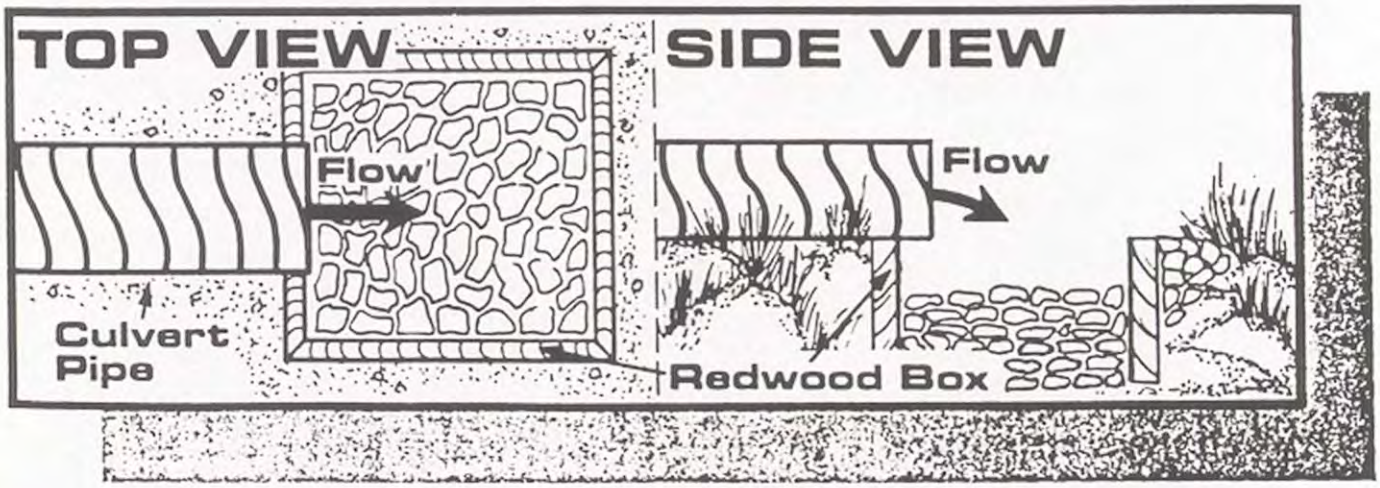
ENERGY DISSIPATER (PLACED ROCK RIP-RAP)



If the rock is not heavy enough, water flow can dislodge it and decrease the effectiveness of the energy dissipater. If necessary, cement grouting, a redwood box, or a section of large culvert pipe can be used to hold rock in place.

ENERGY DISSIPATER (ROCK FILLED CONTAINER)



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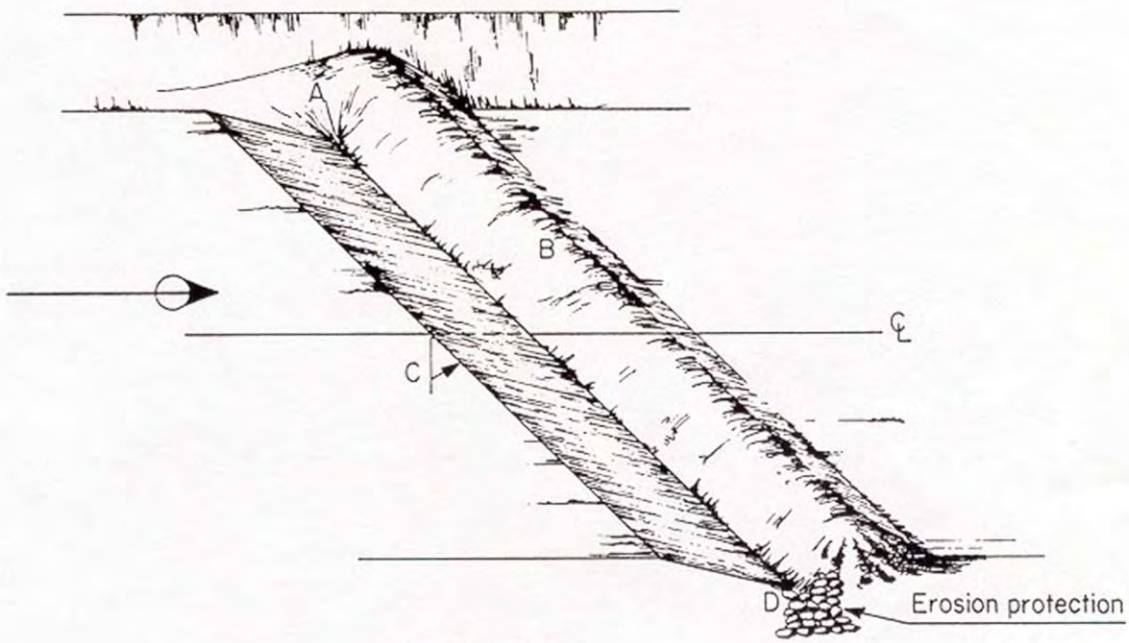

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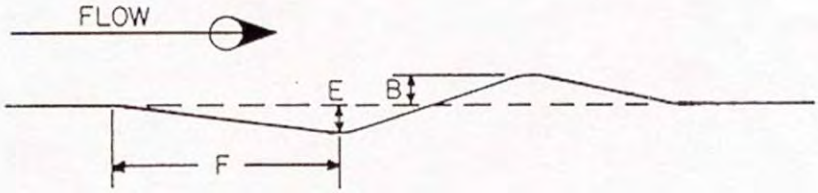

CROSS-SECTION

Note: 1. Waterbar construction for little or no traffic. Specifications are average and may be adjusted to conditions.
2. A, tie-in to bank.
3. B, cross drain berm height 4 to 6 inches above the roadbed.
4. Angle drain 30 to 45 degrees downgrade with road centerline, C.
5. D, drain outlet cut 8 to 16 inches into roadbed.
6. E, depth 4 to 6 inches.
7. F, 3 to 4 feet.

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Stream Crossings BMPs

- ❑ Minimize the number of stream crossings as much as possible through changes in road alignment and reductions in the number of roads.
- ❑ Replace all Humboldt crossings or log stringer bridges with bridges or culverted crossings depending on the site.
- ❑ The best option for crossings of perennial streams are bridges.
- ❑ Culverted crossings should be used only in intermittent and ephemeral streams with concrete fords as another option for some of these sites.
- ❑ Replace culverts that are overflowing, causing deposition upstream or erosion downstream, are plugged or rusty, or are undersized.

Retrofitting of stream crossing culverts should use:

- ❑ Culverts sized for the 100-year frequency flood event.
- ❑ Depending on the site, culverts which are embedded into the stream channel and set at the same slope as the channel to allow natural sediment movement. Bottomless arch and embedded round culverts are examples of this concept.
- ❑ Install a critical dip in the roadbed to direct any overflow.
- ❑ Install an energy dissipater sized to function in the largest storm events.
- ❑ For concrete fords with significant erosion consider installing a bridge or changing to a seasonal at-grade ford made of gravel.
- ❑ For bridges with unstable piers or where the bridge is constricting streamflow, replace with a wider bridge and deeper set piers.

When changing to a new type of stream crossing document the following for use in the design of the crossing:

- ❑ The stability of the slopes on either side of the crossing to support various types of crossing structures.
- ❑ Whether the crossing needs to allow for fish passage. See Appendix 5 for additional BMPs for crossings that need to allow fish passage.
- ❑ The slope of the bed of the creek channel.
- ❑ The 100-year flood discharge volume for the point in the creek where the crossing is proposed.
- ❑ The cross-sectional area of the creek to determine the channel dimensions necessary to convey the100-year flow.

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- ❑ The condition of the channel above and below the crossing to assess flood backwater conditions, the amount of debris and sediment transport in the channel.

- ❑ The orientation of the crossing to the flow path of the creek channel.

Roads near Creeks BMPs

- ❑ Evaluate roads built next to creeks for relocation. This includes roads next to alluvial creeks within 100 ft of the scour channel or riparian corridor and roads along confined channels. If the road is consistently damaged or unstable, it is contributing sediment directly into the stream and should be relocated or possibly reconstructed to a different design to reduce erosion and sedimentation.

On the Farm Conservation Plan Template:

- ❑ Outline the repair/improvement program by addressing the road conditions from your field survey. Check the BMPs and address each of the conditions with a corrective measure.

8. ROAD MAINTENANCE AND WINTER INSPECTION

Background

Proper maintenance of the road system is as important as proper construction and design. If finances of the operation are not adequate to perform road maintenance on a consistent basis for all the roads in the system then the number of roads should be decreased. There are many studies of watersheds where roads have been left unmaintained and the road induced erosion and sedimentation of creeks, a major factor in the decline of the fish and water quality impairments.

Inventory/Assessment: Road Maintenance and Winter Inspection Program

On the Farm Conservation Plan template outline your current yearly road maintenance and winter inspection program including:

Road Maintenance

- ❑ Indicate the time of the year you review the condition of roads, crossings, culverts and other features and when annual repair/maintenance is done.

- ❑ On the table indicate the location and frequency of road repairs and maintenance activities for the various categories listed.

- ❑ The dates you install and remove any seasonal crossings or bridges

- ❑ Indicate the locations used to stockpile any dirt removed from road regarding or ditch clearing.

- ❑ The areas of the property you regularly inspect and those which are inspected on a less regular basis.

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- ❑ The winter inspection program you use and how often you review the conditions of the roads, crossings and culverts.

APPLYING THE BMPs: ROAD MAINTENANCE

Revise your current program as needed to include the following BMPs:

Inspection Program/Winterization

- ❑ Set up a yearly schedule for the inspection of all portions of the road system.
- ❑ Regularly budget for maintenance and the need for both emergency repairs and regular system repairs as well.
- ❑ Inspect all roads and drainage structures in late summer/fall including all road surface and fills, cut banks, culvert inlets and outlets, waterbars, rolling dips, inboard ditches and culverts and all stream crossings.
- ❑ Repair the features of the road system before winter including installing energy dissipaters.
- ❑ Winterize seasonal roads and turnouts around the vineyard by installing waterbars and energy dissipaters, mulching and seeding with grass.
- ❑ Revegetate all stockpile sites along the road system.
- ❑ Plan on inspecting the roads following all major flood events. Make notes of the repairs and improvements needed to be done in the summer. Keep a notepad and jot down the items you see and what needs to be repaired.
- ❑ Revegetate all filter strips near roads.
- ❑ Install emergency erosion control measures as needed to temporarily control erosion problems.

Road Surface/Ditches/Culverts/Waterbars

- ❑ Don’t haul, or grade, in wet weather. It will damage the roadbed. Don't use seasonal roads in the winter.
- ❑ Control dust on roads in the summer to reduce mud.
- ❑ Prior to winter, re-grade those areas of the roads that require it. Fill and grade-out small potholes, and ruts. If these can't be easily filled, re-grade the road and re-compact it. Grade when the roadbed dirt is still slightly moist, but not wet.
- ❑ Clear blockages from inboard ditches.

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- ❑ Watch where the ditches overflow during the winter and add more ditch relief culverts in this section of road.

- ❑ Watch where the road's ditches are eroding and over the summer install rock check dams, line the ditch with rock, or reduce the flow volume in the ditch by adding more ditch relief culverts in this section of the road.

- ❑ Don’t grade ditches on a regular schedule. Only complete this activity if the ditch bottom is less than one foot below the road surface. Unnecessary ditch clearance can undermine the cutbank and create more erosion. Only remove vegetation from the ditch if it is causing water to overflow. Not all vegetation is a problem, it can filter sediment. Don't remove silt from the ditch and leave it on the road to erode. Take it to a stockpile area.

- ❑ During the fall inspection if there are cracks in the outer road fill remove the unstable material before it fails. Then plan to reconstruct the road bench over the summer.

- ❑ Check for slumps and springs during winter inspections and mark the site on the map for drainage improvements during summer work.

- ❑ If the cutslope is a continual problem reconstruct the slope to a flatter angle during the summer and revegetate. Riprap can also be placed at the toe.

- ❑ Inspect all the problem sites during the winter and have materials on hand to perform emergency erosion control if needed.

- ❑ Re-rock rolling dips and waterbars.

- ❑ Reinstall and maintain energy dissipaters at outlets of ditch relief culverts.

Stream Crossings

- ❑ During winter inspect all stream crossings after each storm. Mark the crossing and keep particular track of all those prone to plugging, or overflow.

- ❑ Remove all wood and debris from culverts, replace inlet and outlet rock as soon after the storm as you can.

- ❑ Carry a shovel and chainsaw during winter inspections to allow for a quick clearing job if necessary.

- ❑ Remove debris and sediment to a stockpile location where it won't just wash back into the creek.

- ❑ Repair fords if the repair can be done without equipment. Otherwise wait for summer. Repair bridge abutments immediately if this can be done. Place rock to protect the abutment temporarily if equipment will be needed for the repair. Then fix it in the summer.

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- ❑ Remove trees and debris from the bridge deck and piers and place away from the stream. Take these materials to stockpile area.

9. ROAD CLOSURE AND RESTORATION

Background: Road Closure and Restoration

There are several reasons for closing a road. Perhaps the road is older and is expensive to maintain, or it has numerous erosion problems, or was built across unstable slopes and poses a high risk for failure. The road may not be needed anymore as the operation on the land has changed. Perhaps there are many older abandoned, but not restored, roads from a prior operation that continue to affect the creek with siltation. If a road cannot be inspected and maintained, it should be closed and restored. Abandoning the road by not maintaining it is not the same as restoration. The erosion problems the road can cause are even greater for non-maintained, abandoned roads. Roads are restored by removing their potential for erosion and sediment production to the point where they will no longer require maintenance.

Inventory: Road Closure and Restoration

On the Farm Conservation Plan template list:

- ❑ Roads that have been abandoned or closed on the property

- ❑ Roads identified in your road survey as too close to creeks, on unstable slopes, or no longer needed should be considered for closure and restoration.

APPLYING BMPs: ROAD CLOSURE AND RESTORATION

Use the following guidelines when evaluating a road closure and restoration project:

- ❑ Plan the road closure and restoration just as you would a road construction project. Equipment may be needed and there will be debris and soil to dispose of. There is also likely to be a need for native revegetation. You should involve a professional for the design and construction oversight and a revegetation specialist.

Timing

- ❑ Plan to restore the road in the spring, summer and fall months and complete the project with all erosion control installed by October 15.

Stream Crossings

- ❑ Remove all stream crossing fill and structures to restore the stream to its original grade and size. Excavate to the level of the original stream channel bottom. If the stream has changed a great deal, the size should mimic the channel above and below the crossing site.

- ❑ Set the bank slope back at 3:1 to create a stable base for planting.

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- ❑ Haul all debris and soil to a stockpile for use in other activities.
- ❑ Mulch the area of the crossing and revegetate the channel slopes with the appropriate native species.

Road Surface and Slopes

- ❑ Remove sidecast fill from road bench and swale areas.
- ❑ If the road borders a creek, carefully plan fill removal and revegetation activities to reduce sediment entering the water.
- ❑ Construct waterbars or rolling dips in the old road surface at a 45-degree angle and at a greater frequency than the regular road. These will continue to work to reduce concentrated flows and erosion.
- ❑ Armor the outlets of the waterbars or dips to assure the least amount of erosion.
- ❑ Fill in all inboard ditches, remove ditch culverts and diversion structures.
- ❑ Haul all debris away to the stockpile area.
- ❑ If cut slopes are large and likely to erode, mulch, seed, and revegetate them.
- ❑ Mulch and seed the old road site with fast growing grasses.
- ❑ The road surface can also be ripped during the summer and fall and planted. The ripping should include outsloping and waterbars.
- ❑ Native upland tree and shrub species appropriate to the area should be planted
- ❑ Hydro mulch steep areas and use legumes in the mix along with fertilizer to get a good cover over the road.
- ❑ Continue to watch over the restored road and assure that erosion is no longer occurring

10. GUIDELINES FOR NEW ROAD DESIGN

Background: New Road Design

This section provides some background to review in the design of a new road and how to incorporate design elements to create a non-erosive, fish-friendly road. A civil engineer or other professional should design all roads following these guidelines.

The road prism reflects the type of construction used for the road. Every road involves either cutting into the slope, or filling on top of the slope to create a flat roadbed of a certain width. There are several methods for road construction:

Full bench construction with no side-casting involves the excavation of material from the slope to create the roadbed. Excess material is hauled away to fill in holes, stream

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crossings, or to another site. Full bench design is used where any side casting could cause adverse water quality impacts such as near any drainage channel or on steep slopes where fill may erode.

Partial bench construction involves the excavation of the hillslope and side-casting of the material to create the road fill and is the most common form of road construction. The partial bench design applies in many sites, but should be restricted to slopes less than 50% where fill areas of the road can remain stable. Loading large amounts of fill onto a steep slope can increase the likelihood of slope failure and expensive road repair. The partial bench design should be limited near streams to avoid side-casted fill from filling or eroding into the waterway.

Full fill construction involves the importation of material and placement on the slope to create the roadbed. Full fill techniques are used where the slopes are unstable and any excavation of the slope could cause problems. The fill must be properly engineered and compacted.

In all cases, the cut and fill slope should be designed for the greatest stability. The angle of the cut and fill slope should consider the soil type and its ability to "stand up" at different angles of repose and with different amounts of compaction, vegetative cover and drainage measures.

APPLYING THE BMPs: GUIDELINES FOR NEW ROAD DESIGN

Determine the type of road needed:

- ❑ Determine the season of use for the road, the required size (width) of the road, and other necessary features for safety considerations.
- ❑ If the road is designed as a seasonal road, use it only in the dry season for its designed season of use. Do not plan to use seasonal roads for all weather use.
- ❑ Consider using all weather surfacing for year-round roads to reduce erosion

Use the following steps to evaluate a site for construction of a new road:

- ❑ Obtain aerial photos at the largest scale available (1"=200' to 1”=50’), detailed topographic maps, soil surveys, geologic maps and vegetation maps.
- ❑ Delineate those areas where the site will be developed including water supply, electrical and other areas requiring vehicle access.
- ❑ Determine what type of road is needed - seasonal or year-round, permanent or temporary, size and travel needs.

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- ❑ Delineate all natural stream courses, including ephemeral streams, swales, springs, springs and wetlands.

- ❑ Delineate areas of the site with steep slopes (over 30%), unstable areas (old landslides, erodible soils and rock outcrops, especially serpentine).

- ❑ Delineate high value wildlife areas.

- ❑ Delineate natural low gradient slopes, saddles over ridges and other flatter areas of the site.

Delineate several different alignments for the new road. The alignments should encompass the following design criteria:

- ❑ The **gradient** of the road should not exceed 3-5% and should traverse across the most modest of the slopes on the site. The gradient of the road is calculated by the rise, or fall, in the elevation of the roadbed over the length of the section of road x100 to get the percentage. Very short sections of the road may exceed 15%, but steep gradient roads are subject to erosion. Use steep gradients in the road only to avoid rock outcrops or unstable areas. When outlining the road alignments use low slope areas, saddles and ridgetops to the greatest degree possible. Avoid riparian areas.

- ❑ **Align** the road to minimize the number of crossings of seasonal and permanent creeks and watercourses. The road alignment should leave a significant buffer (see Table VC) between all watercourses and the road. This buffer varies with the slope of the land. The buffer should be in addition to any riparian corridor, natural vegetated corridor along the stream, or swale.

- ❑ Attempt to **minimize** the amount of cut and fill by aligning the road along the contour across the landscape and by using full fill or full bench construction rather than sidecast partial bench design. Particularly avoid cut and fill construction on steep slopes, or near creek corridors.

- ❑ Avoid **unstable and steep slope** areas. If some portion of the road must cross an unstable or steep slope consult with an engineering geologist for special construction and stabilizing techniques.

Evaluate the potential road alignments in the field to improve on the route:

- ❑ Walk the alignments and review them for obstacles, unstable slope conditions, steep areas, creek and drainage channels and other features.

- ❑ Revise the alignments to create the best route with the most stability over time.

- ❑ The road design plays a role in choosing a preferred alignment for the new road. The type of road bench and construction, surface drainage system used as well as the number and type of creek crossings will play a large role in future costs for maintenance. The uses of the road will dictate its size and season of use.

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- ❑ The future maintenance needs created by the alignment should be considered when choosing the alignment. Don't plan for a road without assuring that future maintenance work can be done or the road will become an erosion problem.

11. NEW ROAD CONSTRUCTION

Background: New Road Construction

This section provides some background on the construction of a new road and how to incorporate design elements to create a non-erosive fish friendly road. All roads should be constructed by licensed contractors and designed by a civil engineer using these guidelines.

Road construction is complex and all the aspects of building a road are not covered here. The BMPs focus on those aspects of the construction process that have the greatest effect on soil erosion.

APPLYING BMPs GUIDELINES FOR NEW ROAD CONSTRUCTION

The plans and specifications for the road project either for a new road, or major repair for an old road, should include all the directions to the contractor for erosion control during the project.

Review the plans and specifications to assure that they include:

Seasonal Restrictions

- ❑ Construction activities involving soil movement should only be done in the summer.
- ❑ Clearing and grubbing can begin in spring, once all chance of rain has passed.
- ❑ Tree felling can be done in winter only if no heavy equipment is used to remove the trees. Grading should only be done in the summer.
- ❑ The plans should specify that stream crossings should be constructed in the least amount of time to assure the work is completed quickly. All the materials should be on-hand to allow for the last impact on the stream.
- ❑ All work on wet areas or unstable slopes should be done in late summer and completed and revegetated by fall.
- ❑ All the work should be completed by October 15 including all revegetation and winterization work, the installation of waterbars and rolling dips.

For Clearing and Grubbing

- ❑ Make sure the proper permits are issued.
- ❑ Make sure the alignment is staked and flagged in the field correctly and that the area included is the minimal needed for the road. Overclearing creates erosion hazards.

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- ❑ Remove all the stumps or vegetation from the road alignment and any material to be used for the road fill. Vegetation in the fill will create empty spaces once the wood breaks down.

- ❑ The vegetation may be placed along and parallel to the edge of the road base as a filter for runoff.

For Grading

- ❑ Make sure the plans and specifications clearly show the bench type, road layout, percent compaction, cut and fill amounts and locations for the placement of excess material (stockpile site).

- ❑ Try to keep slope stabilization work as close behind road construction as possible.

- ❑ Never sidecast into streams, from slopes above streams, or into headwater swales.

- ❑ For roads anywhere near streams or on steep slopes near streams, make sure road sidecast is no more than 1-foot thick and no more than 10 feet beyond the road edge.

- ❑ For other roads, make sure the sidecast for the road is no more than 3 feet deep and never more than 30 feet beyond the road edge.

- ❑ Make sure the type of benching used decreases side-casting and loading to reduce the potential for slides and erosion. Excessive fill and sidecast can overload the slope and cause the road and the slope to slide.

- ❑ Seed and mulch all disturbed soil including cut banks and spoil sites by September 30.

For Stream Crossings

- ❑ Review Appendix 5 for guidelines on designing stream crossings on fish bearing streams.

- ❑ Make sure all permits and approvals from the Department of Fish and Game and any other agencies are complete and the conditions from the permits are incorporated into the plans and specifications.

- ❑ Make sure the schedule for the project incorporates working in the stream only when it is dry.

- ❑ If the stream is a year-round stream, the stream will need to be temporarily dewatered through the placement of a diversion pipe and the placement of a small dam across the channel. Make sure the Department of Fish and Game approves these activities.

- ❑ Make sure the construction of all the crossings will occur in an efficient manner and that all the materials will be available with no delays in construction. No creek should remain diverted or dammed longer than the minimum time to complete the construction.

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- ❑ For intermittent streams make sure the specifications for the culverts account for culvert sag (install the culvert below grade) and incorporate all the design BMPs.

- ❑ Make sure the culvert is set slightly (six inches to one foot) below the streambed and that clean backfill is used and compacted around the culvert.

- ❑ The final fill for the road should include a critical dip at the crossing to direct overflow back into the creek.

- ❑ For the approaches to the crossing for an incised channel use no sidecast but construct with full bench constriction.

- ❑ Install additional drainage facilities for wet areas in the crossing approaches.

- ❑ Revegetate the area of the channel near the crossing with native species. Seed and mulch all disturbed slopes and cut banks near to the stream crossing.

- ❑ Use licensed contractors to construct the road and those with experience in the area and soil conditions. For projects over $20,000, consider requiring a performance bond from the contractor to assure all aspects of the project are completed.

12. ROAD RECONSTRUCTION

Background: Road Reconstruction

The decision to reopen or reconstruct an old road should be made after a thorough evaluation of the road. All of the needs for the upgrade should be considered in the costs including upgrading all drainage facilities to the 100-year flood event at stream crossings, ditches and road culverts. The older abandoned road may still be contributing sediment because it was never properly closed. Reopening and upgrading the road could decrease erosion and make the road available for the current land use. The exceptions to this concept are roads adjacent to creeks and those on very steep slopes, slides, or unstable soils where proper closure may still be warranted, but not reconstruction.

APPLYING BMPs: GUIDELINES FOR ROAD RECONSTRUCTION

Timing

- ❑ Use the same timing and erosion control restrictions for reconstruction as construction of roads

Stream Crossings

- ❑ Make sure all new stream crossings will accommodate the 100-year flood flow.

- ❑ To reconstruct a washed out stream crossing, remove all the remaining fill and the structure. The old channel bed will often have rounded stones.

- ❑ Replace old crossings with a bridge for year-round streams or, if it is an intermittent stream, use culverts sized to the 100-year event.

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Table VA*
Spacing Required for Ditch Relief Culverts

Maximum suggested spacing for ditch relief culvert[1] (ft)					
Road grade (%)	Soil erodibility				
	very high	high	moderate	slight	very low
2	600-800[2]				
4	530	600-800[2]			
6	355	585	600-800[2]		
8	265	425	525	600-800[2]	
10	160	340	420	555	
12	180	285	350	460	600-800[2]
14	155	245	300	365	560
16	135	215	270	345	490
18	118	190	240	310	435

[1] Adapted from *Transportation Handbook USDA Forest Service R-6 1966*. Culvert spacing may be too great in locations where ditch runoff is accumulated and discharged onto steep hillsides that are prone to gullying. Spacings are designed to control ditch erosion, not culvert outfall erosion and are based on a 25-year storm and precipitation rate of 1-2 inch/hr for 15 minutes. If less multiply by the intensity 0.50, 0.30, etc. If 2-3 inch/hr divide the distance in table by 1.50; if 3-4 inch/hr divide by 1.75; and if 4-5 inch/hr divide by 2.00.

[2] Even with stable ditches, ditch relief culvert spacing greater than about 600-800 feet is generally not recommended due to the large volume of road surface and cutslope runoff that would be discharged through the culvert and onto lower slopes during peak runoff periods. Culvert outlet erosion may occur with less that 800 ft. of contributing ditch line, so observe local conditions to determine the upper limit of acceptable spacing in your area

* Table derived from Weaver, W. and D. Hagans. 1998. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads. Mendocino Resource Conservation District. Ukiah, CA.

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Table VB*
Drainage Spacing

Maximum suggested road surface spacing based on road gradient and soil composition[1]			
Soil composition	Road gradient (%)		
	2%-4%	5%-8%	9%-12%
Granitic or sandy	400	300	200
Clay or loam	500	400	250
Shale or gravel	600	500	300

[1] MDSL 1991 Distance used only to show importance of soil type in influencing drain spacing.

Table VC*
Rolling Dip Dimensions

Table of rolling dip dimensions				
Road Grade (%)	Upslope approach (distance from up-road start of rolling dip to trough) (ft)	Reverse grade (distance form trough to crest) (ft)	Depth below average road grade at discharge end of trough (ft)	Depth below average road grade at upslope end of trough (ft)
<6	55	15-20	0.9	0.3
8	65	15-20	1.0	0.2
10	75	15-20	1.1	0.1
12	85	20-25	1.2	0.1
12	100	20-25	1.3	0.1

* Tables derived from Weaver, W. and D. Hagans. 1998. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads. Mendocino Resource Conservation District. Ukiah, CA.

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Table VD*
Cut and Fill Steepness

Generalized maximum cut and fill steepness for different earth materials	
Slope ratio	Earth material
¼ to 1	Rock cuts
½ to 1	Hardpan and soft rock cuts
¾ to 1	Clay
1 to 1	Clay, sandy or gravel alluvium
1½ to 1	Fill slopes, lake deposits
2 to 1	Unstabilized, uncompacted fill
3 to 1	Unstabilized soil
Near vertical to sloping; use only where such cuts are working locally	Some sandy or granitic soils; some hard bedrock exposures

Table VE*
Outsloping pitch for roads

Outsloping “pitch” for roads up to 8% grade		
Road grade	Outsloped ”pitch” for unsurfaced roads	Outsloped “pitch” for surfaced roads
4% or less	⅜” per foot	½” per foot
5%	½” per foot	⅝” per foot
6%	⅝” per foot	¾” per foot
7%	¾” per foot	⅞” per foot
8% or more	1” per foot	1¼” per foot

* Tables derived from Weaver, W. and D. Hagans. 1998. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads. Mendocino Resource Conservation District. Ukiah, CA.

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Table VF*
Minimum buffer widths

Recommended minimum widths for buffer/filter strips between wildland roads and streams	
Slope of land between road and stream(%)	Minimum width of vegetated filter or buffer strip (ft)
0	50
10	90
20	130
30	170
40	210
50	250
60	290
70	330

Table VG*
Distances Between Water Breaks on Roads and Trails

Maximum distance between waterbreaks on road and trails (feet)				
Erosion hazard rating (for surface erosion)	Road or trail gradient (%)			
	10% or less	11-25%	26-50%	Over 50%
Extremely high	100’	75’	50’	50’
High	150’	100’	75’	50’
Moderate	200’	150’	100’	75’
Low	300’	200’	150’	100’

* Tables derived from Weaver, W. and D. Hagans. 1998. Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining and Closing Wildland Roads. Mendocino Resource Conservation District. Ukiah, CA.

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- ❑ For all crossings make sure the road has an overflow dip to reduce the potential for flow diversion onto and down the road.

- ❑ Add trash racks if appropriate and energy dissipaters of the proper size.

- ❑ Review Appendix 5 for design guidelines for stream crossings on fish bearing streams.

Road Surface

- ❑ If re-grading from an insloped to outsloped road, excavate all the outer fill and sidecast and use, to the extent practicable, to fill in the inboard ditch.

- ❑ Install rolling dips utilizing all material with no side-casting near any watercourse or where transport to a watercourse could occur.

- ❑ Don't construct using sidecast techniques unless necessary and don't sidecast into or near creeks.

- ❑ Disturb as little vegetated area as necessary.

- ❑ If the entire road bench has failed, have an engineer review the site and suggest alternatives including alternative locations. This is particularly important in unstable sites.

- ❑ If the outer portion of the road fill has eroded and the remaining fill is stable try to use a narrower road or excavate the cut bank (unless springs are present) to increase the road width. It is better to not reconstruct the road by replacing the fill in the eroded areas.

- ❑ Remove all excess sidecast before reconstructing the road.

- ❑ Remove all cut slope failures and haul to stockpile site that will be stabilized and revegetated.

- ❑ Dispose of vegetation and soil at a stable site not near a creek or on a steep slope.

- ❑ Complete all work, install erosion control and revegetate by October 15.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds.

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ELEMENT VI - STREAM AND RIVER CORRIDORS: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for new, existing and replanted vineyards and addresses seasonal and year-round (blue-line) creeks and rivers on the entire property. This element includes:

- ❑ Inventory/assessment of stream corridor condition.
- ❑ Evaluation of current management practices and other factors influencing the corridor condition.
- ❑ Application of Beneficial Management Practices (BMPs) for the corridor.
- ❑ Formulation of a timeline and identification of funding sources (if needed) for the implementation of BMPs and creek corridor restoration.

INTRODUCTION

The focus of this element is perennial and intermittent or “blue-line” creeks and their riparian corridors. The BMPs focus on the long-term sustainability of both the stream corridor and its habitat values, and the vineyard operation. Vegetative methods for creek restoration are emphasized, as well as restoration of natural channel form. These measures involve the lowest environmental impact, have been shown to be the most effective over time and can be implemented with a minimum of regulation and permitting.

The program uses an adaptive management approach in which the condition of the corridor and current management measures are inventoried and evaluated, BMPs and restoration methods are applied, the condition is re-evaluated over time and additional management is applied, or changed, and revegetation continued. As greater understanding and new measures for restoration and management of stream corridors are developed, or as conditions on the creek or river channel change, the use of the BMPs and management methods are revised. In this way, the goals of supporting and sustaining both the farming operation and the stream corridor can be better achieved over the long term.

The time frame for implementing changes and restoring riparian corridors considers both environmental and economic factors. Riparian corridors under natural conditions change over long periods of time. A bank erodes and a large tree falls into the channel. New trees germinate next to the channel on the floodplain. The creek and riparian corridor naturally change over time. Restoration of riparian corridors needs to mimic this natural process and be done in stages, or in response to changes from large storms.

The inventory and assessment in the Farm Conservation Plan may also show that the meandering creek may need a wider corridor area, or changes to the channel width and depth, to create a functional floodplain for riparian trees. Incised, or downcut, channels may need banks set back, the re-creation of a new floodplain, and revegetation. But achieving these changes should not necessarily involve greater environmental impacts than benefits. Instead incremental improvements can be achieved as a bank erodes or changes occur and

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repair and restoration can widen the corridor over time. This restoration approach is less intensive and will require a longer timeline. For this reason a 10-year period is used in implementing the Farm Conservation Plan.

For an incentive-based program like Fish Friendly Farming to function, implementation of riparian corridor restoration must also consider the farmers' needs. Widening and restoration of some riparian corridors may require taking land out of production. This change can result in a reduction of income to the farmer. Causes of change in some riparian corridors, such as incision in the main Russian River channel resulting from the large dams in the watershed and the mining, dredging and channelization of the river are not within the control of individual landowners. However, the farmer often must absorb the cost of repairs to the river channel. Phasing restoration activities into the farm operations make them easier to implement. Many farmers may also realize cost savings by reducing the amount of active management of the creek and using revegetation for bank repair rather than costly riprap.

However, widening and restoration of creek corridors will require financial assistance to farmers for the initial capital investment in project construction. In general, the restored corridor does not create income to the farmer, but does provide public benefits for water quality and habitat. Appropriate management of the corridor done by the farmer, such as on-going control of invasive plants or irrigation of new native plants, will add value to the project. Over the long term, restoring and sustaining riparian corridors and fish habitat will succeed only if both the environmental and economic factors are considered and integrated equally into implementation strategies.

Background: Stream and River Riparian Corridors

This assessment assists the farmer in evaluating the stream/river corridor, determines how to revise management practices, and identifies what short and long-term changes and restoration activities need to be performed.

Overall, the goal is to allow the creek, or river, channel to reach a more stable and natural form that can sustain riparian and fish habitat. Restoration activities focus on:

- ❑ Revising farm operations to remove conflicts with creek processes
- ❑ Restoration of a vegetated corridor of adequate width for alluvial creeks, including necessary changes to the channel form and floodplain
- ❑ Revegetation measures for banks and floodplain areas
- ❑ Restoration and management of confined creek channels in canyons
- ❑ Removal of invasive, non-native plants and revegetation with native plants from local genetic stock

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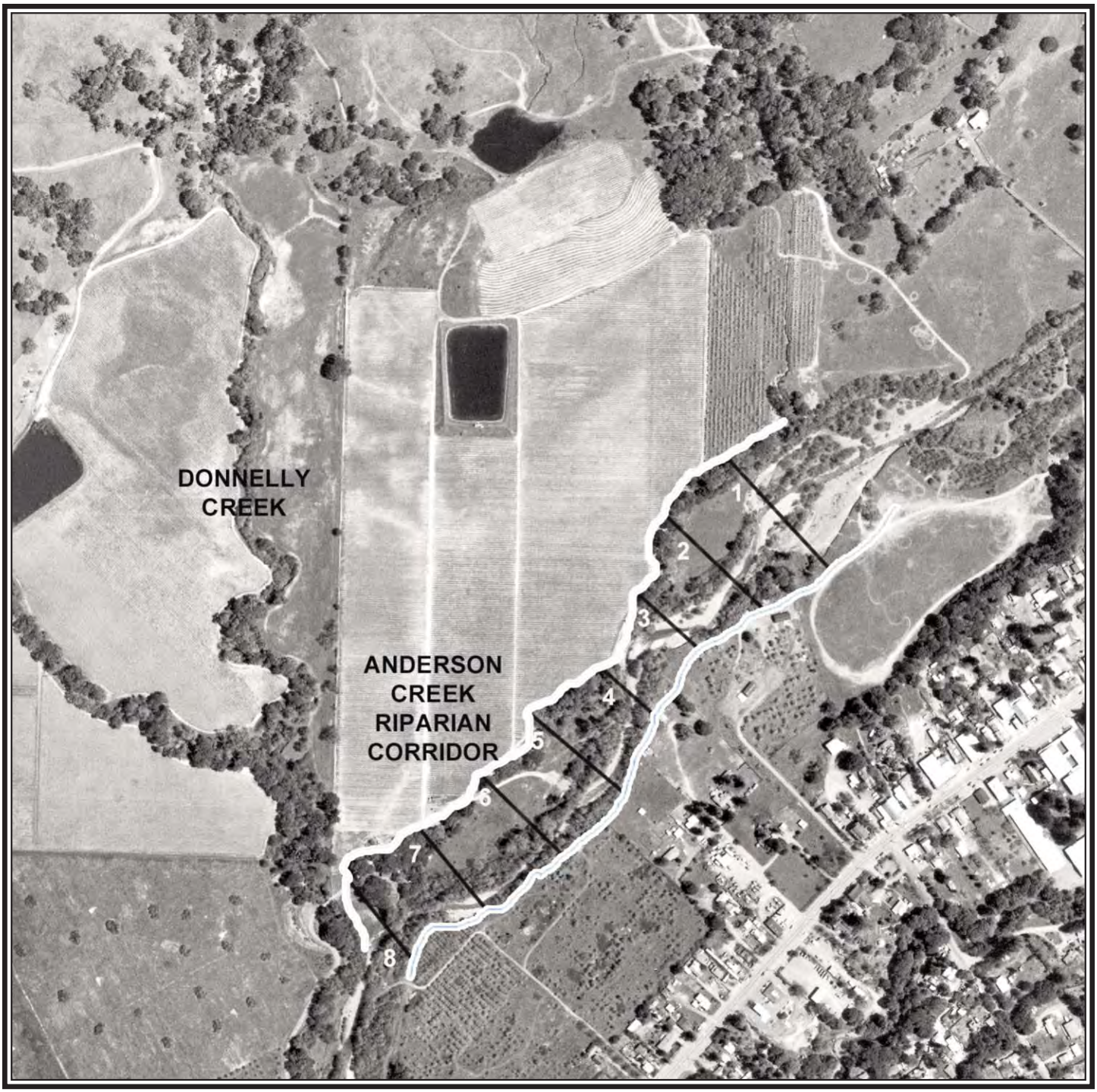

Fish Friendly Farming Environmental Certification Program	FARM PLAN SHOWING EVALUATION OF CREEK AND RIPARIAN CORRIDOR

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- ❑ Avoiding changes to the active or scour channel
- ❑ Correction of upstream erosion and drainage problems to reduce their effect on the creek
- ❑ Protection of the creek habitat and the watershed lands through beneficial stewardship

The restoration approach for this program involves as little intervention in the active (scour) channel as possible. This is the highly dynamic portion of the creek and efforts to manage the active channel with in-stream structures have not been very successful (Roni et al, 2002). Instead, the goal is to create and manage a riparian corridor of sufficient width to be able to undergo natural flood and meandering processes and have an adequate riparian forest for natural habitat to form and regenerate. If there is excessive upstream erosion or increases in flood flows, the channel will be constantly adjusting to these factors. Creek corridor restoration approaches that include the watershed and focus on the overall corridor are most likely to be successful (USDA, 1998). It is not possible to restore fish habitat over the long-term just through manipulation of the creek channel itself.

Fish habitat is formed and maintained in the active, or scour, channel of a river, or creek, by the interactions of many features. During a flood, the energy of water flowing downhill moves sediment, gravel, wood and other materials. With each flood the channel changes. The features, or variables, in each creek channel that affect its form and habitats include:

- Slope of the creek bed
- Sinuosity of the channel
- Volume of floodwater
- Sediment supply
- Supply of large wood for in-channel habitat
- Velocity of the floodwater
- Channel substrate type – gravel, sand, or bedrock
- Width and depth of water flow
- Roughness - vegetation, gravel, rocks, and wood in the channel

A change in one variable induces change in the other variables in different proportions to each other. Looking at the active channel after a flood gives some clues as to how the overall stream channel is changing. But trying to second-guess how the creek will change in the next flood is not reliable. Each flood event is different and a different set of changes in the variables may occur. With the creek being so complex, it is nearly impossible to permanently "fix" a creek for either habitat or flood control. A fix may solve one problem at one location over the short term, but create numerous long-term problems.

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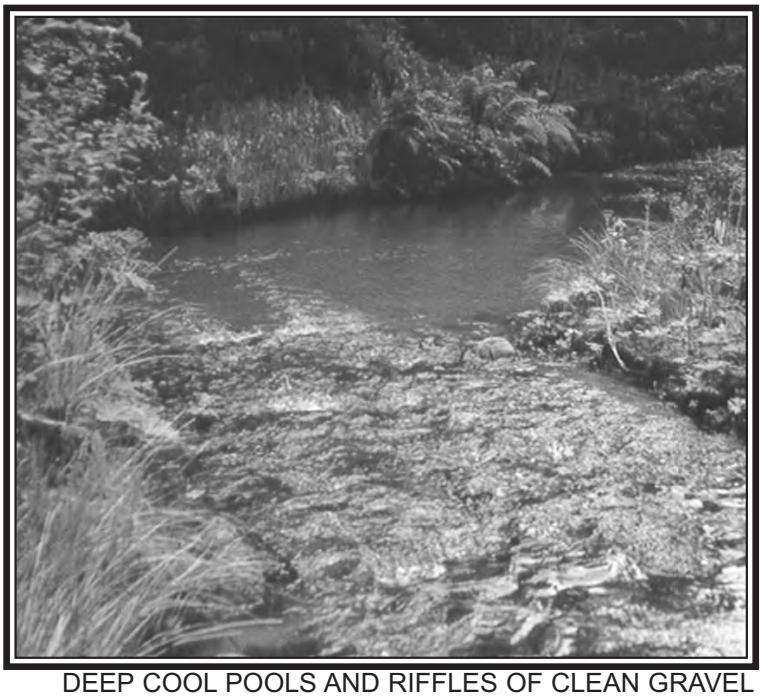
CLEAN NON-SILTED GRAVEL

SHADY WELL VEGETATED STREAM CORRIDOR



DEEP COOL POOLS AND RIFFLES OF CLEAN GRAVEL

LARGE WOOD FROM THE CORRIDOR
CREATES FISH HABITAT IN THE CHANNEL

Fish Friendly Farming Environmental Certification Program	FISH HABITATS ARE THE RESULT OF A HEALTHY WATERSHED AND RIPARIAN CORRIDOR

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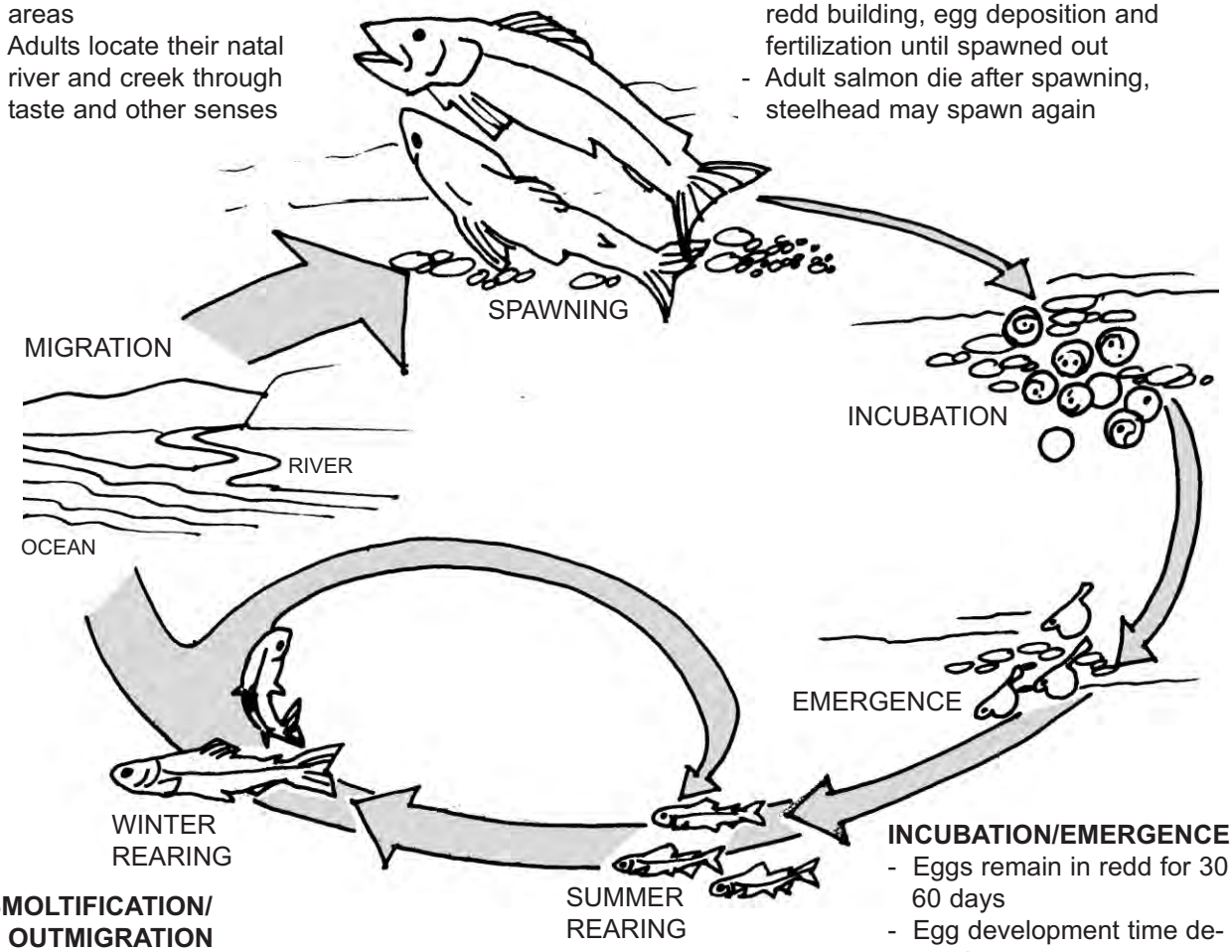
COHO SALMON AND STEELHEAD TROUT LIFE CYCLE

ADULT MIGRATION
- Adults enter river system from ocean
- Adults hold in main river and reach sexual maturity, change color
- Adults jump barriers and fight their way upstream to gravel bed spawning areas
- Adults locate their natal river and creek through taste and other senses

SPAWNING
- Female chooses redd or nest site in gravel near to pool/complex habitat
- Female builds redd by fanning gravel surface and creating depression
- Female lays eggs and male(s) release milt to fertilize eggs
- Female covers eggs with gravel
- Female and male repeat process of redd building, egg deposition and fertilization until spawned out
- Adult salmon die after spawning, steelhead may spawn again



INCUBATION/EMERGENCE
- Eggs remain in redd for 30 to 60 days
- Egg development time depends on water temperature and dissolved oxygen
- Eggs hatch into alevins which remain in the spaces in the gravel while their yolk sac is absorbed
- Fish wriggle out through the gravel into creek and are called fry

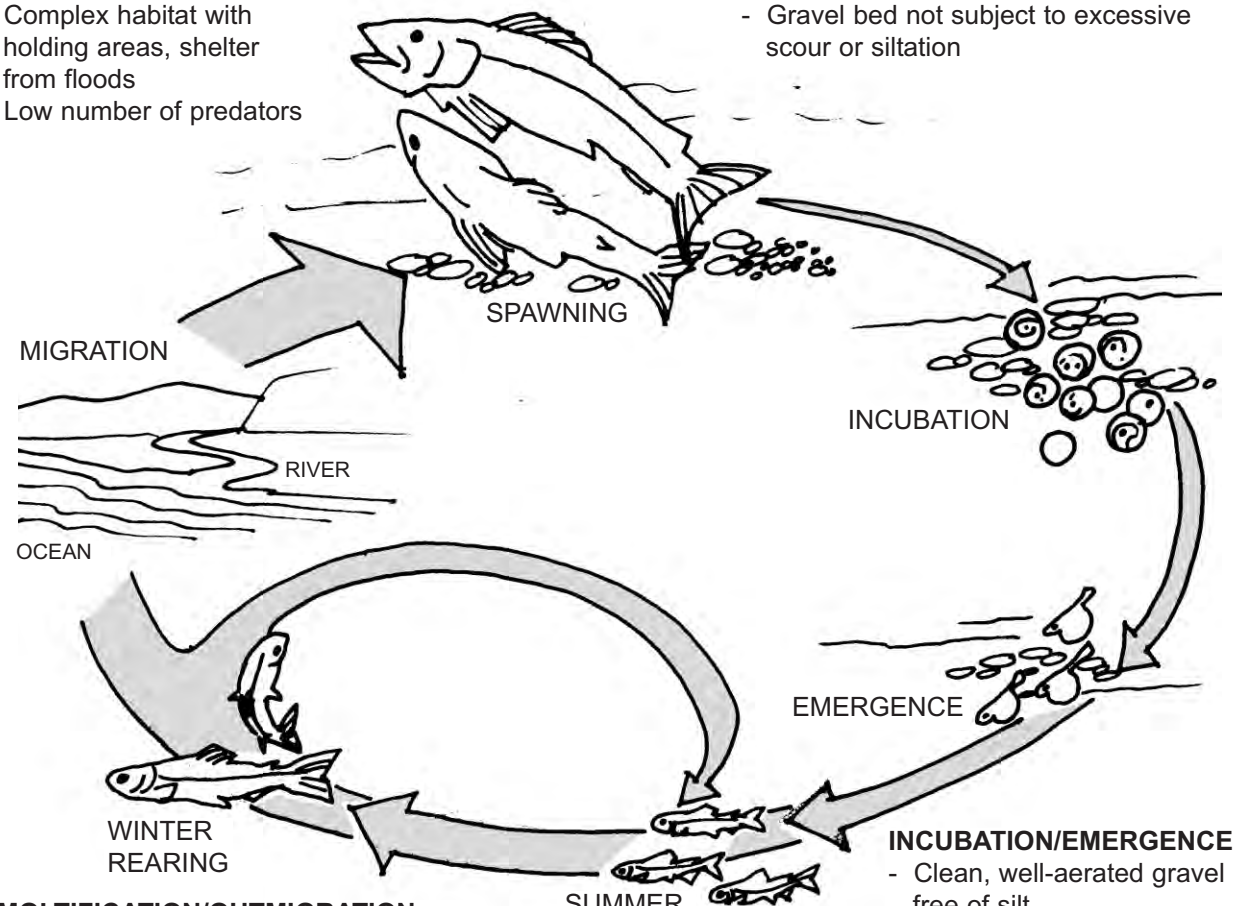
JUVENILE REARING
- Fry school in cover along bank when they emerge
- Fry become parr - larger individuals find and defend their territories
- Parr need cover and feeding areas
- Parr feed on drifting and aquatic insects, and other fish
- Parr remain in the rearing habitat 1 to 2 years

SMOLTIFICATION/ OUTMIGRATION
- Parr undergo physiological change to smolts
- Lack of adequate habitat and overcrowding may induce early transformation and migration out to sea
- Water temperature and season also affect change to smolts
- Smolts may need to hold in estuary while they adapt to salt water

HABITAT REQUIREMENTS FOR COHO SALMON AND STEELHEAD TROUT

ADULT MIGRATION
- Adequate cold water river flows
- Medium flow velocity during migration
- Lack of impassable barriers
- Normal turbidity/high water quality
- Complex habitat with holding areas, shelter from floods
- Low number of predators

SPAWNING
- Clean, medium-sized gravel clean of silt
- Adequate streamflow
- Cold water temperatures
- High water quality/low turbidity
- Channel with complex habitat: pools, riffles, riparian trees, large logs
- Lack of siltation
- Gravel bed not subject to excessive scour or siltation



INCUBATION/EMERGENCE
- Clean, well-aerated gravel free of silt
- Cold water flows high in dissolved oxygen
- Lack of excessive channel scour and siltation
- Channel with complex habitat: pools, riffles, riparian trees, large logs
- Low predator populations

JUVENILE REARING
- Adequate summer cold water flows
- Food production areas
- Channel with complex habitat: pools, riffles, riparian trees, large logs
- Adequate territories for feeding and refuge
- Lack of siltation/high water quality
- Low predator numbers
- Channels without excessive scour or siltation
- Complex habitat for flood refuge areas

SMOLTIFICATION/OUTMIGRATION
- Low number of predators
- Cold water temperatures
- Cover and complex habitat along river channel
- Lack of barriers in channel
- Adequate flow

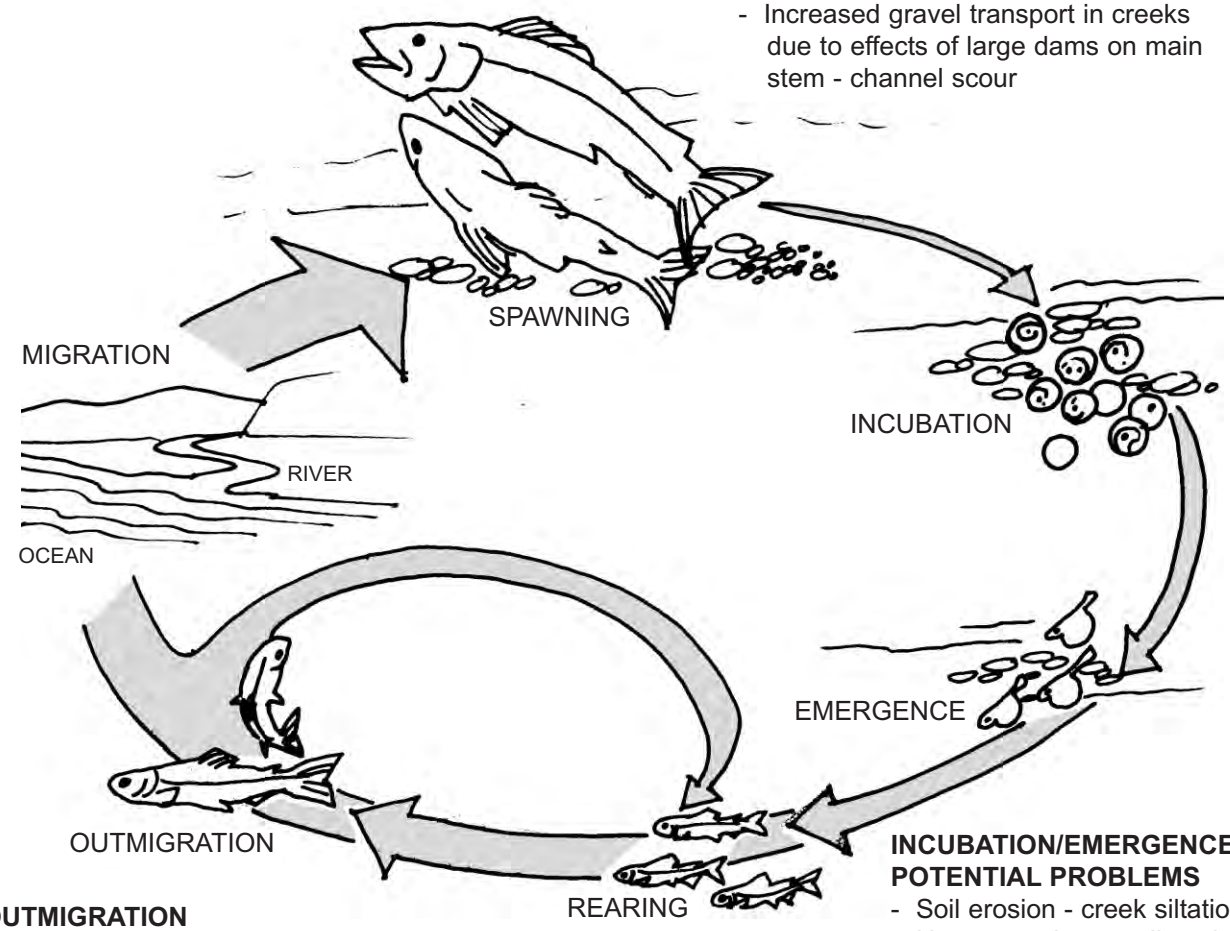
FACTORS AFFECTING COHO SALMON AND STEELHEAD TROUT HABITAT

ADULT MIGRATION - POTENTIAL PROBLEMS

- Reservoir releases - false flows
- High turbidity
- Barriers - road culverts and crossings, temporary dams, high velocity channels
- Channelization of creeks
- Water diversions
- Loss of complex habitat in creek and river

SPAWNING POTENTIAL PROBLEMS

- Soil erosion - siltation of creek
- Loss of channel form - channelization, removal of gravel, riparian forest and large wood
- Lack of gravel due to mining, channel incision, reservoirs and watershed changes
- Increased peak storm runoff due to roads, urbanization and land clearing causing channel scour
- Increased gravel transport in creeks due to effects of large dams on main stem - channel scour



OUTMIGRATION POTENTIAL PROBLEMS:

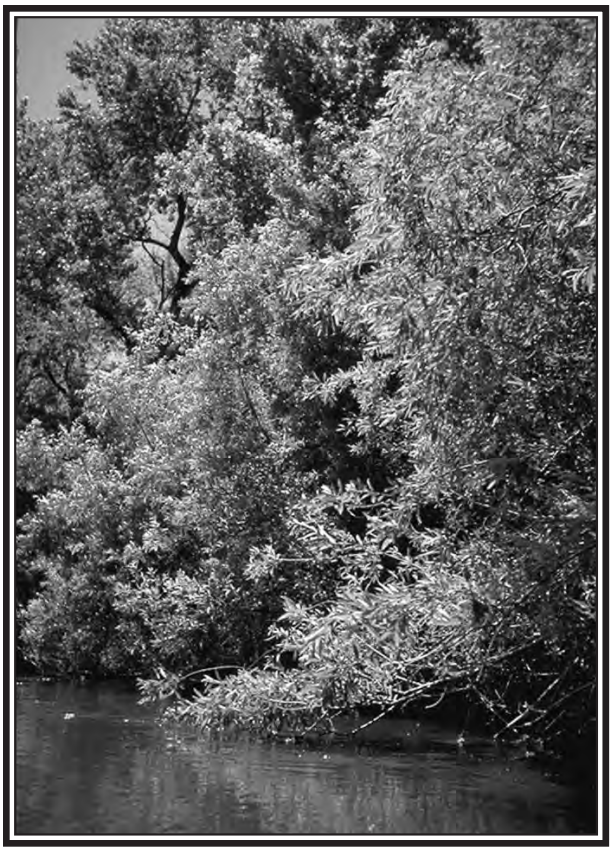
- Warm water reservoir releases cause increased numbers of predator fish
- Water diversions
- Loss of channel form and habitat
- Barriers - temporary dams
- Connection of gravel pits to river - increased predator fish, loss of guiding river current
- Excessive water temperatures

JUVENILE REARING POTENTIAL PROBLEMS

- Excessive surface water/groundwater pumping, no screens on diversions
- Loss of channel form - channelization, removal of riparian forest, large wood
- Soil erosion - siltation of creek
- Warm water releases from reservoirs
- Excessive channel scour or fill
- Urban runoff, leaking septic systems - poor water quality
- Excessive water temperatures

INCUBATION/EMERGENCE POTENTIAL PROBLEMS

- Soil erosion - creek siltation
- Unscreened water diversions
- Loss of channel form - removal of riparian forest, large wood, gravel
- Urban and agricultural runoff, leaking septic systems - poor water quality
- High velocity flows - urban areas and roads - channel scour
- Reservoir releases - channel scour
- Channelization of streams - loss of habitat
- Excessive water temperatures



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RIPARIAN CORRIDORS PROVIDE SHADE TO STREAMS AND INSECTS FOR FISH AS WELL AS A FILTER FOR THE VINEYARD FROM FLOOD DEBRIS.

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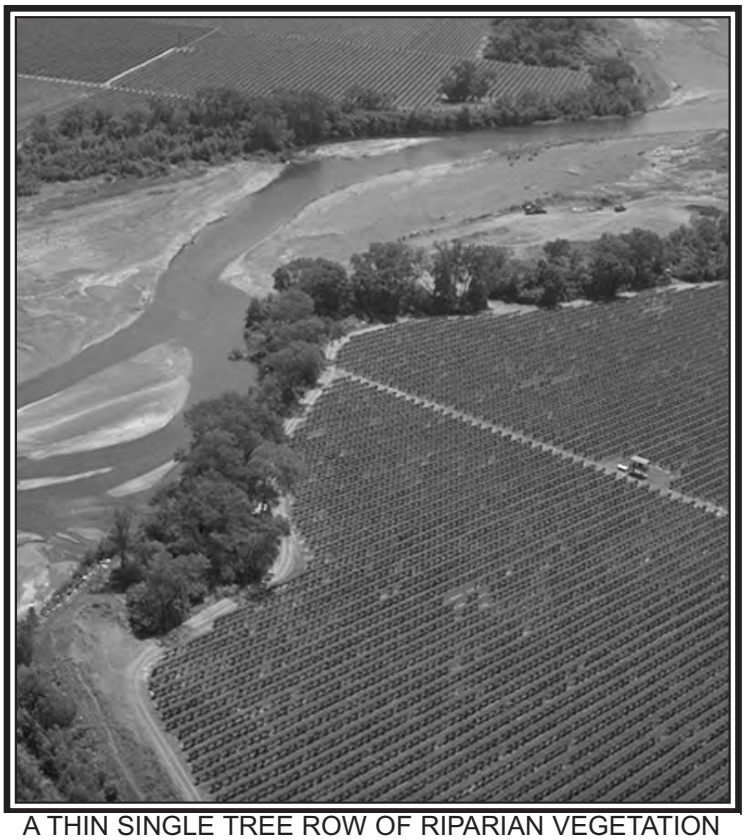

A THIN SINGLE TREE ROW OF RIPARIAN VEGETATION PROVIDES LITTLE SHADE TO THE WATER OR PROTECTION TO THE BANK OR VINEYARD

RIPARIAN VEGETATION PROVIDES THE ONLY SHADE FOR MANY AREAS OF THE CREEK OR RIVER CHANNEL

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Allowing natural processes to occur is the easiest and cheapest way to manage the system over the long-term.

In natural alluvial streams, riparian forest grows adjacent to the active channel on the floodplain. The floodplain is next to the channel usually not more than a few feet higher than the active channel edge. This floodplain is frequently inundated in the winter. The spatial relationship between the channel and its floodplain is a very important part of restoration design. Incised, or entrenched, channels may require a change in form to re-create this relationship in order to support and sustain riparian plants and reduce erosion. Riparian plant species grow at particular distances from the active channel and the specific requirements of the plant species must be incorporated into each restoration design.

An important step in creek management is to evaluate and gain an understanding of the entire creek. The entire corridor should be evaluated along with the watershed, not each individual bank blowout. Simplifying the creek in order to control just one feature is likely to fail. Misdiagnosing the problem will lead to mis-management. For these reasons, our program focuses on letting the creek corridor function with as little intrusion as possible and letting the farmer operate with as little impact from the creek or river as possible. Developing a workable strategy to accomplish this balance requires observing the system and measuring its features. The first step is to complete an assessment.

INVENTORY: STREAM/RIVER CORRIDOR

This inventory requires measurement of a number of features of your stream corridor to document its current condition and review of the watershed. These features include: the shape of the channel, its width and depth and features of the drainage-erosion in the watershed, urbanization, gravel mining, dams and other conditions. Land use and corridor management on the farm as well as the management of adjacent lands also affect the condition of the corridor. Assessing many features of the corridor provides a variety of clues as to what is affecting the corridor and how it is changing.

The FFF program staff will assist with these measurements and complete the inventory. Take photographs of the sites you measure and number and mark each on your map or aerial. The measurements can be repeated at the same location to document how the creek is changing and establish a record about the creek's condition. These measurements and photographs can protect the owner should a regulatory situation ever arise.

These features are then used by the FFF program staff and other restoration specialists involved with the program, in conjunction with the farmer, to devise an appropriate and successful restoration project. There are numerous regulations that affect what actions can be taken in creeks and limit management and restoration options and must also be included.

Once completed, the inventory will include:

- A delineation of the entire stream network on the property including the swales, ephemeral streams, intermittent streams, and year-round creeks (completed in Element III).

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- A determination of the types of creeks on the property – alluvial, partly alluvial/partly confined, or confined by hard rock

- An assessment of the condition of the active, or scour, channel - including bars, pools and riffles, large wood, summer water flows, flood levels, and bank erosion areas

- An analysis and measurements of the channel form - high steep banks, low banks, narrow or wide channel, a trend of deepening or widening in the channel.

- Measurements of the riparian corridor width and the proximity of the vineyard.

- An assessment of vegetation types and sizes in the corridor as well as the extent of non-native invasive species including Pierce's disease host plants.

- Observations of fish and wildlife

- Identification of upstream and downstream areas of erosion, locations of reservoirs, roads, and other features which may affect the creek

- An inventory of the current management regime.

- Measurement of proximity to the main river channel

- Evaluation of main river channel conditions

1. STREAM SYSTEM

- ❑ Delineate the entire system of streams on the entire property. Check Element II – New Vineyard Design, and Element III – Managing the Vineyard, as you may have already done this. Use a copy of your topo map and aerial photo. The following features should be included:

  - ❑ Year-round or perennial creeks - typically a solid blue line on the topo map

  - ❑ River frontage – portions of the property which are adjacent to the main stem of the river

  - ❑ Seasonal or intermittent creeks – typically a dashed blue-line on the topo map

  - ❑ Ephemeral creeks/swales – these have been identified for the vineyard Elements II and III, but there maybe others on the property that should also be outlined. Detailed directions on how to identify these are in Element III.

  - ❑ Vineyard drainage system – use the map or aerial from Element II or III

  - ❑ Reservoirs – on-site and upstream (within five miles) of the stream corridor

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The focus of this section, Element VI, is on year-round and seasonal or blue-line creeks. However since these creeks are highly affected by ephemeral creeks, reservoirs and drainage systems, the entire system needs to be included.

- ❑ For each stream, use the name from the topo map, or if the creek has no name give it one, or give it a number. Use the same names, or numbers, for all the streams that you used in Elements II and III.

- ❑ Measure the length of each creek and fill in the summary table in Section 15.

- ❑ Photograph the corridor along its edge with the vineyard and from all crossings and bridges, from roads above canyons and other views both in the summer and the winter. This section should include year round and seasonal creeks and, to a lesser degree, ephemeral creeks as these may be documented in other elements.

2. CREEK TYPES

There are different types of creek channels depending on their location in a watershed and their features. The physical processes of water and sediment movement and channel adjustments occur in all stream channels. However, the expression and effect of these processes has a different outcome in different types of channels. Therefore specific restoration and management strategies are needed for each channel type.

Generally, the defining features of a channel used in this program are the slope, the seasonality of water flow, the material the channel is composed of, and whether the channel is naturally confined by bedrock. In the most upstream areas of a watershed channels are steep and can undergo very rapid movements of sediment, termed debris flows or landslides. These channels, often ephemeral streams, are important to restore and manage and are dealt with under the BMPs for natural drainage channels and soil conservation in Elements II and III. Ephemeral channels are more likely to occur near hillside vineyards and grazing lands and, although they carry water and sediment in storms, they generally do not have fish habitat. However the condition of these ephemeral streams can have a large effect on downstream areas with fish habitat.

The types of channels more likely to be found in the farm setting are:

Alluvial, unconfined channels with seasonal or year-round flow: Alluvial channels are made up of unconsolidated material such as gravel and sand which the stream or river can easily move. Alluvial channels have creeks with banks made up primarily of gravel, silt, clay, and sometimes cobble. Alluvial channels typically occur in flat, or low slope valleys, and are not directly confined by the walls of the valley.

Alluvial streams typically meander and have a gravel bed with bars, pools, and riffles. These streams have an adjacent floodplain and riparian forest. During floods water will flow out of the alluvial, unconfined channel onto the floodplain. On the floodplain, the floodwater slows in velocity and may deposit fine sediment. There is usually a shallow groundwater basin below and to the sides of the channel and, while the flow may be very low in the summer, there can be isolated groundwater-fed pools where the fish may rear over the summer. The riffles and bars may provide spawning habitat.

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Alluvial fan: Another type of alluvial channel found in part of Sonoma and Mendocino Counties is an alluvial fan. A fan forms where a relatively steep canyon discharges onto a valley floor and the creek deposits a fan of cobble, boulders, sand and gravel. Alluvial fans are higher slope at 1-4% than most valley channels. Alluvial fans are most common in tectonically active mountains where the rate of uplift of the mountains is great.

Alluvial fans differ significantly from low slope (<1-1%) meandering channels. The fan has multiple channels which change radically in flood events. The main channel may fill in with bedload during a flood and a new channel form in another location. Alluvial fans may not support riparian vegetation exclusively as valley streams do. Because of their higher slope and more porous features plants such as live oak, Ca. bay laurel, Ca. buckeye, grey pine and others are distributed over the fan not just along channels. Willow, alder and box elder are riparian species also found along the channels.

Restoration and management measures for alluvial fans must take into account the substantial differences between these higher slope, multi-channeled systems and the more familiar meandering single channel valley streams.

Partially confined, alluvial channels with seasonal or year-round flow: Creeks may also flow through a wide area or flat valley where bedrock or rocky slopes or banks may be prominent. These channels have a floodplain in many areas with riparian forest. The channel may meander and have gravel bars and pools in sections with an alluvial bank on one side of the channel and a rocky bank on the other. These types of streams often occur in valleys and flat areas in mountains and along the mountainous edge of floodplain valleys. There may be a groundwater basin under and to the side of the channel that provides summer water for fish rearing. Bars, riffles and gravel deposits can provide spawning habitat.

Confined bedrock channels with seasonal or year-round flow: Confined or bedrock-controlled channels are another type of channel found in most watersheds. The creek channel is dominated by bedrock or confined within a gorge, or canyon, with little or no floodplain. The bedrock keeps the channel from meandering. Confined channels can be much higher in slope than unconfined channels. Floodwaters tend to move at a high velocity and be deep in the confined channel. Confined channels change due to watershed conditions often with different results than alluvial channels.

You may have a creek that comes out of a canyon or gorge and into a valley. Typically the valley section is the unconfined alluvial part of the creek and the canyon section is the confined section of the creek.

Further evaluating channel confinement

If after reading the above descriptions you are still not sure about what type of creek you have, try this approach:

The depth of the water in a stream determines the weight of the water on the streambed. For a given slope, deeper water can move a greater amount of heavy material, such as rocks and cobbles, than shallow water. The volume of flowing water (discharge), the slope

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of the channel and the width and roughness of the channel control the depth of the water. Generally, a narrow channel can transport more sediment than a wide channel. Most of the sediment is transported during flood events. Thus, for a given channel segment, the width of the channel during flood events determines the water depth. During a flood a river that flows through a wide flat area will overflow its banks and spread out over its floodplain. During this flood the water depth in the main channel of the river will be limited to slightly greater than the scour channel or bankfull (the 2-year flood) depth. In contrast, during a large flood a river that flows through a steep walled canyon has no area for the water to spread out and the water becomes very deep. Thus, rivers in wide valleys differ from rivers in narrow valleys in the depth and power of flood flows.

Another term for this difference is channel confinement. The river is confined by the narrow valley and unconfined by the wide valley. Confinement measures the ability of floodwaters to spill over the banks of the stream.

Channel confinement is defined as the ratio of valley width (VW) to channel width (CW).

Table VIA
Definition of Channel Confinement

Confinement Class	Definition
Confined	VW < 2CW
Moderately Confined	2CW < VW < 4CW
Unconfined	VW > 4CW

VW = valley width; CW = channel width

Using the three classes of confinement, a stream is confined if the valley width, including the channel, is less than 2 bankfull channel widths. It is moderately confined if the valley width is 2 to 4 bankfull channel widths. And it is unconfined if the valley width is greater than 4 bankfull channel widths.

Here is a simplified method to determine confinement from a topographic map:

- On each side of the stream there is a contour line that is roughly parallel to the stream. These contour lines are actually the same line and so have the same elevation.

- Follow one of the lines upstream, it will eventually cross the stream.

- On a standard 7.5-minute topographic map with a 40 foot contour interval, measure the distance between the contour lines on each side of the creek. Note that the scale of a 7.5-minute quad map is 1:24,000, or one inch equals 2,000 feet. If the distance, is 1/8 inch or less we will consider the stream to be confined. If the distance is between 1/8 inch and 1/4 inch we will consider the stream partially confined. If the distance is greater than 1/4 inch we will say the stream is unconfined.

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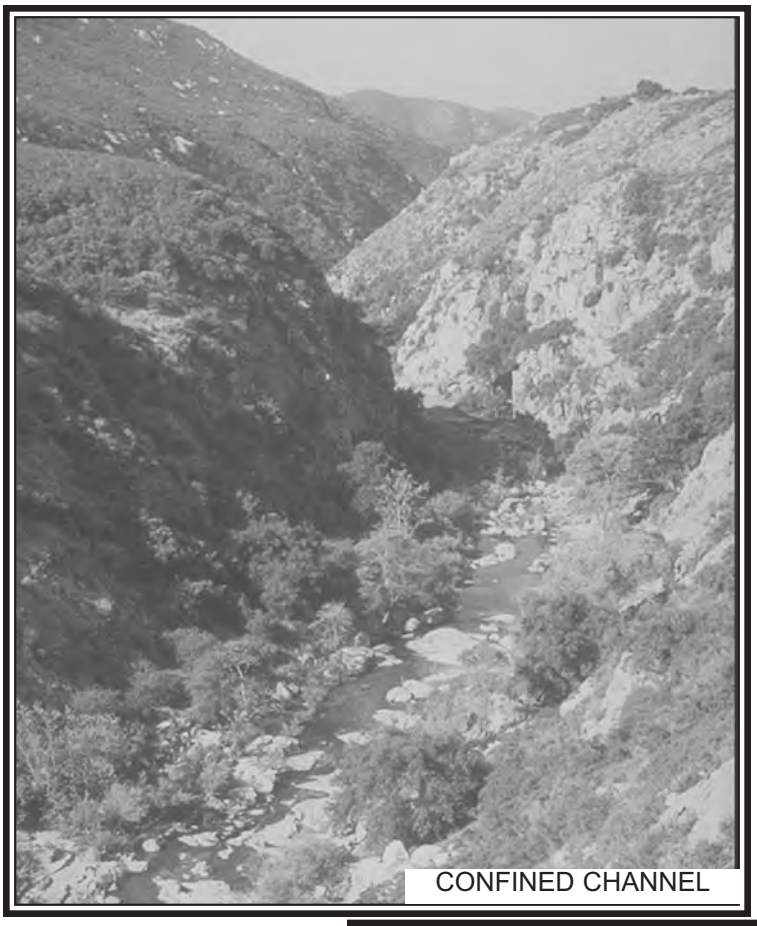
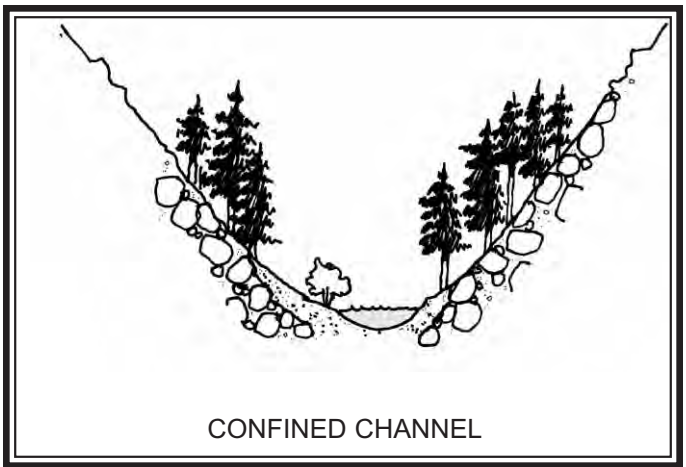
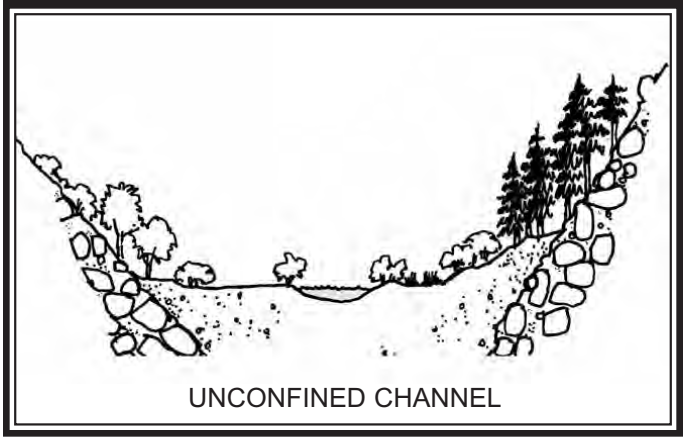


CONFINED CHANNEL



CONFINED CHANNEL



UNCONFINED CHANNEL

UNCONFINED CHANNEL

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ALLUVIAL UNCONFINED CHANNEL AND CONFINED BEDROCK CHANNEL

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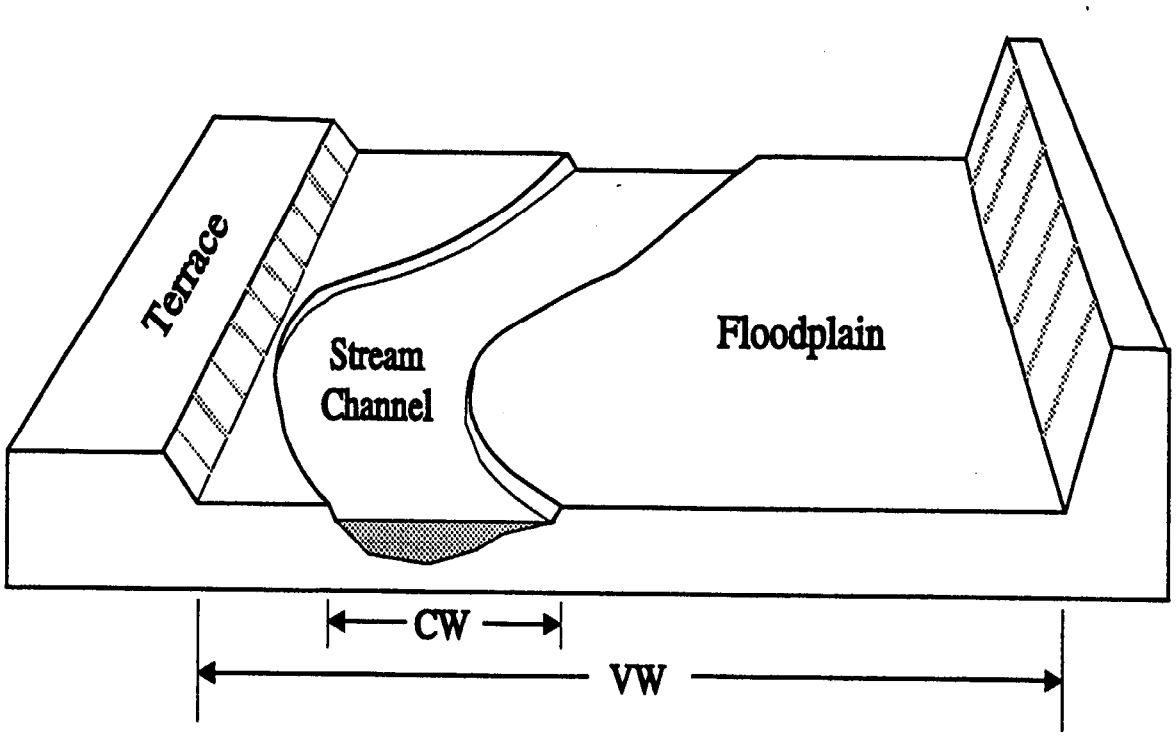
Table VIB
Definition of Confinement as measured on a 7.5-minute topographic map with a 40 ft. contour interval

Distance between contour lines Map Scale 1"=2,000'	Confinement Class
1/8" or less	Confined
1/8" to 1/4"	Moderately Confined
Greater than 1/4"	Unconfined

In mountainous regions, most stream segments will be confined. Occasionally there may be short segments of unconfined or moderately confined channel. Unconfined stream segments may be expected along larger streams and in valley areas.

- ❑ Using your review of the creek channel features, determine what type of creek you have and complete sections A or B of the Farm Conservation Plan, or both. The FFF program staff will assist you with all of the evaluations.



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ALLUVIAL AND PARTIALLY CONFINED CHANNELS: ASSESSMENT OF STREAM CORRIDOR CONDITION

For each alluvial and partially alluvial stream you will need to do a series of measurements. If you only have confined channels on your property, leave Section A blank and complete Section B.

The FFF program staff, in conjunction with the farmer, complete the creek assessment. Additional specialists may also assist with the restoration designs, if needed. Measurements are done at 500-1000 foot intervals along the stream channel (or closer if you have a shorter corridor with great variability).

A3. WIDTH OF THE ACTIVE OR SCOUR CHANNEL

The active or scour channel is the area of the creek that is usually unvegetated. There may be gravel bars, pools and riffles in this area. This measurement involves several measurements of the scour area from one edge where there is an obvious break in the elevation and a clear difference in the channel edge.

On the Farm Conservation Plan template, record these measurements:

- ❑ Using a tape measure, measure the width of the active, or scour, channel at the locations you've marked. This is the area that typically has a gravel bed and usually has gravel bars, pools and riffles. There may be some vegetation as well but it is usually sparse. The scour channel will probably be larger than the low flow or summer flow channel. Record all the measurements on the table and then take the average.

A4. WIDTH OF THE RIPARIAN CORRIDOR

The area of land next to the scour, or active, channel of the creek or river is termed the floodplain and under natural conditions supports riparian forest. The floodplain is usually at a slightly higher elevation than the scour channel and a variety of plants extend from the outer edge of the active channel onto the floodplain. The floodplain area nearest the channel may be flooded several times a year whereas the area farther away may be flooded only once in a decade. This measurement is of the corridor of vegetation that currently exists along the creek and may be made up of all sorts of plants. In some areas there may not be a corridor and this condition should also be noted.

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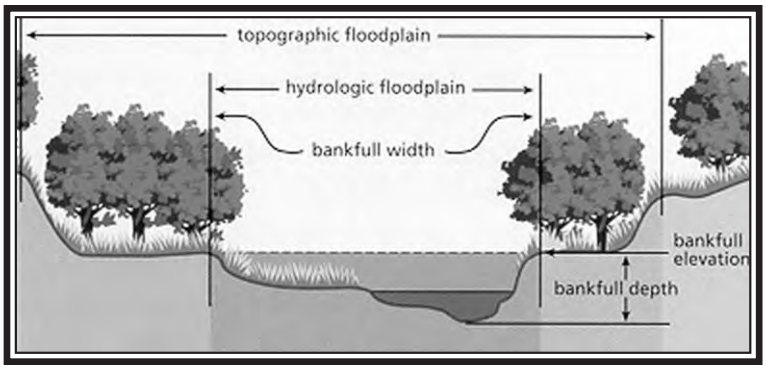

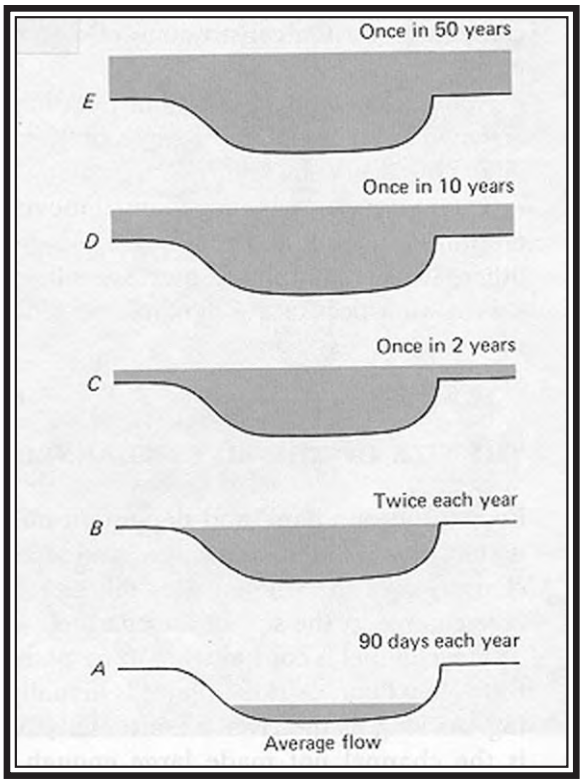

LARGE FLOODS ARE INFREQUENT AND, OVER THE LONG TERM, HAVE LESS EFFECT ON THE SIZE AND FORM OF THE STREAM CHANNEL THAN SMALLER, MORE FREQUENT FLOODS. LONG TERM STUDIES HAVE SHOWN THAT THE 1.5 - 2 YEAR FLOOD, ALSO CALLED THE DOMINANT DISCHARGE, CREATES THE SIZE AND SHAPE OF NATURAL ALLUVIAL STREAM CHANNELS. THIS SIZE FLOOD MOVES THE GRAVEL BED OF THE STREAM AND JUST BARELY FLOODS OUT OF THE CHANNEL ONTO THE FLOODPLAIN. THE 2-YEAR FLOOD CHANNEL IS CALLED THE BANKFULL CHANNEL AND IS SHOWN ON THE DRAWINGS AND PHOTO

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On the Farm Conservation plan template fill in the measurements:

- ❑ On a copy of the aerial outline the outer edge of the riparian corridor for each alluvial creek. Mark both edges even if there are different owners on the other bank. If you are on the main stem of the river also mark the outer corridor edge on both banks of the river.

- ❑ Measure the entire width of the corridor from the outer edge to the other outer edge including the scour channel. Use the same measurement locations as for the scour channel. For the main river channel, you can measure this distance from a recent aerial photo.

- ❑ Record all the measurements on the table in the Farm Conservation Plan template.

A5. CHANNEL/CORRIDOR/VINEYARD

Typically the vineyard will be located on the floodplain or a terrace near to the creek. The vineyard may be located very close to the scour channel, or there may be a riparian corridor separating the scour channel from the edge of the vineyard. If the vineyard is next to the scour channel, any change in the channel is likely to cause erosion, or failure of a portion of the vineyard.

On the Farm Conservation Plan template fill in the measurements:

- ❑ Measure the distance from the edge of the scour channel to the first row of vines in the vineyard at the same locations used for the other measurements. If this varies on each side of the creek record it for both the right and the left banks. Right and left banks are determined by facing downstream.

- ❑ Measure the distance from the edge of the riparian corridor to the first row of vines. Depending on the site, this may be the same as measuring from the scour channel edge or it may be very different. If this varies on each side of the creek record it for both the right and left banks.

- ❑ Record all the measurements on the table.

A6. BANK HEIGHTS/CONDITION

Besides the width of the active channel, the depth of the channel is also very important. The bank height is an indicator of whether the stream channel is entrenched, or incised. This condition means that the bottom, or bed, of the channel has dropped in elevation and the channel has incised into the floodplain and has steep and potentially unstable banks. Restoration techniques for creeks with this condition are different than for channels that are not entrenched. The entrenched channel may have no area for flood flows to spread out. The floodwater is contained entirely in the channel with all the velocity and power of the floodwater being directed into the bed and banks often resulting in frequent and large bank failures.

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On the Farm Conservation Plan template, fill in the measurements:

- ❑ It can be difficult and sometimes dangerous to measure channel depths during winter. During the dry season measure with a tape, yardstick or graduated rod from the top of the bank to the lowest point in the channel (usually a pool). You should make many measurements of tall banks, moderate, and shorter banks and include the locations where channel and corridor width was measured. Always measure the deepest point to the top of bank above that deep point, not anywhere else.

- ❑ Mark all the measurements on the table in the template. While you are measuring the banks, note if the banks are generally real steep (1:1), moderate (2:1), or gentle (3:1 or flatter) and if it is vegetated, or unvegetated. Also note what the bank is made up of: loose gravel and sand, silt/loam, compacted clay, or large boulders with silt, gravel, and sands.

A7. VEGETATION

The type and extent of vegetation along the outer and inner edges of the corridor is an indicator of the health and sustainability of the stream corridor. It is also an indicator of the need to eradicate invasive non-native plants. Each plant species grows a different distance from the scour channel due to different tolerances for inundation and mechanical damage from floods. Each plant species has a particular strategy to set seed, spread vegetatively or compete with other species. Generally for this measurement, the primary features to evaluate are the type and size of the trees, amount of undergrowth and presence and extent of invasive non-native plants.

On the Farm Conservation Plan template, fill in the measurements:

- ❑ Walk the outer corridor edge and look at the vegetation. Walk the scour channel and look at the vegetation. Fill out the template regarding:

  - ❑ The type and size of the trees and density of vegetation on the outer edge of the corridor

  - ❑ The type and size of the trees and vegetation along the edge of the scour channel

  - ❑ The occurrence and extent of invasive non-native plants.

- ❑ There are several good field guides for riparian plants: A Guide to Restoring Native Riparian Habitat in the Russian River Watershed is available from Circuit Rider Productions (707-838-6641) and Common Riparian Plants of California by Phyllis Faber is available from the California Native Plant Society at www.cnps.org.

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RIPARIAN FOREST CONSISTS OF MANY SIZE AND SPECIES OF TREES. MATURE FOREST IS DENSE AND VARIED SUPPORTING NUMEROUS SPECIES OF WILDLIFE. MATURE TREES ALONG THE CHANNEL EDGE ARE UNDERCUT AND BECOME LARGE WOOD IN THE CHANNEL FOR FISH HABITAT

LARGE TREES BECOME WOOD IN THE CHANNEL AND HABITAT FOR FISH

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A8. CREEK CHANNEL FEATURES

The features of the creek channel will vary over time and for every different stream. This basic evaluation sets a baseline of information about your stream channel to use as indicators of the condition of the stream and to use to compare with later evaluations. Generally the scour channel is the dynamic changing part of the creek or river. The movement of flood water and sediment through the channel creates and modifies such features as pools, riffles, gravel bars, banks, and the overall width and depth of the channel, as well as the size of its meanders.

On the farm plan template fill in the features you observe for the creek channel:

- ❑ If the creek is highly variable, then make notes next to the different conditions listed and how often or where each applies.

- ❑ An important aspect of fish habitat is the presence of large logs and wood in the stream channel. As you walk the stream, record the presence of large wood.

- ❑ If possible take a graduated rod or other measuring device and measure the depth of several of the pools. Record the dates of the measurement and whether it was a wet or dry year.

- ❑ For the water flows in the summer, ask your neighbors if you have only recently purchased the site. Otherwise record your observations and be as accurate as possible.

- ❑ For the evaluation of the stream bottom the focus is on bar and riffle areas rather than the pool bottom. It is sometimes useful to pick up a few handfuls of material on each bar and really look at the amounts of gravel, sand, and silt. The gravel on the bars, or riffles, must have large rocks with large air spaces dominating the surface of the bar. If there are some large rocks, but there is a lot of silt and sand around each rock, then indicate this condition on the template. Write down any details you observe.

A9. FISH AND WILDLIFE

Landowners/managers often observe wildlife and this is your chance to record the animals you see. There is also a section on the template to record your observations of small fish in the stream.

Fill in the template about the fish and wildlife you observe:

- ❑ It is difficult to determine if you are seeing trout or salmon fry or other small fish unless you use behavior as an indicator. The juvenile trout and salmon will dart very quickly into a protected area, such as next to the bank or under a submerged log, at the first sound of a person approaching the creek. There are other small fish, but these are not as quick to hide as the trout. This behavioral difference can be used to confirm the type of fish you are seeing.

- ❑ Record the other animals you see on the template.

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A10. FLOOD AREAS

The overflow of floodwater onto the floodplain is a natural event that slows down flood flows. Some portion of the vineyard, near a stream, or river, may be flooded either on a regular basis or only occasionally when a large flood comes. If a channel is highly incised, floodwater may be carried entirely in the channel with no overbank flow.

On the Farm Conservation Plan template, fill in the information:

- ❑ On the aerial mark the areas where flooding occurs most often along each creek. Also mark the areas that flood only in real big storms. Indicate any road area that regularly floods.

- ❑ If you are along an area of a creek corridor below a large municipal reservoir, record your observations regarding the effects of the reservoir on the stream, or river, corridor.

A11. STREAM CROSSINGS

Roads are addressed in Element V. However, a road crossing a stream can have an impact on the stream corridor that needs to be considered in the restoration and management of the corridor. The road crossing may need to be modified or rebuilt.

On the Farm Conservation Plan template, fill in the information:

- ❑ Mark all permanent and temporary road-crossing locations on the aerial.

- ❑ List the type of crossing and its season of use. This same information should be completed for Element V and the improvements to the crossing that may be needed are addressed in that element.

- ❑ List any public roads that cross the stream within one-half mile of your site.

A12. CHANGES OVER TIME

If you have owned, or managed, the property for a period of time - what large changes have you noticed in the stream/river corridor? There are often not adequate records of how a stream has changed from large floods, fires, reservoir construction, upstream developments and downstream changes.

On the Farm Conservation Plan template:

- ❑ Indicate those changes you have observed and fill in the name/number of the creek.

A13. CHECK YOUR PRACTICES

Often a management practice gets started after a large fire or flood and is only really appropriate for a few years, but is continued long past that time. Continued use of a

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management strategy can change features of the creek, not produce the intended result and be detrimental to the farming operation, as well as fish habitat.

Some examples of management practices and their potential effects:

Annual clearing involves removal of the vegetation in the channel. This practice increases the speed of the floodwater in the channel, moving water faster to downstream areas. However, faster moving water erodes more sediment from the channel and the creek often eats away at its bed and banks and the channel incises, or downcuts.

Channel incision, also called entrenchment, can produce:

- ❑ Steep unstable banks which eventually collapse as the channel widens.
- ❑ Increased delivery of fine sediment and water quality degradation
- ❑ Back cutting into the streams and drainageways that feed from the vineyard into the incised channel. This back-cutting can erode the vineyard and its installed drainage system.
- ❑ A loss of riparian habitat from bank erosion and loss of in-stream habitat from channel scour. As these changes occur and the channel entrenches further, riparian vegetation cannot re-establish on the steep banks or in the channel with high velocity flows.
- ❑ Entrenched channels undergo a process of adjustment involving further bed erosion, followed by bank slumping and the formation of a new floodplain.

If the vegetation along the channel edges is allowed to grow larger and shade the stream, there will be less brushy vegetation in the floodway. Active replanting of native vegetation can protect banks and reduce erosion.

Channelization involves ditching and straightening of a meandering creek to allow for greater amounts of land to be farmed. Along many alluvial streams this practice will produce additional farmland for a limited time. As the straightened creek carries faster moving water, it undergoes the incision process. As its banks become steeper they are prone to collapse and the channel will widen out again reclaiming the farmland. This process may take several decades. Channelizing the creek, combined with vegetation removal, can create greater rates of incision.

Removal of gravel is done to reduce meandering and bank erosion, and in some instances, for confining floods to the channel. Again, the management activity may achieve these purposes for a period of time, but if the quantities of gravel removed are greater than gravel replenishment, which is very common, the channel is likely to incise. Despite the gravel removal, deposition can still occur in the next flood, making any flood control improvement temporary. Careful measuring, surveying and monitoring every year must be done to avoid over-extraction of gravel. Removal of gravel also disturbs the gravel bar surface and removes the protective "armor" of larger rocks and can leave the under layer more vulnerable to erosion in floods with an increased lowering of the bed. Annual removal of gravel can destabilize the stream and result in more long-term negative effects. Although it may be necessary from time to time to remove gravel if it builds up, this practice should be

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carefully considered and limited. Creating an adequate riparian corridor and reducing upstream erosion can reduce the need for gravel removal.

Levees are built on the floodplain adjacent to the channel to restrict floodwater from inundating the floodplain. The levees are usually several to many feet higher than the floodplain. For a period of years, this practice will reduce many floods from inundating the floodplain; however, once the floodflows are confined in the channel, they have greater velocity and will erode the bed and banks, causing incision. Over time, as the channel deepens, the banks grow tall and collapse and the levees may eventually be undercut.

Bank stabilization with various materials involves using rock, old cement and other hard materials to cover the bank to reduce erosion at one point along the channel. Generally, the bank needs to be laid back to a stable slope. Often rock and vegetative methods are combined. In many sites, this practice is done because the river or creek is meandering in response to previous management actions or other watershed changes. Riprap armoring of banks often results in erosion of the opposite bank or downstream areas of the channel because the riprap increases water velocity. Riprap used in an incised channel can be undercut and become ineffective over time. If many areas of the channel consistently undergo bank erosion, the stream corridor needs a different management approach.

On the Farm Conservation Plan template, check all of the practices you use currently or have used in the past, and list the creek name or number.

- ❑ Indicate if the practice is used over small areas of the creek as a problem site application or if it is applied to the entire stream corridor. Indicate if you have recently made changes to your management practices.

- ❑ If you have recently purchased or begun management of a site, list the previous owner's practices to gain a better understanding of the causes of the corridor condition.

- ❑ For the bank erosion section, determine where and how often bank erosion occurs for each stream and fill in the template. If there are one or two problem areas, indicate these on your map or aerial and list them on the template. If there is a persistent problem over one or more creeks, also indicate this condition.

A14. UPSTREAM/DOWNSTREAM CONDITIONS

Watershed Conditions

Creeks function within the context of their watersheds. Most property boundaries have little to do with watershed boundaries and few landowners control an entire drainage. Although the focus of the farm conservation plan is to manage and restore creeks on the individual farmer's property, this requires taking watershed conditions into account. Use the inventory of ephemeral creeks done for Elements II and III to identify upstream erosion sites on the property.

The reason for looking at watershed features is that land uses can change the sediment supply and/or the amount and timing of floodwater in the creek. The creek on your property will adjust to changes in these variables. Knowing some of the reasons for the sudden

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changes in the creek will help in determining an effective repair and restoration strategy. A change in the watershed may take many years to reach your part of the creek and it is sometimes difficult to connect the cause with the effect. For example, the failure of a road, or a landslide, may send a slug of sediment into the system. Several years later this slug reaches your section of the creek causing the banks to erode as the channel widens to accommodate the increased load. However, in other cases, a new reservoir may retain sediment and your creek may incise due to a drop in sediment supply. A new urban area may drastically increase the volume of stormwater and again the creek may incise rapidly.

Russian River

In the main stem of the Russian River another major cause of change in the creek system comes from change in the river channel. The large dams and the gravel mining of the channel in many areas have caused the bed of the river to drop or incise up to 20 feet. This incision works its way back up the alluvial tributaries until hard rock stops the back-cutting. The area downstream of the hard rock continues to incise and deepen.

Channel incision may also create barriers to fish migration by lowering the elevation of the channel below hard rock areas, culverted crossings and other types of features fixed in the channel.

Reservoirs are one cause of channel incision in the Russian River. Reservoirs interrupt sediment supply to the stream below the dam and cause incision, as well as other changes. There are 2 large reservoirs with storage capacity - Lake Mendocino and Lake Sonoma. There are also numerous small reservoirs in the Russian River watershed.

Channel and floodplain alterations have also contributed to incision in the main Russian River channel. In the 1960s, the river channel, mined for gravel in many locations, and leveed in some locations. As part of agricultural and urban development, floodplain wetlands were filled and side channels eliminated. The banks of the river channel in various locations were lined with riprap, gabions, concrete, and other hard materials for stabilization. Levees are constructed in many locations.

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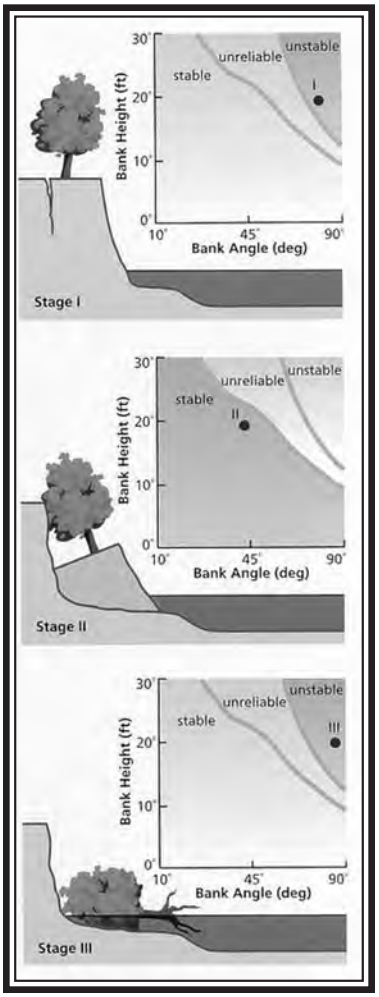
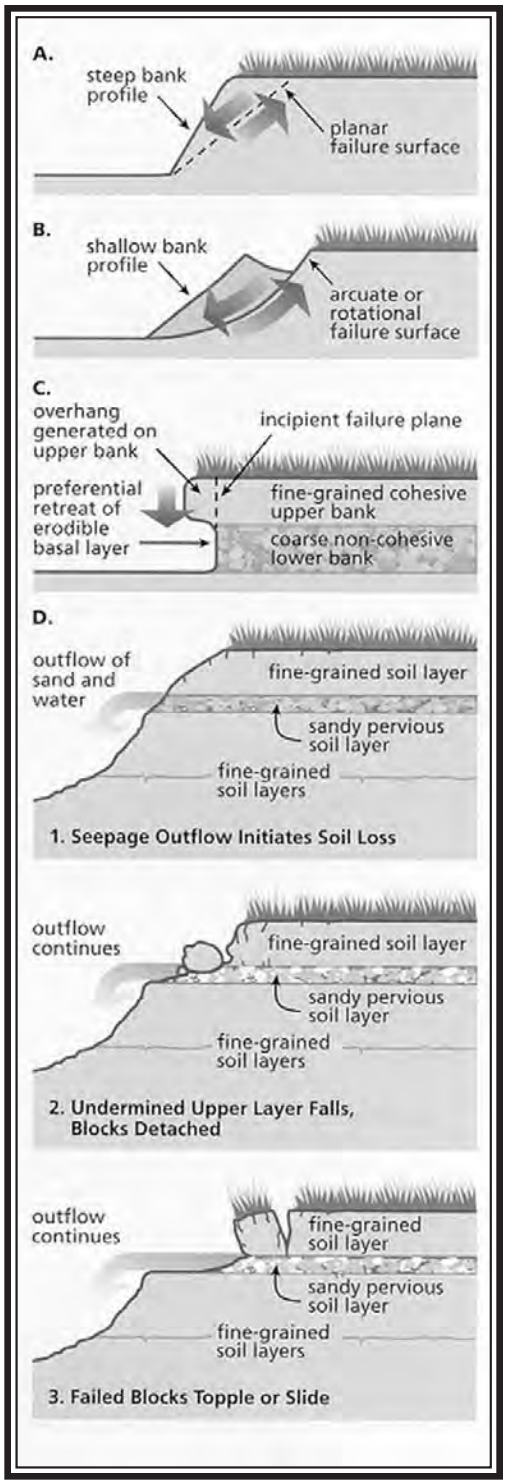
THIS ALLUVIAL BANK IS EXPOSED TO EROSION DURING THE NEXT FLOOD. REVEGETATION WITH NATIVE PLANTS WOULD PROTECT IT.





Fish Friendly Farming Environmental Certification Program	PROCESSES OF BANK EROSION

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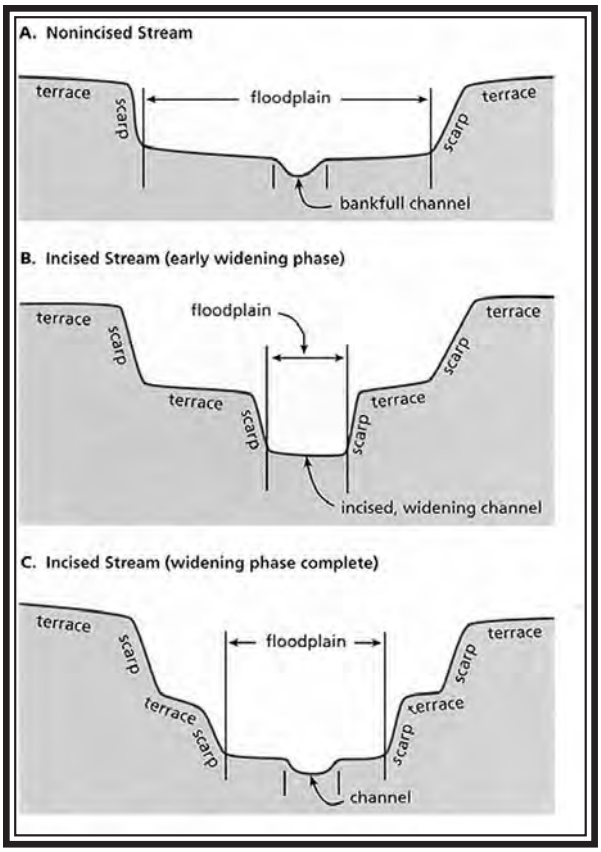

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CHANNEL INCISION CAN CAUSE INCREASES IN BANK EROSION WITH LOSSES OF VINEYARD AND RIPARIAN FOREST

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On the Farm Conservation Plan template, indicate:

- ❑ Use the topo map to locate both small and large farm ponds and reservoirs upstream of the creek(s) on your site. For each creek list the number and size of the reservoirs. The reservoirs do not need to be on the main stem of the creek to affect your stream. Indicate all the reservoirs and estimate the distance to your site.

- ❑ Indicate any areas where land uses have recently changed including hillside vineyards, timber harvesting, or major roads and list the name or number of the creek.

- ❑ For each creek, indicate any urban areas upstream.

- ❑ Indicate any large landslides upstream of each creek.

- ❑ Indicate any known barriers to salmonid migration within your creek segment upstream, or downstream of it.

- ❑ Indicate erosion sites or erosion in ephemeral creeks as identified in Elements II and III.

- ❑ If the stream corridor is within one mile of the confluence with the main Russian River channel, the conditions of the river channel are likely to affect your creek. List the creek name or number.

A15. SUMMARY

The measurements and features evaluated in Sections 1 –14 should be summarized on the two tables in the farm plan template for each year round or seasonal creek.

- ❑ For each creek, list all the measurements and then list the average of the number. Only list the features you checked and observations you've made.

A16. DETERMINING CORRIDOR CONDITION

The assessment and review of current conditions and management practices allows the farmer to determine which of several types of conditions occur. Use these descriptions for all year-round and seasonal creeks. The conditions of the main stem Russian River are listed separately.

On the Farm Conservation Plan template:

- ❑ For each creek, review the summary table of measurements.

- ❑ Review the following detailed descriptions of corridor conditions.

- ❑ Determine which corridor condition best describes your creek/river corridors. Pay particular attention to:

    - ❑ Bank height measurements (A-6)

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- ❑ Proximity of vineyard to the active, or scour channel (A-3- A-5)
- ❑ Current management practices(A-13)
- ❑ Fill in the condition on the summary table in Section 15.

Highly Altered

The following are descriptions of some typical conditions for highly altered corridors. There maybe other situations that also create highly altered creeks.

- Vineyard is within 30 feet of the bank of the scour channel, creek banks are 12 feet high or more and require repair often. There is little to no riparian vegetation. Management activities occur often and may involve vegetation removal, channelization, gravel removal, or other direct manipulation of the channel. If the creek should erode the bank, the vineyard would be directly affected.
- Creek channel is braided and wide, gravel is extracted on a regular basis, there is little riparian vegetation and the vineyard is within 30 feet of the bank.
- Creek is straightened with little to no vegetation and requires frequent clearing of the channel.

Moderately Altered

The following are descriptions of some typical conditions for moderately altered corridors. There maybe other situations that also create moderately altered corridors.

- Vineyard area is 30 feet or so from bank of scour channel. Creek banks are over 12 ft. in height. There is one row of riparian trees; channel is managed every few years.
- Specific areas of the creek channel require constant management. The corridor has some vegetation, but the channel is narrow and has been stabilized with rock, cement or other materials in many spots.
- Creek bed is broad, channel braids, and some areas have riparian vegetation. There has been a rapid widening of the channel. Creek bed is actively managed at least every 5 years.

Occasionally Problematic

The following are descriptions of some typical conditions for occasionally problematic corridors. There maybe other situations that may create occasionally problematic corridors.

- Only large storm events cause bank blowouts. Creek banks are greater than 12 feet in height and vegetated. Recently after a major storm banks began eroding and large trees were undercut and fell into the creek.

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- Large storm events consistently cause problems in one area of the channel. This area is next to the foothills where the creek flattens out onto the valley floor from a steeper hilly section. After big storms, the scour channel braids and widens affecting the vineyard area that is about 30 feet from the scour channel edge.

- Vineyard area is 50 feet from creek channel; banks are over 12 feet in height and there is very little floodplain along the channel. Banks have failed, causing the area between vineyard and creek to get smaller.

Rarely A Problem

The following are descriptions of some typical conditions for corridors that are rarely a problem. There maybe other situations that also create corridors that are rarely a problem.

- Vineyard area is on a terrace away from the creek and creek is not managed.

- Vineyard area is 30 feet or more from the edge of a densely vegetated riparian corridor. Corridor is rarely managed and problems are few. Vineyard is not affected by bank erosion.

- The creek may benefit from removal of exotic invasive plants and some enhancement. Generally there is little the farmer does and the corridor and creek do fine.

Suddenly a Problem

The following are descriptions of some typical conditions for corridors that are suddenly a problem. There maybe other situations that also create corridors that are suddenly a problem.

- The creek corridor changed from rarely a problem to have some major bank erosion during a wet winter. There are some changes in the watershed that might have started this change.

- A large increase or decrease in the width or depth of the scour channel occurs after a major flood.

Alluvial Fan

- The corridor has multiple channels, is located between the mountains and the valley floor, the channel is dominated by cobble, gravel and sand and may have sparse vegetation dominated by larger trees such as live oaks or pines.

Main Stem River

Indicate the area your site is located in:

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- ❑ **Mendocino County Reach** – This river reach is highly affected by reservoir releases from Coyote Dam, channel incision and bank saturation, erosion and collapse. Record your specific observations and measurements for your river frontage.

- ❑ **Alexander Valley Reach, Cloverdale to Geyserville Bridge** - This river reach has some areas with relatively stable conditions and other with bank erosion. Record your specific observations and measurements for your river frontage.

- ❑ **Alexander Valley Reach, Geyserville Bridge to Jimtown Bridge** – This reach has experienced channel incision in some areas. Record your specific observations and measurements for your river frontage.

- ❑ **Middle Reach, Healdsburg to the Wohler Bridge** – This river reach has been highly affected by gravel mining and releases from the Warm Springs Dam. Channel has incised up to 20 ft. and is now undergoing widening with large bank collapse and channel form adjustments. Record your specific observations and measurements for your river frontage.

- ❑ **Lower River, Wohler to Duncan's Mills** – River is in a canyon with small alluvial area subject to bank erosion. Record your specific observations and measurements for your river frontage.
- ❑ M**ainstem Navarro and Gualala Rivers** sites should use the creek condition analysis and evaluation.

A17. DETERMINING NECESSARY CORRIDOR WIDTH

Many stream channels have been altered, narrowed, channelized, or cleared, and no longer reflect the conditions needed for fish habitat. The first step in recovering and restoring the stream is to determine the width needed to undergo natural processes. This section includes a summary of a method developed for the Russian River watershed using extensive analysis of flow gage data and cross-sectional measurements. The method provides a guideline for determining the needed corridor width for a specific creek based on the size of the watershed and the streamflow from a 1.5 - 2.0 year flood event. By using this method rather than some arbitrary number such as 100, 200, 300 feet as the needed width, the actual physical features of the stream are taken into account. Appendix 6 has the detailed data analysis for the method.

A Method to Determine the Minimum Width of the Riparian Corridor

Stream channels are part of a dynamic system. Over a period of time, stream channels adjust their shape so that they can carry the water, sediment and debris supplied by the watershed. Bank collapse is a normal part of the dynamics of a stream. Therefore, it is prudent to keep land uses away from the top of the stream bank. How far away is adequate to avoid problems? Since streams are dynamic, we must frame our answer in terms of a specific time period, say 20 years. Next we must recognize that streams have a tendency to meander. The meandering process is the result of repeated bank collapse, at a specific location, on one side of the channel and deposition on the other side of the channel.

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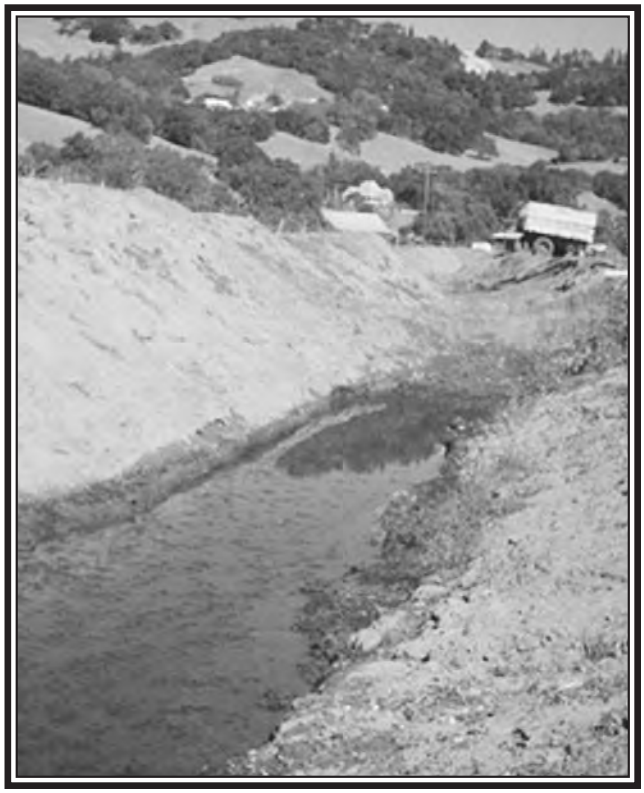

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EXAMPLES OF HIGHLY ALTERED AND MODERATELY ALTERED CORRIDOR CONDITIONS

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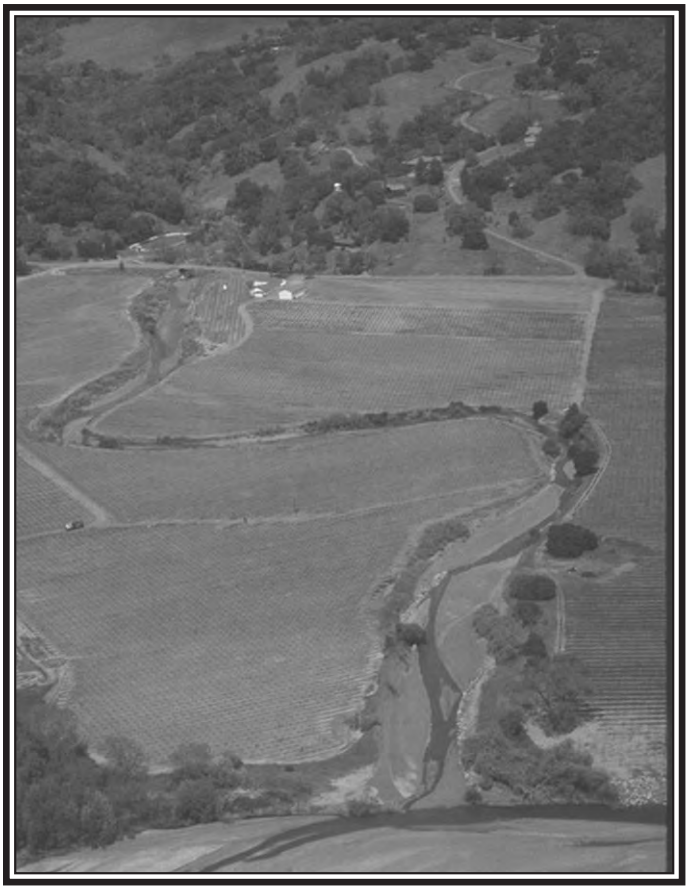

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EXAMPLES OF OCCASIONALLY PROBLEMATIC, RARELY A PROBLEM, SUDDENLY A PROBLEM CORRIDOR CONDITIONS

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Meandering can result in the rapid retreat of the streambank. So the riparian corridor must provide enough set back distance to allow bank collapse and meandering to occur during the planning horizon of 20 years.

Bankfull Discharge

Contemporary fluvial geomorphology has demonstrated that the shape of a stream channel is dictated by flood flows. Analysis of extensive sediment transport data shows that the flows that do the most work, that is carry the greatest total amount of sediment over a period of many years, correspond to the floods that occur roughly every other year. The frequent floods shape the channel and are called the bankfull discharge, or channel forming flow.

Most natural alluvial streams have a well-defined floodplain. In these streams the bankfull discharge fills the active, or scour, channel and begins to flow onto the floodplain. That is, the water level reaches the top of the bank of the scour, or active, channel and begins to spill onto the floodplain.

Meander Amplitude

The terms used to describe stream and river meanders typical of alluvial channels are shown in the figure below. A well-developed meander has a radius of curvature of 2 to 3 bankfull channel widths. On a natural stream the bankfull channel is slightly larger than the active, or scour, channel but typically larger than the low flow or summer channel. The meander belt width is twice the radius of curvature. Therefore, the meander belt width is 4 to 6 times the bankfull channel width.

If we are dealing with streams that have not been significantly straightened or altered, we can assume that a certain amount of meandering is already present in the stream. That is we do not need to provide a setback that is large enough to provide for the development of a completely new meander. Therefore, the width of the riparian corridor may already be 4 to 6 bankfull channel widths.

Channel Entrenchment

Luna Leopold (*A View of the River*, 1994) defines a floodplain as:

> "A floodplain is a level area near a river channel, constructed by the river in the present climate and subject to overflow during moderate storm events."

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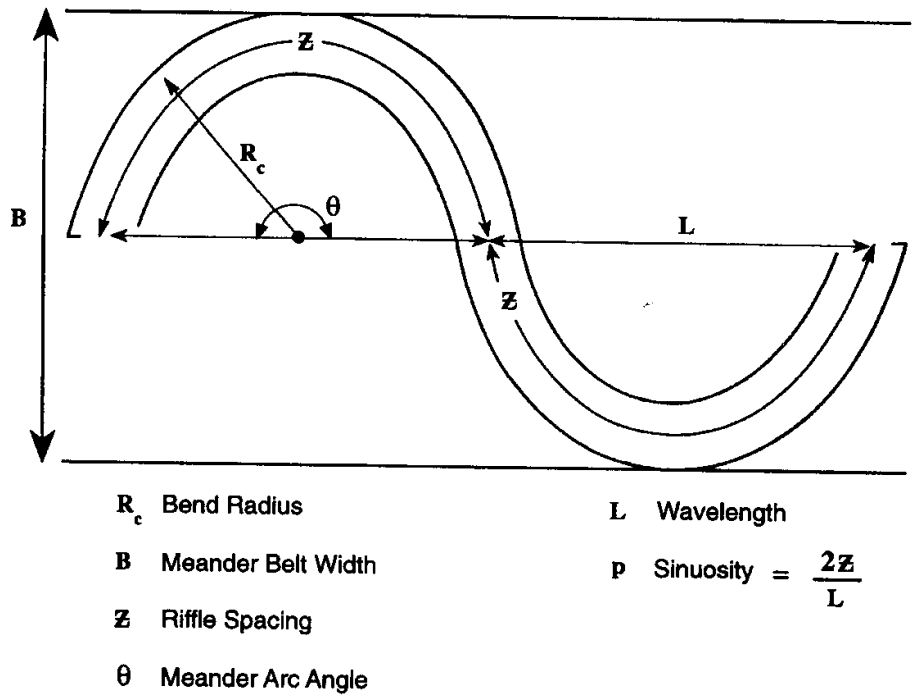

Definition diagram for meander plan form. From *Applied Fluvial Geomorphology for River Engineering and Management*, Edited by Thorne, Hey and Newson, 1997.

The idea that the river constructs its own floodplain is an important one. The material that forms the floodplain was transported to its present location by the river, or stream, and the material is termed alluvial. An incised, or entrenched, channel is one that lacks a floodplain. Entrenched channels have often incised due to channelization, straightening, and the effects of reservoirs, urbanization or the clearing of vegetation. If a corridor has a floodplain, then stormflows can spill out of the channel and onto the floodplain. This limits the depth of floods and allows the water to spread out and slow down, which in turn limits the amount of force on the bed of the stream. For stream corridors that lack a floodplain the amount of force on the streambed can be substantially greater for the same size of flow. Greater force erodes the streambed and undermines the banks. So, if the banks of the stream are higher than the level of the bankfull discharge then the banks will tend to collapse. This process of bank collapse will continue until a bench is created that is wide enough to act as a new floodplain. After the bench is formed the top of the banks of the bench will be at the level of the bankfull discharge.

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Channel entrenchment is one of the processes that can cause this cycle of bank collapse. However by creating a wide enough corridor, the channel can develop a floodplain. As the channel develops its floodplain, the bank collapse caused by channel entrenchment will stop.

One scientist, Dave Rosgen, approaches channel entrenchment by defining the entrenchment ratio as the flood prone width of the channel divided by the bankfull channel width. The flood-prone width is defined as the valley width at the elevation of twice the maximum bankfull depth above the streambed. Rosgen's flood-prone width is a specific portion of the floodplain and could also be called the stream corridor width. The floodplain can extend beyond Rosgen's flood-prone area.

Rosgen judges a channel to have a floodplain when the entrenchment ratio is greater than 2.2. Since the entrenchment ratio is defined in terms of bankfull width, we see that the riparian corridor must be at least 2.2 bankfull channel widths to accommodate the development of the flood-prone area.

We also reviewed the Natural Resource Conservation Service (NRCS) Conservation Practice standard for Riparian Forest Buffer. This standard uses a similar approach to Rosgen.

Riparian Corridor Width

The above considerations suggest that the minimum width of the riparian corridor should be a total of 3 to 4 bankfull channel widths. This will allow for the development of a flood-prone area and provide some room for meander development. The most practical way of laying out a riparian corridor that is a minimum of 3 to 4 bankfull channel widths wide is to measure one to one and one-half bankfull widths away from the top of the bank on each side of the stream.

Determining Bankfull Channel Width

A study of 50 bankfull cross sections measured by the Department of Fish and Game and stream gaging data collected by the USGS (see Appendix 6) resulted in the following formula to predict bankfull channel width of Russian River tributaries from their watershed area.

$$\text{Bankfull Width} = 13.1(\text{Watershed Area})^{0.5} \qquad R^2 = 0.760$$

Appendix 6 describes in detail the derivation of the method of predicting bankfull channel width based on watershed area for tributaries of the Russian River. Table VIC gives the bankfull width for various watershed areas.

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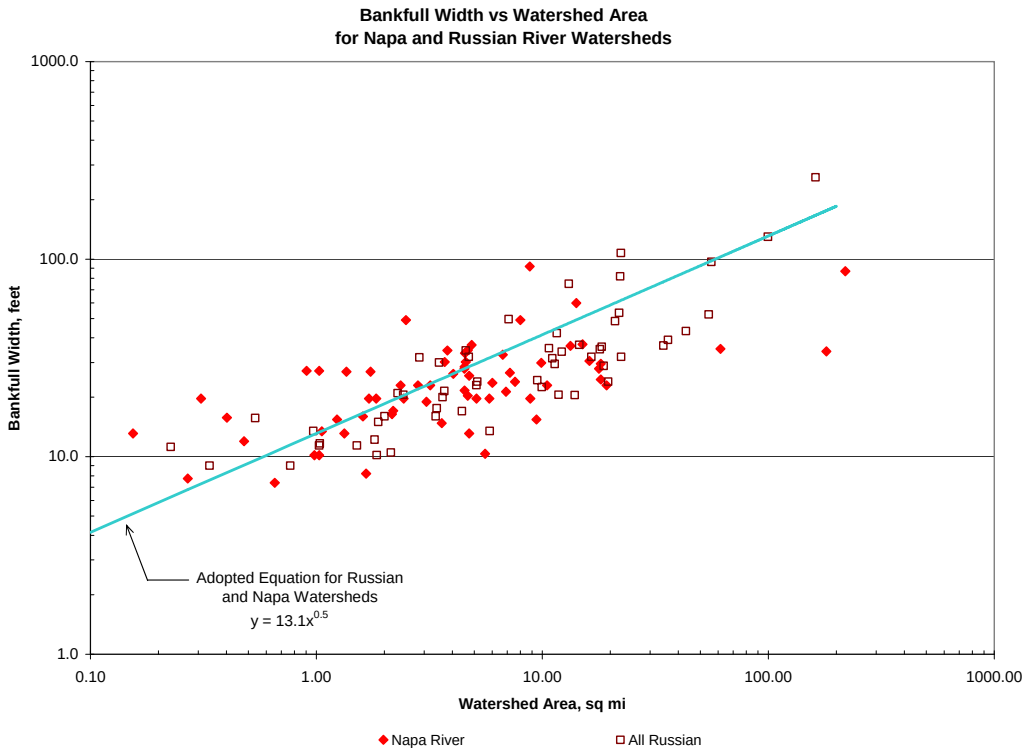
These data were used to create a formula to predict bankfull channel width based on watershed area:

$$\textit{Bankfull Width} = 13.1(\textit{Watershed Area})^{0.5} \qquad R^2 = 0.760$$



Graph 1. Bankfull width versus watershed area data is shown from 56 sites in the Russian River watershed and 66 sites in the Napa River watershed. The line shows the adopted relationship between bankfull width and watershed area from the Russian River watershed. The Napa River watershed bankfull width data appears similar to the Russian, so the same equation was used for both watersheds. Y is bankfull width, X is the watershed area and R^2 is the regression coefficient.

Bankfull data from 66 sites in the Napa River watershed was combined with the 56 Russian River sites. Graph 1 shows both sets of bankfull width data plotted against watershed area. The line shows the adopted relationship between bankfull width and watershed area from the Russian River watershed. The Napa River watershed bankfull width data is similar to the Russian River, so the same equation was used for both watersheds.

This methodology is applied to tributary creeks that are alluvial and unconfined or alluvial and partly confined channels (see Table VIC). The methodology is not applied to the mainstem of the Russian River and any confined channels. The corridor measurement for a restoration plan would be completed based on the actual watershed area upstream of the site.

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Determining your necessary corridor width:

- ❑ On a topo map(s) of your tributary basin mark the upstream boundary of the creek corridor. You will need to measure the acreage, or square miles, of the land area or the watershed that drains to this point on the creek. The FFF program staff will complete this analysis with the farmer.

- ❑ Once you have the watershed area, make sure it is in square miles. Use Table VIC to determine the necessary width of scour channel and the width for the riparian corridor.

- ❑ Record these numbers on the farm plan template for each year-round and seasonal creek in Section 17.

- ❑ If you have over one-half mile of creek corridor, do the estimate for the upstream and downstream ends of the corridor and record both numbers.

- ❑ If you have frontage on the main river channel, fill out the river corridor table. The above methodology is for alluvial tributary creeks, not the main river channel.

- ❑ If your existing riparian corridor is greater in width than described in Table VIC, do not remove vegetation to make it smaller.

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Table VIC.
Estimates of Russian River tributary bankfull width for various watershed areas based on combined USGS and DFG data and estimated necessary corridor width.

Watershed Area (square miles)	Estimated 1.5-Year Discharge (cfs)	Estimated Bankfull Channel Width (feet)	Estimated Necessary Corridor Width* (feet)
Less than 1		11.3	50
1	110	13.1	50
2	200	18.5	74.0
3	290	22.7	90.8
4	380	26.2	104.8
5	460	29.3	117.2
6	540	32.1	128.4
7	630	34.7	138.8
8	710	37.1	148.4
9	790	39.3	157.2
10	870	41.4	165.6
12	1,030	45.4	181.6
14	1,180	49.0	196.0
16	1,340	52.4	209.6
18	1,490	55.6	222.4
20	1,640	58.6	234.4
22	1,790	61.4	245.6
24	1,940	64.2	256.8
26	2,090	66.8	267.2
28	2,240	69.3	277.2
30	2,380	71.8	287.2
32	2,530	74.1	296.4
34	2,670	76.4	305.6
36	2,810	78.6	314.4
38	2,960	80.8	323.2
40	3,100	82.9	331.6
42	3,240	84.9	339.6
44	3,380	86.9	347.6
46	3,520	88.8	355.2
48	3,660	90.8	363.2
50	3,800	92.6	370.4
60	4,500	101.5	406.0
70	5,180	109.6	438.4
80	5,850	117.2	468.8
90	6,520	124.3	497.2
100	7,180	131.0	524.0
110	7,840	137.4	549.6
120	8,490	143.5	574.0

*Four times bankfull width

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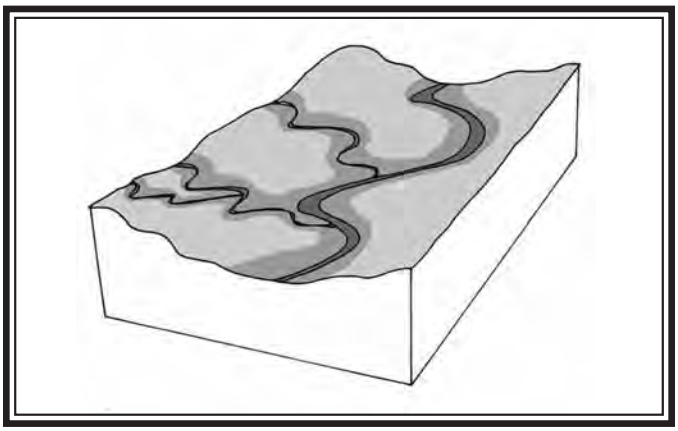
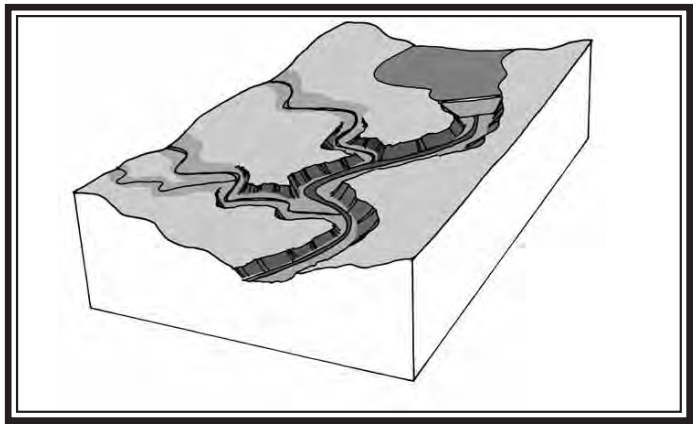
COYOTE DAM IMPOUNDS THE EAST FORK OF THE RUSSIAN RIVER AND WAS BUILT IN 1959. THE RESERVOIR HOLDS BACK SEDIMENT - GRAVEL AND COBBLE STARVING THE RIVER AND CAUSING IT TO ERODE ITS BED AND BANKS



RIVER AND TRIBUTARIES BEFORE THE DAM



INCISED RIVER AND TRIBUTARIES AFTER THE DAM

Fish Friendly Farming Environmental Certification Program	RESERVOIRS CHANGE DOWNSTREAM CONDITIONS BY IMPOUNDING SEDIMENT AND CHANGING HYDROLOGY

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ALLUVIAL AND PARTIALLY CONFINED CHANNELS: APPLYING BMPs:

A18. DETERMINING CORRIDOR RESTORATION STRATEGY

Repair, Restoration and Management Practices

Here are some general guidelines for restoring and repairing creek/river corridors:

- ❑ Use the inventory to carefully and thoroughly evaluate your creek in order to make well-informed decisions.
- ❑ Address watershed problems on the property such as slope erosion, effects of reservoirs and roads.
- ❑ Have caution and respect for the power of floods. Even the best-vegetated corridors can change greatly in large flood events. Highly altered corridors are often the most damaged in floods.
- ❑ The most important features of the corridor to restore are: corridor width, channel form to offset incision, re-establishment of native vegetation and repair of upslope problems.
- ❑ Continue to observe and monitor the creek and revise management over time as the corridor changes. Sometimes creeks are misunderstood due to a lack of information and management is misdirected. Careful observation is best. Watch the creek and how the repair/revegetation project progresses. Take photos in the winter. Keep a logbook of your observations as part of Element VIII.
- ❑ Focus restoration work on creating a stream corridor for natural stream processes and riparian vegetation. Work with the natural system rather than against it. Low cost methods using vegetation, not structural measures, are best. Avoid projects designed to modify the active, or scour ,channel. Instream enhancement such as adding large wood to the channel can be beneficial, but such activities should only be used after the corridor is wide and well vegetated enough to allow for in-stream changes.
- ❑ Allow the stream to function with little management and it will interfere less with the farm.
- ❑ In some cases the transition from a highly altered stream to a well-vegetated corridor may take several years and require financial assistance. However this approach will create a more stable and functional creek and farm over the long term.
- ❑ These BMPs provide guidance for restoration of corridors with native riparian plants and the use of native plants to repair eroded banks. The FFF program staff will provide professional assistance in the design and implementation of creek restoration projects.

Background: Riparian Vegetation

Riparian vegetation can be used as a low cost and effective method to reduce bank erosion and revegetate entire creek corridors. However to use native plants most effectively, it is helpful to know how they grow and where to plant what species.

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Riparian vegetation consists of a range of plants that grow in the areas next to streams where water is available in the summer.

For alluvial creeks, there is a progression of different species of riparian plants from the edge of the scour channel up to the outer edge of the corridor on the floodplain. It is very important when restoring riparian areas to mimic the natural system. If the plants are put in the wrong location in relation to the scour channel, they may not live long and the project will need to be re-planted. It is also essential that native plants grown from plants from the watershed of the restoration site be used. Riparian plants from other areas (Lombardi poplars, for example) are not native to California and do not belong in restoration projects as they are not part of California's ecosystem. Native plants from other areas of California, such as Los Angeles, or Sacramento, are also not acceptable; only local genetic stock should be used. Only reputable native plant nurseries and experienced restoration ecologists should develop and implement revegetation projects.

Generally riparian plant species vary in:

- ❑ Tolerance of mechanical effects of floods – scour and high velocity flows
- ❑ Tolerance of inundation
- ❑ Need for sunlight/tolerance of shade
- ❑ Ability to compete with other species
- ❑ Need for organic material in the soil for seed germination
- ❑ Methods for reproducing /spreading
  - ❑ Vegetative means through roots and runners
  - ❑ Seed
  - ❑ Size and dispersal method of seed
- ❑ Location in relationship to the active/scour channel

Zone 1: Species growing closest to the active or scour channel

These are the pioneer plants, mainly willow, cottonwood, alder and mulefat. The wind blown seed of these species, termed cotton, lands along river or creek bars and thousands of little seedlings germinate. Very few will survive. The willow, for example, is adapted to survive several weeks of inundation and can withstand relatively high velocity flows of up to 6 feet per second. However the willow cannot withstand drought for very long. The seedlings must establish a deep root system that can "chase" summer groundwater levels downward to remain well watered over the dry season. Willow and cottonwood also need bright sunlight and do not tolerate shade as seedlings. They can however grow on the nearly mineral soil of gravel bars. White alder also grow along the edge of the bankfull channel.

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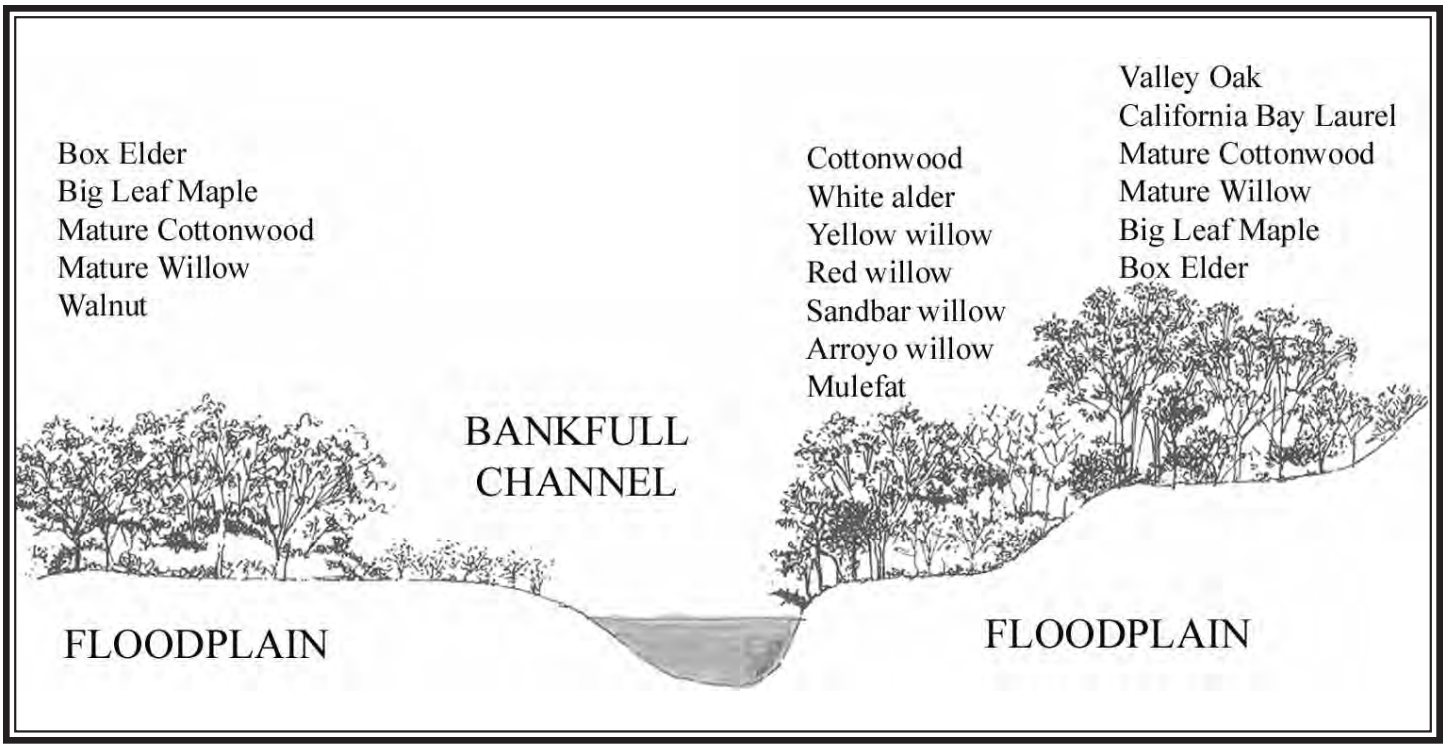

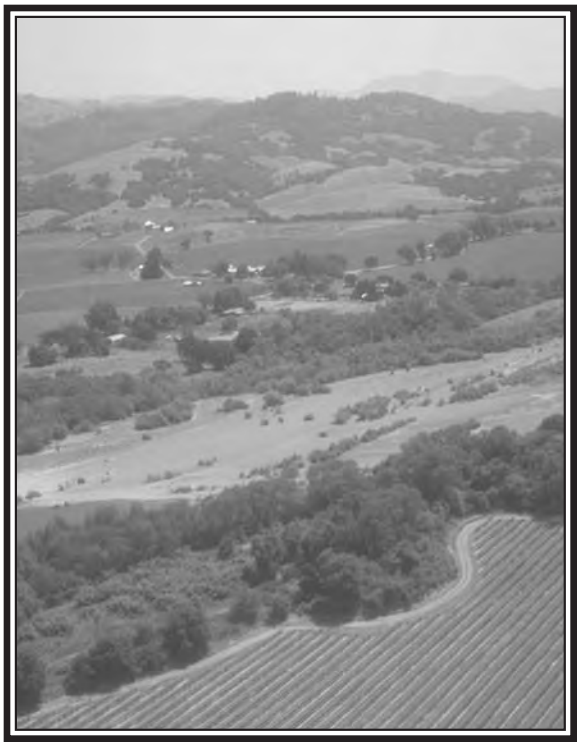

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RIPARIAN PLANT SPECIES GROW IN PARTICULAR AREAS OF THE CORRIDOR IN RELATIONSHIP TO THE ACTIVE OR SCOUR CHANNEL

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OF THE RIPARIAN SPECIES, WILLOWS LIVE CLOSEST TO THE ACTIVE OR SCOUR CHANNEL AND GERMINATE IN GREAT NUMBERS IN THE SPRING. FEW SURVIVE THE SUMMER DROUGHT UNLESS THEY CAN GET THEIR ROOTS INTO GROUNDWATER. WILLOW CAN WITHSTAND FLOODS AND SPREAD BY RUNNERS AND ROOTS. WILLOW CAN BEND AND WITHSTAND THE MECHANICAL EFFECTS OF FLOOD WATER. PLANTS THAT ARE SCOURED OUT CAN RE-ROOT IN A DOWNSTREAM GRAVEL BAR.

WILLOWS ARE ONE OF THE PIONEER PLANTS IN THE RIPARIAN ZONE GROWING CLOSEST TO THE ACTIVE CHANNEL. WILLOW IS OFTEN USED TO REVEGETATE BANKS AND STREAM CORRIDORS.

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MAPLE

ALDER

WALNUT

BAY LAUREL

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RIPARIAN PLANT SPECIES

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Due to their natural ability to grow quickly and withstand high velocity flows, cottonwood, alder and willow are the best species to use for vegetative bank protection. However, willow will not survive in the scour channel over the long term. They may invade this area during years of drought, but will likely be washed out in the first large flood. Revegetation of this active, moving section of the streambed is not necessary.

Zone 2: Species Growing Midway in the Riparian Corridor

Away from the scour channel on the floodplain are larger willows and cottonwoods as well as other trees and a dense understory of vines and herbaceous plants. Willows trap sediment during floods and the elevation of the area around them will build up as the active scour channel migrates to a different location. As the willows are covered over with sediment, they sprout adventitious roots from nodes on their branches and grow up through the new alluvium. In this manner, they are able to thrive in the ever-changing conditions along the creek channel.

The larger the willows and cottonwoods get, the more shade they create and the fewer of their species will germinate. The shady conditions as well as the absence of frequent high-powered floods allow for other plants to grow. There may be box elder, Ca. walnut, big-leaf maple, Oregon ash, California buckeye and other species. These trees are tolerant of inundation and have larger seeds which float to new locations, or are eaten or carried by animals. These tree seedlings can grow in shadier conditions and need more organic matter in the soil. Understory species may include native blackberry, snowberry, spicebush, sedges and rushes, wild rose and others.

Zone 3: Species Growing Along the Outer Edge of the Riparian Corridor - Mature Forest

This is the floodplain forest with the largest trees and the greatest diversity of species. There are willows and cottonwoods intermixed with box elder, Ca. walnut, big-leaf maple, Oregon ash, alder, bay laurel and valley oak. Redwoods also grow in this zone along coastal streams. Two species – bay laurel and valley oak, are good to have along the outer corridor edge to reduce the spread of Pierce's disease into the vineyard.

The mature forest supports many animals and most of the tree species in this zone can be planted. Understory species may include native blackberry, snowberry, spicebush, sedges and rushes, wild rose and others. Non-native invasive plants must be removed to avoid competition.

The locations and sizes of these zones will be different for every stream but can be generally estimated from the necessary corridor width and bankfull channel width. As a rule of thumb, zone 1 should only be planted on the edge of the bankfull channel, and zones 2 & 3 on the adjacent floodplain.

Channel Form and Function

Besides evaluating the distance from the active, or scour, channel another important feature of successful revegetation projects is consideration of channel form and its function in supporting the plants. Generally **stream banks should be re-sloped** to create a 2:1 or 3:1

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slope for planting, or a low floodplain bench created. It is difficult to have a successful riparian restoration project on a 1:1 bank.

In an **incised or entrenched channel** the active channel may be 12-25 feet or more below the top of the bank. There may not be a floodplain or any area for floodwater to spread out. Instead the incised channel is more like a canyon or gorge with steep walls and no place for riparian plants to create a corridor. Trying to revegetate these steep high banks is not likely to succeed. Bioengineering of a 20+ ft. steep bank with willow and rock is a temporary fix at best as this technique does not address the cause of the incision - high velocity flows and scour in the channel.

In these situations, a new floodplain needs to be created. The new floodplain bench is constructed out of the existing high bank through excavation and should be located no more than about 5-7 feet above the channel edge. It should start at the edge of the existing scour channel (or predicted scour channel width for highly altered channels) and extend away towards the terrace. In some cases, a combination of a new floodplain bench and setting back the existing bank at an angle of 3:1 or in some cases 2:1 is needed. The new bench and re-sloped bank are densely revegetated. A willow wall, or other vegetative structure, can be placed at the scour channel edge of the new bench to add stability to the project. Rock may also be placed at the toe of the new bench to protect the new slope in the first year, but should be limited in use in order to create a natural channel. This type of design should be completed by a civil engineer and an ecologist.

Aggraded channels are also problematic. The active or scour channel and parts of the adjacent floodplain are receiving more sediment than the flood flows can carry downstream. Trying to plant riparian trees too close to the scour channel will not be successful. If the channel is highly or moderately altered, start at the outer edge of the necessary corridor width and move inward with the plantings. Set any banks back at a stable angle of 3:1 and plant willow or cottonwood along the edges. Using dormant willow poles may be good if large poles are available and can be deep augured or trenched. Don't try to get too close to the scour channel, it is changing and your project may be jeopardized. Be careful not to disturb the active channel and do not remove or rearrange the gravel in the channel as this may further destabilize the situation and affect your plantings. The dense plantings will reduce flow velocities and increase sediment deposition and allow for the scour channel to deepen.

In some blue-line channels surface flows dry up in the summer due to changes in the main river channel, a general lowering of groundwater levels, extensive water storage or pumping, or a lack of vegetation and shade resulting in high evaporation rates. There are also some channels that naturally have subterranean flow. For channels in this type, deep auger or trench willow poles, or use large size container stock. Don't plant very high (5 feet) above the lowest channel elevation. Plant along the edges of the calculated bankfull channel width outward to wherever the banks exceed 5-feet above the lowest channel point. This is the area most likely to support plants and revegetation potentially can be expanded from this narrow area to a broader area. You might also dig some test wells to watch fluctuations in the groundwater levels and use this information to fine-tune your project. Always plant in the winter and provide irrigation over the summer.

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Pierce's Disease Concerns

Element III contains information on the relationship of riparian plants species to blue-green sharpshooters and Pierce's disease bacteria. Non-native plants as well as some native understory plants are the primary hosts of both the insect and the bacteria. In restoring your corridor or completing a bank repair, remember that many of the Zone 3 trees which are best suited to the outer corridor next to the vineyard are the least likely to host the blue-green sharpshooter or the P. D. bacteria. It will likely be necessary for you to manage the corridor to remove the non-natives and those native understory plants that can spread the disease.

Invasive Plant Removal and Management

Exotic plant species are capable of invading riparian zones and replacing native habitats. Highly invasive species may negatively affect the stream corridor in the following ways:

- ❑ Replacement of native species due to competition with invasives and loss of native riparian forest
- ❑ Increased water temperature as most invasives do not provide adequate shade canopy
- ❑ No contribution of large wood into the stream for fish habitat
- ❑ Ineffective for bank protection
- ❑ High level of transpiration of water may reduce stream flow
- ❑ Reduction in wildlife habitat values

The following lists the most common invasive species and the recommended methods for eradication. It is important to note that any use of herbicides should be done in full accordance with label directions and restrictions. In general, if the area to be treated is next to water, the herbicide suggested is a formulation safe for use near to water. Consult with the County Agricultural Commissioner for details on herbicide use. In many instances cut and paint methods where full strength herbicide is painted directly onto the cut stem of the invasive plant is the most effective control and avoids drift into creek areas. It is also important to note that if a large area of invasive plants is removed, a plan for revegetation of the area should be completed. Native plant sprigs or container stock from local genetic stock should be on order when the eradication is done, as these species are not readily available from nurseries.

Invasive plants typically move from upstream to downstream and should be removed starting from the upper watershed or channel. In almost all trials and studies of invasive plant removal, herbicide has proven more effective than mechanical removal methods. However, hand removal performed several times a year consistently for a decade or more can completely eradicate invasive plants if no re-infestations occur from upstream.

Giant reed (*Arundo donax*) - Cut the reeds to the ground in September and paint with glyphosate within 30 seconds of cutting. This is a very difficult plant to remove once established. Try to cut and paint as soon as any of these are found on your property. Cut

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and paint all survivors and continue removal on a regular basis. In areas where flooding is not common, the Arundo can be cut and covered with thick black tarps secured to the ground with 12" staples for 12 months. This method should not be used adjacent to the channel where tarps can be scoured away by floodwater. Another method involves cutting the Arundo to remove the biomass in the winter, then spraying the re-growth with Habitat (Imazopyr) in the spring. All cut Arundo should be moved to an area outside the floodplain and be burned or chipped as soon as possible.

Blue periwinkle (*Vinca major*) **-** Spray with glyphosate when plant is green and growing vigorously, being careful to avoid other plants and any drift. Don't spray when plant is wilted. Re-spray all survivors. This understory plant provides little to no erosion control and soil can be washed out from underneath without notice. This plant is a host species for Pierce's disease. This plant will dominate the understory of established riparian areas and reduce or eliminate the germination of native tree seedlings and shrubs. Over time, as the riparian trees age and die, the corridor will have no replacement trees and a monoculture of Vinca is created. Hand removal can be done, but must be repeated several times a year and done thoroughly.

Himalayan blackberry (*Rubus discolor*) - This is the blackberry that has bigger leaves, bigger thorns and bigger berries and is found both on streams and roadsides. It is a host species for Pierce's disease and an invasive plant that will take over native areas and provide little erosion protection for banks. Spray with glyphosate only in areas where other native riparian plants will not be affected. Cutting and painting stems with glyphosate is also effective. If it is interspersed with natives or if mechanical methods are preferred, cut and pull by hand using really thick gloves and follow up with removal several times a year.

Tamarisk (*Tamarix ssp*.) - This is a desert species of tree that is becoming established in California and is tough to get rid of. Cut the tree before it has a chance to flower and paint with triclopyr or glyphosate immediately following cutting. Remove duff with seeds to the greatest extent possible. Pull out all seedlings and retreat any re-sprouting stumps.

Tree of heaven (*Ailanthus altissima*) and Acacia *(Acacia sp.)***-** These invasive trees should be cut and then painted with glyphosate to kill the root system. They can also be cut continuously several times a year and all seedlings removed.

Scotch (*Cytisus scoparius*) or French (*Genista monspessulana*) broom - There are a number of invasive brooms that can be cut and painted with glyphosate and seedlings hand pulled. Hand removal requires all parts including roots and the seed bank be removed. There are areas in the riparian corridor that may have broom, although it is more common on hillsides. A weed wrench works well for removal of this species because broom generally does not re-sprout from roots.

Cape (*Delairea odorata*) and English (*Hedera helix*) ivy - These very invasive species spread by runners. Spray with glyphosate and remove and re-spray all survivors until it is gone. Cape ivy will climb trees and smother them resulting in the dead tree falling and often taking the stream bank or slope with it. If it is interspersed with natives, cut and pull by hand.

A good reference book on invasive plants is Invasive Plants of California's Wildlands by Bossard, Randall, and Hoshovsky available from www.caleppc.org. or www.cnps.org

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ARUNDO DONAX OR GIANT REED IS A NON-NATIVE PLANT WHICH INVADES RIPARIAN AREAS. ARUNDO DOES NOT PROVIDE BANK PROTECTION LIKE NATIVE PLANTS AND SHOULD BE REMOVED

ANOTHER INVASIVE PLANT IS BLUE PERIWINKLE.

Fish Friendly Farming Environmental Certification Program	INVASIVE NON-NATIVE PLANT SPECIES

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ALLUVIAL AND PARTIALLY CONFINED CHANNELS: APPLYING BMPs: RIPARIAN REVEGETATION

Revegetation of the corridor may involve large areas or small areas. In either case follow these practices:

PLANNING AND INSTALLATION

The FFF program staff and other professionals will complete revegetation/restoration designs and permits and assist in proper implementation of revegetation projects. Each site should follow these guidelines:

- ❑ Determine the scour channel or bankfull width as well as the overall corridor width for the site using the BMPs and plan how to achieve this width on your site.

- ❑ Replanting should focus on the upper or outer edges of the scour channel up the banks to the floodplain and to the outer edge of the stream corridor. If you are restoring a highly or moderately altered corridor, you can determine this area by the estimate of the needed corridor width and bankfull channel width. Only the edges of the bankfull channel should be planted, not the main channel where scour is common. Use those native species grown from plants that naturally grow in your area for best results.

- ❑ Through the FFF program, a professional ecologist will prepare planting plans using the appropriate plant species at the appropriate distances from the bankfull channel. The plan should include removal of all invasive non-native species including Pierce's disease host plants and revegetation with native non-host plants. An engineer, hydrologist or other professional may also be involved in the design process.

- ❑ The plan should evaluate the channel form from your assessment and determine if some changes are needed prior to planting such as: re-sloping of banks; making alterations to incised channels to create a new floodplain bench or set banks back at a 3:1 angle or flatter prior to planting; incorporate changes to replanting plans for aggraded channels and summer dry channels.

  If your corridor needs some bank protection, the plan may use vegetative methods – willow sprigging, brush mattress, or bank re-sloping and planting. Depending on the site, a civil engineer may need to be involved. If your assessment shows the corridor needs to be widened, the plan should create this wider corridor as part of each bank repair over time. The bank should be set back or a combination of new floodplain bench and bank re-sloping done to add the needed width to the corridor.

- ❑ The implementation of the plan should begin planning early, apply for permits, line up sources of native plants for the site, line up contractors if needed and expect to complete earthwork construction by October 15 with erosion control. The FFF program staff will assist or complete these steps. Revegetation should begin when soil moisture will support the plantings typically in fall and early winter. If earthwork is extensive, temporary revegetation may be needed prior to winter rains with irrigation until the rainy season begins.

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- In certain circumstances some structural component may be called for such as rock along the toe of the bank repair. Other structural elements such as complete bank armor or other types of revetments are very expensive and do not serve to increase habitat.

- For these reasons, hard solutions are only recommended as a component of a creek project where a house, road or other building or facility needs structural protection. A civil engineer should design all structural projects and project near buildings.

- For **suddenly a problem, occasionally a problem, and rarely a problem** corridor conditions, the emphasis is on low cost vegetated solutions and increasing the width of the corridor over time if your assessment shows this is necessary. It can cause greater harm than benefit to widen a vegetated corridor by removing the existing vegetation unless the vegetation is very sparse or made up of non-native species. Instead the corridor can be increased in width by planting along the outer corridor edges. For incised channels, a secondary channel or bench can be created next to the existing vegetation to widen the corridor. It is also possible to carry out adaptive management of the corridor by allowing banks to collapse and having a revegetation plan which defines follow-up actions and species to be sprigged and planted in the slumped bank area. In this way the vineyard can move away from the creek bank before it collapses. If there are sections of the creek where there is little vegetation or a great deal of non-native cover this section needs a large restoration plan and project.

- For the highly altered and moderately altered corridor conditions major restoration plans and phased projects may be required. In these areas a section of creek corridor is planned out using the necessary corridor width and vegetation restoration BMPs. Revegetation and channel form alterations are done in phases - one section per season. Remaining areas are protected from erosion and invasive plants are controlled.

- Changes to streams and riparian corridors require approval and permits from the California Department of Fish and Game. For in-stream work, permits from the Regional Water Quality Control Board and the Army Corps of Engineers may be needed.

Revegetation Methods

- Seeds, or propagules, should be collected as close as possible to the project site. This method ensures that only the genetically appropriate plants (those that are adapted to the local conditions) will be used on the site. Introduction of plant material from other areas should be avoided.

- Propagation of plants in containers needs to begin up to 18 months prior to planned revegetation work. For example, a particular species may have seed that ripens in June. After treatment of the seed and germination and culturing in a nursery, the plant will be ready for planting the following fall.

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Fish Friendly Farming Environmental Certification Program	EXAMPLES OF USE OF THE WILLOW WALL REVETMENT

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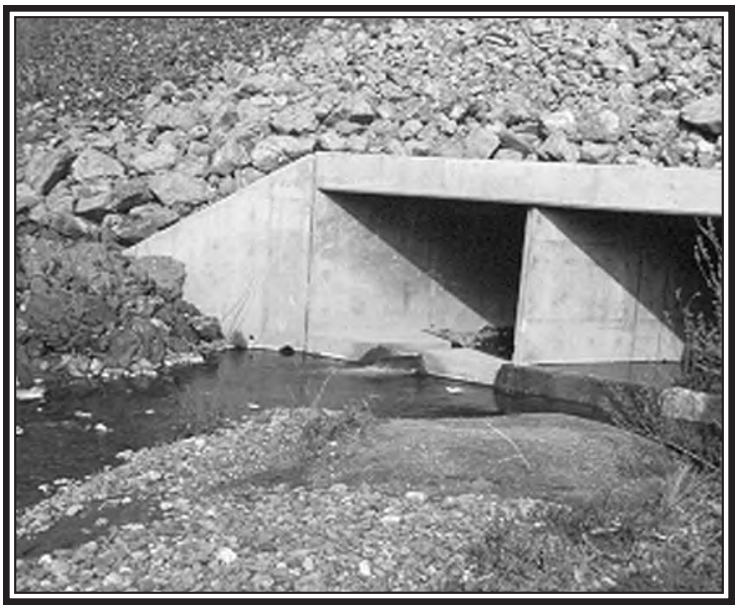
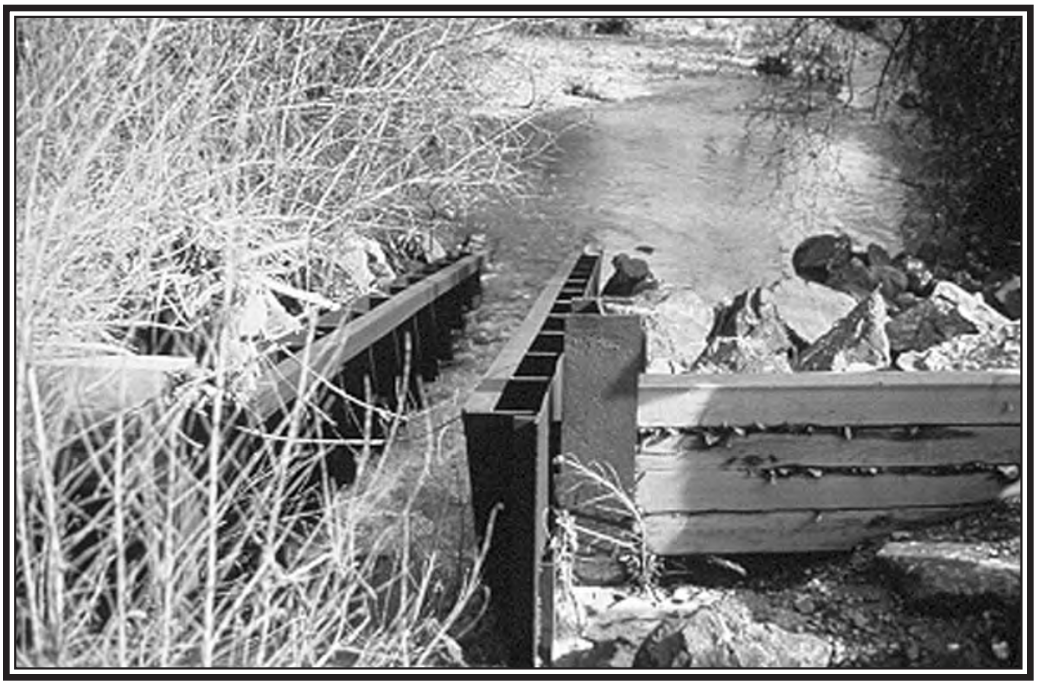


THE CULVERT ON THE LEFT IS A BARRIER DUE TO THE FLAT SHEET OF WATER. THE BOX CULVERT ON THE RIGHT HAS HAD A NOTCH CHISELED INTO THE BOTTOM TO DIRECT FLOW TO ALLOW FISH TO SWIM THROUGH



THIS FISH LADDER WAS PLACED ON A STRENGTHENING STRUCTURE ADDED UNDER A BRIDGE ON A TRIBUTARY TO THE RUSSIAN RIVER. THE BRIDGE WAS BEING UNDERCUT DUE TO THE INCISION IN THE MAIN STEM OF THE RIVER CAUSED BY COYOTE DAM. THE NEW STRUCTURE WOULD HAVE BLOCKED FISH MIGRATION INTO THE TRIBUTARY WITHOUT THE FISH LADDER

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- ❑ Planting should be done during the winter when moist soil conditions persist and plants are most likely to establish and grow. While not recommended, if planting is done earlier in the season then irrigation will be needed to provide adequate soil moisture until the rainy season. Irrigate immediately after planting and on a regular basis to avoid soil drying out or the plants will die.

- ❑ Broadcast seeding of native grasses and forbs should take place prior to September 30 of each year to ensure adequate time for seed germination prior to the onset of cold weather.

- ❑ Relocation of plants found growing near the restoration site is sometimes appropriate. Some species are best acquired by thinning in nearby thickets and stands.

Willow sprigging

Willow sprigging can be an effective and inexpensive way to revegetate along streams. Willow must be planted in sunny areas where plants can establish roots and reach summer groundwater. Sprigs should be collected and planted when willows are dormant in January. Some willows, such as the sandbar willow, do not sprig well and should not be used. Cottonwoods also work well for sprigging.

Sprigs should be at least one-half inch in diameter and 18 inches long. Sprigs two to three inches in diameter and three to four feet long work the best. Cuttings should be planted on the same day they are cut. If this is not possible then the entire cutting should be placed in water in a cold area until used.

Plant the willow with the buds up after sharpening the bottom end of the sprig with an axe or pruners. Springs should be driven into the soil 75 to 80 percent of their total length at a slight angle downstream to decrease the resistance to water flows. In hard soil, an iron bar, or auger, can be used to bore planting holes. After placing the cutting in the hole, tamp firmly around the cutting to remove any air pockets in the soil. In soft soils, sprigs can be driven in with a wooden mallet or sledgehammer. Cut off the tops of the sprigs if they should split while hammering. Leave only one or two buds exposed.

Along stream banks spacing of the sprigs may be as close as one foot. Cattle tend to browse on young willow; the revegetated areas may need protection with exclusionary fencing.

Summer irrigation

For the first three summers following planting of native riparian plants, each plant will require irrigation. Dormant willow sprigs may not require irrigation. Unlike many ornamental plants, natives need deep infrequent watering.

In April, install a drip irrigation system for the native plants and irrigate for an eight-hour period every three weeks. Irrigation should extend from late April if rains have ended to the beginning of the next rainy season. If a drip system cannot be installed, hand water.

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Weeding and protection from deer and rodent browse

When native plants are put in, weeds around the site should be removed and a square of weed mat installed around the plant. As part of spring or summer maintenance, weeds should be removed next to the new plant. Dormant willow sprigs should have weeds removed if appropriate as well, but not have weed mat installed. There are a variety of protective tubes used for native plants to reduce browsing by rodents and deer for the first several years of growth. These are placed around or over the plant and should not be used near the actively flooding portion of the channel. All tubes and protective hardware should be removed after 2-3 years.

Pruning native vegetation

Only prune your native plants when they become so successful that they are extending into the vineyard. Prune in the winter and spring months when plants are dormant. Within the corridor area no pruning or trimming is needed and in fact is detrimental to the wildlife values in the corridor.

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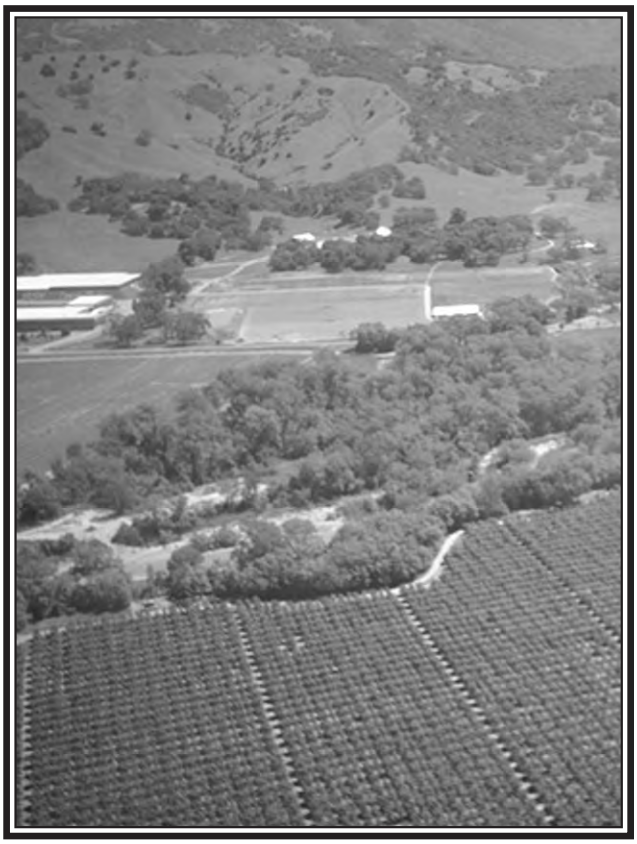

Fish Friendly Farming
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FARMS WITH RIPARIAN CORRIDORS AND ACTIVE RESTORATION MANAGEMENT

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A19. IMPLEMENTATION TIMELINE

CORRIDOR CONDITIONS: SUDDENLY A PROBLEM
RARELY A PROBLEM
OCCASIONALLY A PROBLEM

The FFF program staff will work with the farmer to determine the restoration strategy.

For these corridor conditions the Farm Conservation Plan should indicate one of the following restoration strategies:

- ❑ **Increase the width of the corridor over time (10 years).** As bank erosion occurs, revegetation will be completed. Vineyard and roads are moved back over time to increase corridor width. BMPs used are:
    - ❑ Revegetation of the corridor
    - ❑ Revegetation of banks, revegetation of floodplain area
    - ❑ Removal and management of invasive species
    - ❑ Incised channels, aggraded channels and summer dry channels conditions are addressed.
- ❑ **Increase the width through several seasons (3-5 years of active revegetation)** Vineyards and roads are moved back to increase the corridor width. BMPs used are:
    - ❑ Revegetation of the corridor
    - ❑ Revegetation of banks, revegetation of floodplain area
    - ❑ Removal and management of invasive species
    - ❑ Incised channels, aggraded channels and summer dry channels conditions are addressed.
    - ❑ Corridor restoration under this option should be scaled to allow for phases of vineyard setback and revegetation to occur in seasonal periods between April 15 and October 15. Indicate the phases on a site map or aerial photo. This is not a good option for the corridor if it is currently well vegetated with native species.
- ❑ **Corridor width is adequate** on your site as defined in the necessary corridor width calculation. A management only option is needed consisting of the following BMPs:
    - ❑ Revegetation along the outer edge of the corridor
    - ❑ Removal and management of invasive species
- ❑ **Main Russian River sites** – Revegetation and management will involve setback of vineyard over time and bank revegetation as feasible using the following BMPs:

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- ❑ Revegetation of banks and floodplain areas as appropriate
- ❑ Removal and management of invasive species
- ❑ It is highly likely that any revegetation effort on the banks of the river will require a set back to a 3:1 slope or in some cases 2:1, or re-creation of a new low floodplain area. However, the owner has little control over such factors as reservoirs, historic channel management and historic gravel mining effects and cannot repair the problems these factors may produce. Bank blowouts may require major financial assistance.

❑ **The lower mile of tributary streams may be highly affected by river conditions**

- ❑ Owner will revegetate and manage using the BMPs indicated for the corridor condition on the site.

❑ **Alluvial fans**

- ❑ Revegetation involves review of current active channel, other channels, width of fan and current extent and type of vegetative cover
- ❑ Bank revegetation techniques such as willow walls or mattresses will not work well for this type of channel.

CORRIDOR CONDITIONS: HIGHLY ALTERED
MODERATELY ALTERED

For these corridors a phased restoration program is needed. The FFF program staff will work with the farmer to determine the restoration strategy.

For highly altered corridors, complete phased revegetation/restoration plan over a 10-year time frame. Plan to set back vineyard with each phase. If you own one side of the channel, accommodate half the required width on your side. The plan should use the following BMPs:

- ❑ Changes to channel form appropriate to the site
- ❑ Revegetation with native species at appropriate distance and elevation to active channel
- ❑ Revegetation of banks and floodplain area
- ❑ Removal and management of invasive species
- ❑ Incised channels, aggraded channels and summer dry channels conditions are addressed. Since many highly altered corridors are also incised channels, address this issue by incorporating a floodplain bench into the revegetation plan.

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- ❑ Invasive plant removal should be addressed both prior to revegetation efforts and over the course of the restoration program as a maintenance activity. Make sure your workers are trained in the differences between the newly planted native species and the invasive ones.

For moderately altered corridors there are areas with some vegetation or just several problem areas where the corridor needs additional width, increase the width through several seasons (3-5 years of active revegetation). Vineyards and roads are moved back to increase the corridor width. BMPs used are:

- ❑ Revegetation of the corridor
- ❑ Revegetation of banks and floodplain area
- ❑ Removal and management of invasive species
- ❑ Incised channels, aggraded channels and summer dry channels conditions are addressed.
- ❑ Corridor restoration under this option should be scaled to allow for phases of vineyard setback and revegetation to occur in seasonal periods between April 15 and October 15.

Indicate the phases on a site map or aerial photo. This is not a good option for the corridor if it is currently well vegetated with native species.

Main Russian River sites – Highly and moderately altered corridors of the main river are likely to be unstable and capable of eroding banks and vineyards easily. Setting the vineyard back from the scour channel is likely to save money over time, particularly if implementation funds are available. The river can erode 20-30 feet of bank and floodplain vineyard in one large storm, making these vineyards very vulnerable. Revegetation and management will involve setback of the vineyard over time and bank revegetation as feasible using the following BMPs:

- ❑ Vegetated bank protection
- ❑ Removal and management for invasive species
- ❑ It is highly likely that any revegetation effort on the banks of the river will require a set back to a 3:1 slope or in some cases 2:1, or the re-creation of a new floodplain area. However, the owner has little control over such factors as reservoirs, historic channel management and historic gravel mining effects and cannot repair the problems these factors may produce. Bank blowouts may require major financial assistance.

The lower mile of tributary streams may be highly affected by river conditions.

- ❑ Owner will revegetate and manage using the BMPs indicated for the corridor condition on the site. Factors outside the owner's control may cause the stream to be less stable and the owner may not be able to revegetate the site.

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- **Alluvial fans**
  - Revegetation involves review of current active channel, other channels, width of fan and current extent and type of vegetative cover
  - Bank revegetation techniques such as willow walls or mattresses will not work well for this type of channel.

ALLUVIAL AND PARTIALLY CONFINED CHANNELS: IMPLEMENTATION TIMELINE

The implementation timeline sets out how the Farm Conservation Plan will get done. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds. Generally, the implementation timeline for each element should outline a sequence of events. For creek and river corridor sites which need a revegetation plan this need should be identified in the timeline.

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CONFINED/BEDROCK CHANNELS: ASSESSMENT OF STREAM CONDITIONS

Confined stream channels differ significantly from alluvial channels in the way they change and are affected by floodflows and sediment transport. Since the channel size and shape is dictated by bedrock, the shape does not alter the way an alluvial channel adjusts its width, depth and meander characteristics during a flood. Confined channels do undergo changes and do need to be assessed, restored and their watershed lands managed well.

During a flood event in a bedrock channel, the confined nature of the channel keeps water from spreading out and creates a deeper flow of water with a high velocity. The flow will scour loose material, deposit material, move large logs and wood, and erode banks or the toe of canyon slopes. Bridges, road crossings, banks and unstable areas are often damaged in floods along these types of channels.

The supply of sediment to the stream and changes to the volume of floodwater (from urbanization, or vegetation clearing, for example) can have an effect on confined channels. Construction of roads, crossings and buildings are also typical problems in these canyon streams.

For these reasons, the focus of the inventory for confined channels is not on the width of the corridor, as the canyon largely determines this. It focuses on the condition of the watershed, the supply of fine sediment to the stream, the number and type of road crossings and other channel obstructions, and the adequacy of large wood and tree canopy along the stream.

B3. PHOTOGRAPH

- ❑ Take photos (you will need a flash) of all year-round and seasonal confined stream channels. Try to photograph each creek from above and from every bridge and crossing. Photograph during both the winter (if safe) and the summer. Label each photograph when developed with the location and the date.

B4. VEGETATION

- ❑ On the Farm Conservation Plan template, check the vegetation types on the slopes and/or the stream banks.

- ❑ Stand in the channel if you can and determine if it is well shaded. If you can only view the channel from a road, look at how thick the canopy is over the low flow channel. Fill in the template.

- ❑ On the template, describe the condition of the canyon or banks of the stream.

- ❑ On the template, describe the size of the trees and condition of the creek banks for each creek. Describe the amount and size of large wood in the channel

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B5. CHANNEL FEATURES

Bedrock or confined channels can vary greatly in regards to where pool, gravel areas and other features are located. If you can easily see the features of the channel from a road or by walking along the channel, mark the features you observe for each creek on the Farm Conservation Plan template. If only a part of the channel is visible, indicate the features and the area you reviewed on your map or aerial. If none of the channel features can be seen indicate this and skip this section.

B6. WATER FLOW

- ❑ On the Farm Conservation Plan template indicate the features of water flow in the channel.

B7. ROADS AND CROSSINGS

- ❑ Does a road run along the creek or above the creek along the canyon slope? Be sure this road and all the crossings are evaluated in Element V.

B8. HILLSLOPE STABILITY

- ❑ Indicate on the template if there are landslides along the channel or on the hillslopes above the channel.
- ❑ Mark the locations on a map.

CONFINED/BEDROCK CHANNELS: APPLYING BMPs

The management priority for confined channels is to reduce sources of excessive fine sediment from roads, cleared areas and other uses of watershed lands. Revise road crossings, retain canopy over the stream and make sure that water flows are not reduced through excessive diversions and storage. Additionally, enhancement of the channel through placement of large logs and stumps as well as some streamside revegetation may increase fish habitat. For many of the larger watershed issues, it may not be possible for one landowner to address all the problems. Formation of a stewardship group in conjunction with the RCD may be the best method for addressing the larger watershed issues of sediment and water use (see Element VII).

The following BMPs address these issues:

- ❑ Elements II, III and V address many methods to control erosion. Be sure these elements are completed and all erosion control BMPs are used.
- ❑ Roads and road crossings of confined channels may need reconstruction and drainage and erosion improvements. Review Element V to make sure all roads along confined

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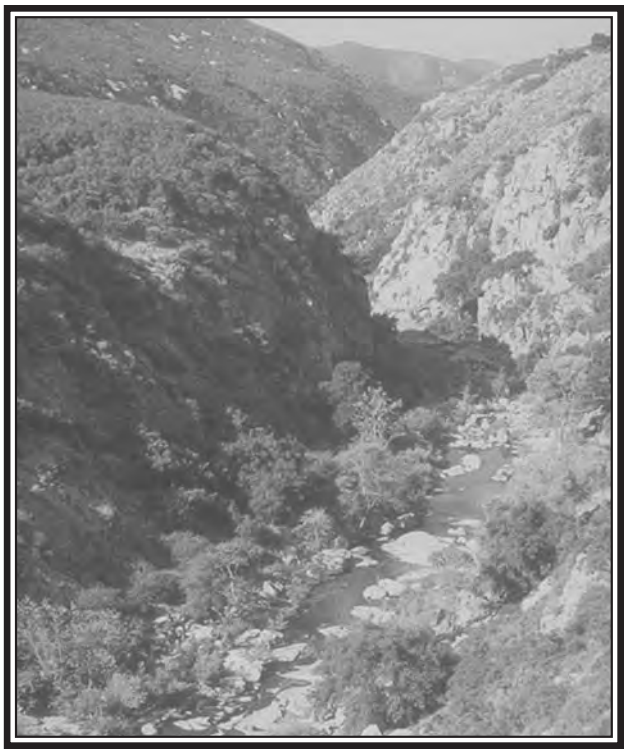

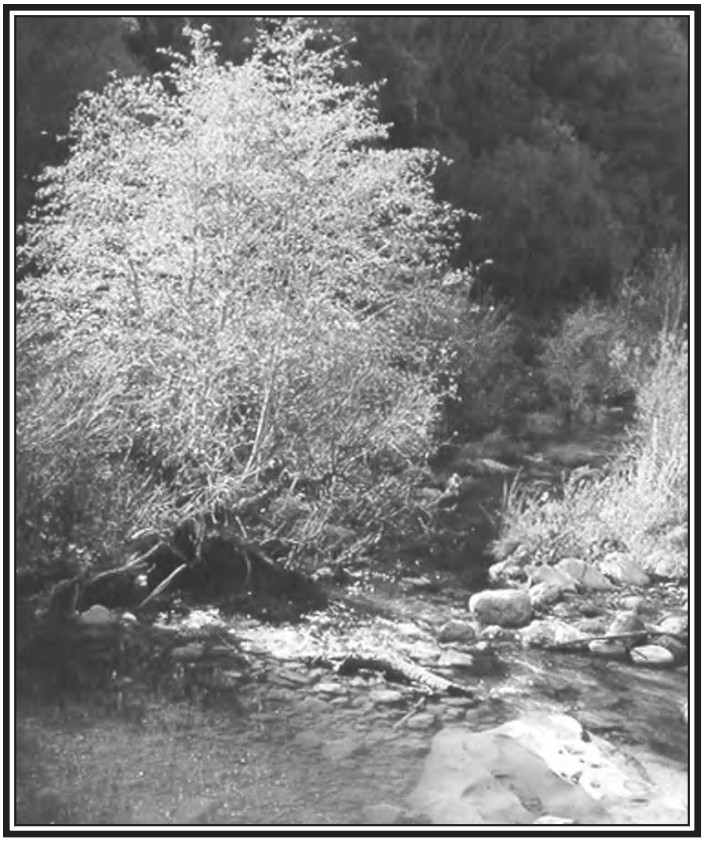

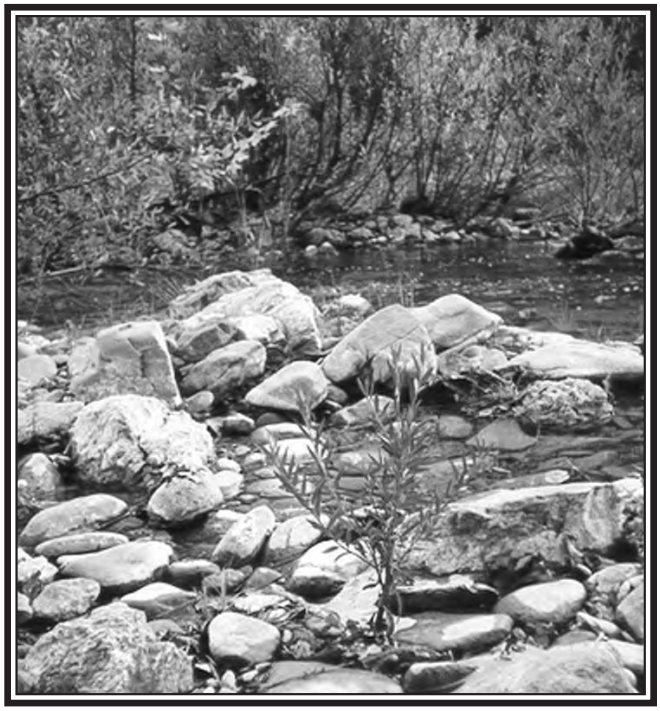

Fish Friendly Farming
Environmental Certification Program

CONFINED CHANNEL RESTORATION REQUIRES MORE FOCUS ON THE WATERSHED AND REDUCING SEDIMENT THAN CHANGING THE CORRIDOR OR CHANNEL

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channels are addressed. If possible avoid using streamside roads and restore these to avoid affecting the creek.

- ❑ Review the water conservation section of Element II and III to make sure adequate flows remain in the stream.

Additional BMPs that may address particular features on your creek include:

- ❑ Stabilize landslides along the channel and on canyon slopes. Consult with NRCS, or an engineering geologist, for assistance.

- ❑ Do not remove trees that fall into the stream unless a bridge or structure is threatened. Work with Fish and Game to relocate large wood rather than removing it.

- ❑ Revegetate channel banks identified on the inventory as bare or without canopy if revegetation with riparian species is appropriate.

- ❑ Revegetate slopes and hillsides with native species and forest to increase future supplies of large wood and increase canopy over the stream, as well as reduce soil erosion and stabilize slopes.

- ❑ Install large wood and stumps to increase habitat for fish – consult with Fish and Game on locations and project design.

- ❑ All new activities on slopes near to the streams should avoid disturbing the channel or removing trees within 300 feet of the channel. Forestland studies have shown that this 300 feet streamside buffer area provides large wood and shade canopy.

- ❑ Work with neighbors to reduce erosion and fine sediment from getting into the creek. Avoid increasing flood volumes though avoidance of new road construction, vegetation clearing and urbanization.

- ❑ Review your inventory of the confined channel to determine which features it has and which BMPs are needed. On the Farm Conservation Plan template indicate the BMPs to be applied to the confined channel.

CONFINED/BEDROCK CHANNELS: IMPLEMENTATION TIMELINE

The implementation timeline sets out how the Farm Conservation Plan will get done. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds. Generally, the implementation timeline for each element should outline a sequence of events.

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ELEMENT VII – PHOTO-MONITORING: INSTRUCTIONS AND BENEFICIAL MANAGEMENT PRACTICES

This element is for new, existing and replanted vineyards and addresses creating a photo-monitoring program for your farm to document your use of BMPs and to document natural changes from floods and other events.

Background: Photo-monitoring

Taking photographs of selected sites preserves a record of your use of BMPs on the site and can be very useful to document your efforts. It is also useful to photograph creek or river corridors at bridges and other fixed points during and after storm events to document changes over time. Photo-monitoring is part of the Fish Friendly Farming certification process. You will need to take photos throughout the year to document your use of BMPs.

You will need:

- ❑ Camera with flash
- ❑ If you intend to go into the water you may want to purchase a low cost or disposable waterproof camera. You should not wade into the stream for any reason during high or swift water flows
- ❑ Notebook to record the order and the subjects of the photos you take or computer file folders and captions for digital photos

APPLYING THE BMPs: PHOTO-MONITORING

- ❑ On the Farm Conservation Plan template, indicate any type of monitoring such as a rain gage or a waterflow stage gage you regularly watch or measure. This includes any stream flow you measure as part of your water rights or diversions.
- ❑ Review the list of features on the Farm Conservation Plan template and mark the ones you need to include in your photo-monitoring. On a copy of your aerial photo, mark with an **X** the sites where you will photograph your site features. Give each photo-monitoring site a number and use the number on your photos.
- ❑ Mark the date the photo was taken or use a camera with a date setting. Mark the site number or location and time on each photo. Keep the photos in your Farm Conservation Plan.

IMPLEMENTATION TIMELINE

The implementation timeline sets out a schedule for the actions identified in the Farm Conservation Plan. The timeline covers a ten-year period and allows for the costs of repair and restoration work to be spread out over this period. The timeline section of the Farm Conservation Plan should also identify the projects that the farmer intends to apply for cost share or grant funds.

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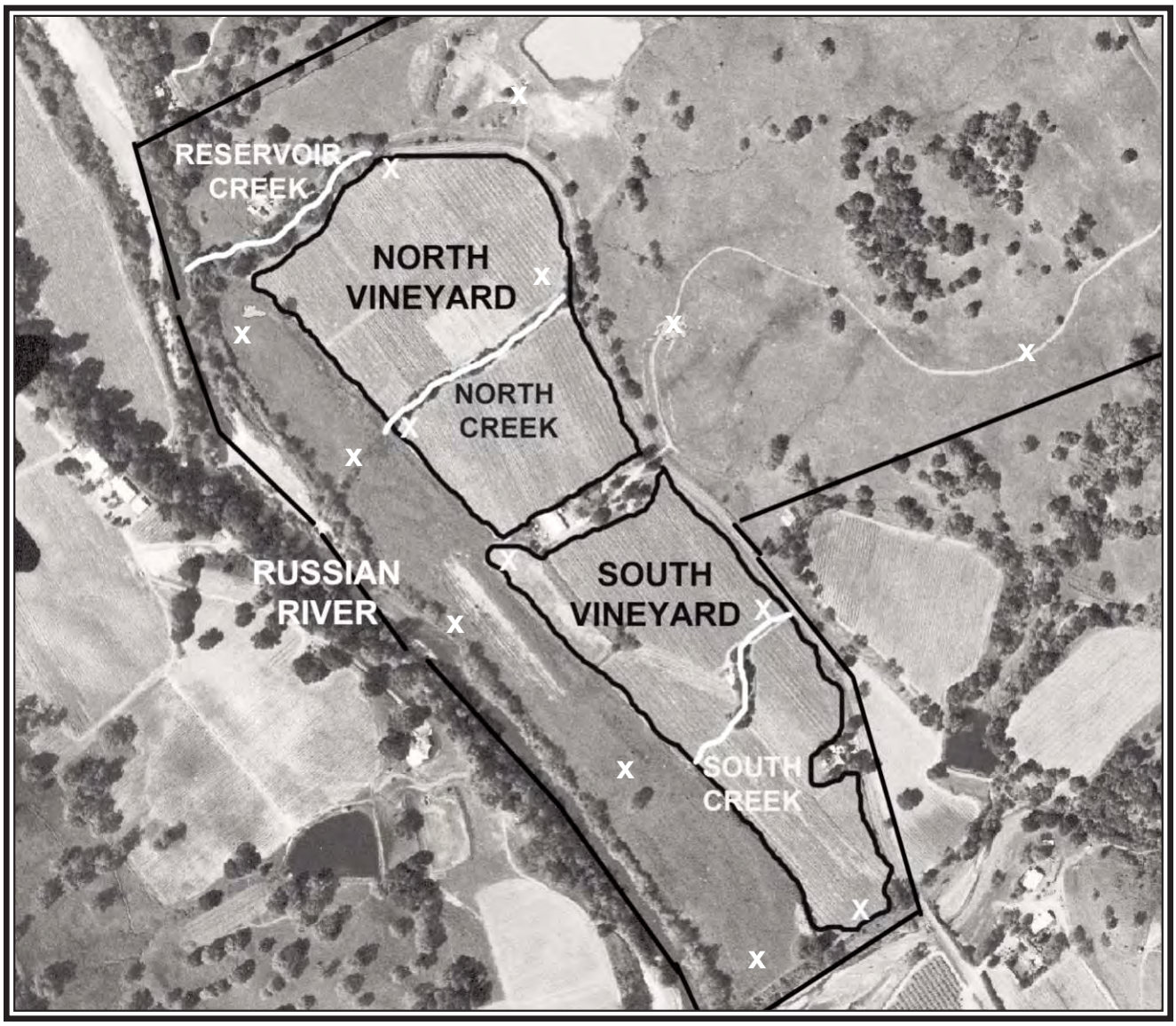

Fish Friendly Farming Environmental Certification Program	FARM PLAN MAP SHOWING PHOTO-MONITORING SITES WITH “X”

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DATABASES USED FOR TOXICITY INFORMATION TABLE

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http://www.epa.gov/docs/envirofw/html/emci/chemref/index.html. US EPA Envirofacts Master Chemical Integrator

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http://www.pw.ucr.edu/WQ_Homep.asp. Pesticide Wise – University of California, Riverside Cooperative Extension Water Quality Program

www.pesticideinfo.org. Pesticide Action Network Pesticide Database

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APPENDICES

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Available upon request

Appendix 1	**Universal Soil Loss Equation** (Source: *The Universal Soil Loss Equation: Special Applications for Napa County, California. 1994. USDA Natural Resources Conservation Service.*)
Appendix 2	**Modeling of Stormwater Discharges** (Source: *Laurel Marcus and Associates*)
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Appendix 7	**Certification Process** (Source: *Fish Friendly Farming Program*)

SCANNED FOR KRIS

HANDBOOK FOR FOREST AND RANCH ROADS

A Guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads

PREPARED BY

WILLIAM E. WEAVER, PHD.

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FOR

THE MENDOCINO COUNTY RESOURCE CONSERVATION DISTRICT

IN COOPERATION WITH

THE CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

AND THE U.S.D.A. SOIL CONSERVATION SERVICE

JUNE 1994

All programs and services of the U.S.D.A. Soil Conservation Service, Mendocino County Resource Conservation District, and the California Department of Forestry and Fire Protection, are offered on a non-discriminatory basis, without regard to race, color, national origin, religion, sex, age, marital status, or disability.

ACKNOWLEDGMENTS

Many individuals and organizations have made important contributions to the preparation of this road guide. Funding was provided by the California Department of Forestry and Fire Protection, through a cooperative agreement with the Mendocino County Resource Conservation District (RCD), in cooperation with the USDA Soil Conservation Service (Ukiah office). This book was prepared by Pacific Watershed Associates, Arcata, California, under contract with the Mendocino County RCD[1].

John Munn, California Department of Forestry and Fire Protection; Tom Schott, USDA Soil Conservation Service (Ukiah); Trinda Bedrossian and Tom Spittler, California Division of Mines and Geology; Craig Blencowe, Mendocino County RCD; and Pete Passof, Cooperative Extension Service (Ukiah) provided technical reviews of portions or all of the text. These and other individuals also served on a Technical Review Committee that steered the book's early development

Many other individuals have reviewed portions of the text or provided comments, graphics or ideas on individual topics covered in the document. Invaluable ideas and discussions came from staff of the California Department of Forestry and Fire Protection, California Department of Fish and Game, North Coast Regional Water Quality Control Board, California Division of Mines and Geology, U.S. Forest Service and agencies of other western states.

A summary book like this necessarily draws from a wide variety of sources for ideas and technical information. Ideas for some of the text and graphics came from publications produced by the States of Montana, Oregon, Washington and California, the U.S. Forest Service, the Soil Conservation Service, the National Park Service and the Ministry of Forests, British Columbia, Canada. These publications are listed in the references to this document. Many figures were developed or modified from these sources. Special appreciation is extended to the Information and Extension Branch, Ministry of Forests, Province of British Columbia for permission to borrow graphics and ideas from their publication A *Guide for Management of Landslide-Prone Terrain in the Pacific Northwest.*

Special thanks is also extended to those forest and ranch landowners who not only gave us permission to inspect and photograph their road systems, but who also took time-out to lead field trips and discuss their strategies and techniques for successful wildland reading. Foresters and engineers from Sierra-Pacific Corporation (Weaverville and Anderson), Louisiana-Pacific Corporation (Ukiah), Simpson Timber Company (Korbel), Champion International Corporation (Redding), The Pacific Lumber Company (Scotia) and Coastal Forestlands, Ltd. (Ukiah) were especially helpful.

NOTE: Local, County and State regulations in California cover many of the same subjects presented in this guide. Regulations change quickly, as do the technical methods of reading and the standards for environmental protection. Be sure to follow applicable regulations covering private land road building and related activities for your area. We have provided a general description of the requirements of many (but not all) regulatory agencies, but you will need to be sure that your specific project meets all applicable standards and regulations before you begin work. The information presented in this guide is not an exact "mirror" of California's Forest Practice Rules. However, we have tried to be consistent in terminology, in general content, and in spirit with the goals of the Z'berg-Nejedly Forest Practice Act and California's Forest Practice Rules.

[1] Any errors in the text are those of the authors and not those of the agencies or individuals who provided review of the text. Technical comments and suggestions related to future updates and revisions should be forwarded to Pacific Watershed Associates, P.O. Box 4433, Arcata, CA 95521.

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CHAPTER I: INTRODUCTION

A. Purpose

If you work in a wildland area, own forest or ranch land, or are concerned about our natural resources, this book is for you. It contains guidelines for developing and maintaining a single forest or ranch road or an entire wildland road-access system. It describes how to plan and design a stable road or road network in mountainous lands or gentle valley bottoms, and avoid many of the common pitfalls and environmental/pollution problems for which rural and forest roads are noted. Nearly everything discussed in this manual is aimed at producing efficient, low-cost, low-impact roads that have a minimal effect on the streams of a watershed.

Reading and understanding this manual is not enough. It takes the common-sense, intelligent, practical application of the general principles described here on each "on-the-ground" situation you encounter. Correctly applying these "roading" concepts requires practice and personal judgement. The concepts presented in this handbook are not rules or laws; rather, they are tools which should serve as one of your many sources of information and guidance. The success you achieve will be reflected not only in the stability of your roads, but also in the quality of the water and the health of the streams and watersheds through which they pass.

California's forest and ranch lands provide beauty, clean water, abundant wildlife, fish habitat, recreation, timber and thousands of jobs. This book is dedicated to the wise stewardship of these resources. It describes how we can and should protect our streams, water resources and productive soils, while at the same time provide recreational opportunities and natural resource jobs for our local communities.

B. Contents and organization

This is a practical guide and field manual, and therefore does not cover all topics in the same depth or detail as a textbook. It is designed to be descriptive and informative, yet cover the fundamentals of road planning, design, construction, reconstruction, maintenance and closure. The handbook is organized under these basic topics, and they appear in the general order that they are encountered in the road-building process.

The text of this manual contains both simple informational and instructional material, as well as more detailed discussions of specific practices. For the lay reader, some of the discussions may be too technical, or contain unfamiliar terms and concepts. It is assumed that readers have a basic understanding of road terms (such as fillslope, cutbank, roadbed, stream crossing, etc) and reading practices (such as sidecasting, compacting and endhauling, to name a few). Many of the more technical or uncommon terms have been defined in the text where they first appear, and in the glossary of defined terms included at the end of this book. If you find the descriptions in the text too complex for your needs, a shorter companion volume to this text is available which illuminates the basics of road planning, location, construction and maintenance with a minimum of technical "jargon."

The following summary outlines the chapter contents of this handbook. Within each chapter, some of the more important principles of modem forest and ranch land reading practices have been highlighted in bold print to draw them to your attention.

Chapter 1 discusses how this handbook is organized and serves as an introduction to the concepts of what makes a good road, how a watershed works, and what naturally affects the quality of its water and stream resources. **Chapter 2** describes the need for, and process of, planning for roads. It describes road standards and route planning, using maps and photographs.

Included in **Chapter 3** are discussions of what obstacles to look for during on-the-ground scouting for a road alignment, laying out curves and switchbacks, and a description of the tools that are useful in locating a road in the field. Road design is covered in **Chapter 4,** including road prism and landing design, surface drainage design, and special designs for wet or unstable soils.

Chapter 5 is dedicated to the important topic of road drainage. It includes detailed information on proper surface drainage techniques and structures, ditches, spacing and design of rolling dips, waterbars and culverts, stream crossings, bridges, culvert sizing and placement, and temporary stream crossings.

Chapter 6 covers the construction process, including grubbing and clearing, grading, stream crossing and bridge installation, surfacing, erosion control and spoil disposal. The special but increasingly common activity of road reconstruction is discussed in **Chapter 7**, where the topics covered include road relocation, road redesign, drainage structure upgrading and replacement, and erosion control.

Chapter 8, road maintenance, reviews the topics of road surface maintenance, stream crossing maintenance, maintenance of fills and cuts and winterizing roads. Techniques for indentifying problem culverts and establishing prioritized storm maintenance schedules are also outlined.

Road abandonment and road closure techniques have only recently begun to receive special attention because of their potential long-term effects on water quality. **Chapter 9** describes techniques by which roads that are to be temporarily closed or permanently abandoned can be "erosion-proofed" to prevent subsequent soil loss and to put land back into timber production and other uses.

Finally, the appendices to this handbook contain information on specific topics, such as culvert sizing and curve layout, as well as other sources of information you may find helpful.

C. Watersheds

Wildlands act as the collectors of pure water. Watershed areas collect precipitation and funnel it to downslope and downstream areas through a network of swales and channels carved into the landscape (Figure 1). Some water flows as surface runoff and some enters the soil and groundwater system. Logging, road construction and other activities can disturb the soil and drainage patterns, thereby causing erosion and the release of sediment into stream systems and downstream areas.

Figure 1. *Watersheds in forested and rangeland, areas present a diversity of opportunities and. challenges for water, land and resource management. Roads provide access to areas within a watershed and thoughtful planning, design., construction and. maintenance of road systems are important to protect sensitive streams and aquatic life.*

Streams are classified as **ephemeral** (flowing only during periods of extended rainfall), **intermittent** (flowing during and for a period following rainfall), or **perennial** (flowing most of the year, flow during the summer coming from emerging groundwater). Ephemeral streams may drain water into either intermittent and perennial watercourses. Streams carry both water and sediment to downstream areas, so care must be taken to minimize disturbance to channels and the slopes which drain directly into them. It should be noted that only the largest streams of a watershed are shown on a topographic map, and that many more watercourses, particularly intermittent and ephemeral streams, are likely to be found on the ground. ***Don't rely solely on map information to find and identify streams.***

For forestry operations, the term **"watercourse"** is often used instead of stream. California's Forest Practice Rules (CFPR) describe watercourses as "any well defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel or soil... including manmade watercourses." Watercourses are categorized into Class I, Class II, Class III or Class IV. In general. **Class I** watercourses contain fish or provide domestic water supplies. **Class II** watercourses have fish present within 1000 feet downstream or contain habitat for non-fish aquatic species. **Class III** watercourses have no aquatic life present, but show evidence of being capable of sediment transport to downstream locations and **Class IV** are man-made watercourses.

Although not included in the definition of watercourses, roads, road-side ditches, skid trails and landing surfaces can act as man-made drainages which carry water and sediment into natural streams. Care should be taken to disperse surface runoff so these "man-made" watercourses do not impact water quality.

Wetlands are also common watershed features. Wetlands may occur wherever groundwater emerges onto the surface, such as at a spring, a seep, a marsh or a bog, or where water ponds for some time during the year. Some wetlands drain into streams, while others do not. Even when dry, many wetlands can be recognized by the presence of certain water-loving plants. Wetlands should be avoided during road construction activities, as they result in special problems that often require expensive construction techniques and may cause continuing land stability problems. Wetlands require special protective measures and are highly sensitive to disturbance. The California Department of Fish and Game can provide assistance on wetland delineation and protection measures, and can advise you concerning which agency to contact about applicable wetland regulations.

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. Riparian vegetation may be impacted, resulting in increased summer water temperatures and loss of food and cover for fish and wildlife.

D. Typical erosion and sedimentation problems caused by roads

Roads are a major source of erosion and sedimentation on most managed forest and ranch lands. Compacted road surfaces increase the rate of runoff, and road cuts intercept and bring groundwater to the surface. Ditches concentrate storm runoff and can transport sediment to nearby stream channels.

Figure 2. *This stream crossing "washed out" (eroded) when the culvert plugged and streamflow scoured through the road road fill. Sediment was delivered directly to the stream system as the fill eroded. Stream crossings and culverts need to be properly designed and maintained to minimize the potential for such failures.*

Culverted stream crossings can plug, causing fill wash outs (Figure 2) or gullies where the diverted streamflow runs down nearby roads and hillslopes (Figure 3).

Figure3. *When a stream crossing culvert plugs, or its capacity is exceeded, flood/low can either build up and/low over the road, washing out the stream crossing/ill, or it can be diverted down the adjacent road or roadside ditch, creating a gully on the road and adjacent hillslope. Diverted flow from this plugged culvert has created a large gully in the down-road ditch. Note scale located at plugged culvert inlet. Road prism is to the right.*

Roads built on steep or unstable slopes may trigger landsliding which deposits sediment in stream channels (Figure 4). Filling and sidecasting increases slope weight, road cuts remove slope support, and construction can alter groundwater pressures, all of which may trigger landsliding. Unstable road or landing sidecast materials can fail, often many years after they were put on steep hillslopes. Lack of inspection and maintenance of drainage structures and unstable road fills along old, abandoned roads can also result in soil movement and sediment delivery to stream channels.

Figure 4. *Sidecast road construction on steep or unstable stream-side slopes and canyons has a high potential/or causing landslides which deliver sediment to downslope stream channels.*

E. Importance of proper planning and construction

Road construction does not have to result in excessive erosion and downstream sedimentation. Proper planning, design and construction techniques used in road location and building, and drainage structure installation, can prevent water quality problems and can significantly extend the useful life of the road. Roads can be planned and located to avoid unstable, credible areas, and stream crossings can be planned, located and built using techniques which minimize the potential for post-construction erosion or slope failure. Good planning, proper location and the use of progressive construction practices can largely avoid the impacts normally associated with road building. Do it right, and youll end up with a low-maintenance, low-impact road. Do it wrong, and you're destined for high maintenance costs and high environmental impacts. The choice is clear.

F. Elements of a stable road

The features described in this section form the building blocks of stable roads. They include elements of the road's physical environment, critical control points (locations of special concern or sensitivity along the alignment), restrictions on road location (legal and physical), how to keep a stable road once it's built, and where to find additional help and information.

1. Physical environment

The physical environment of the road includes such factors as the slope of the land, the types of bedrock and soils through which the road passes, as well as surface and subsurface drainage across the alignment Together, these physical factors determine the best choice for road location in a watershed, as well as the most suitable techniques for constructing a stable, low-maintenance road.

a. Slope of the land: The slope of the land is one of the most important elements that control where and how roads are built. Road building becomes more difficult and expensive as land slopes become steeper. Roads built on steep slopes are also more likely to have erosion and stability problems.

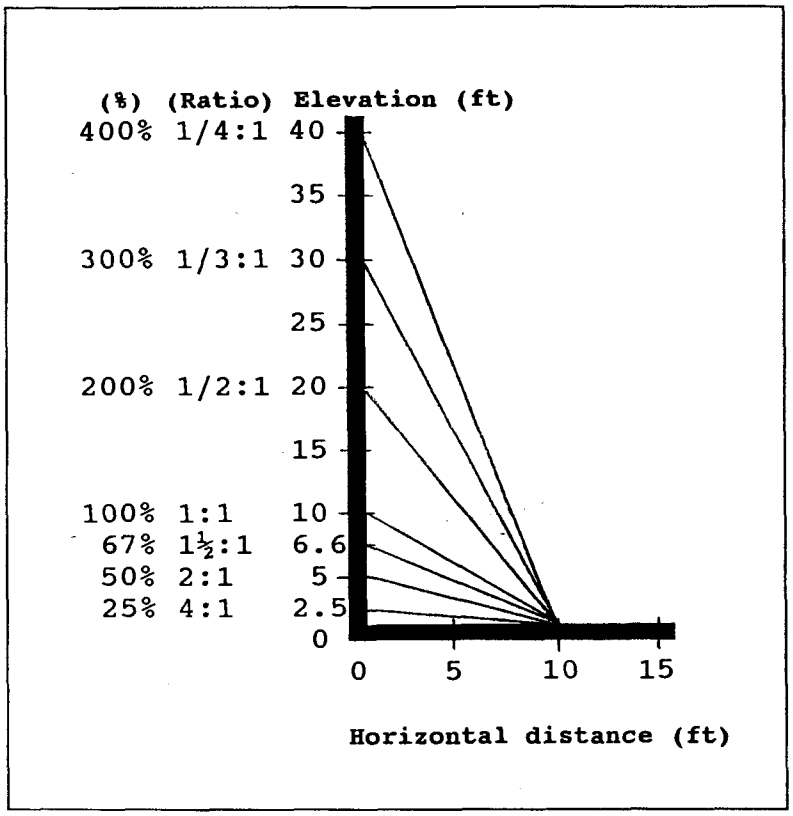
Slope gradient can be expressed in several different ways. The slope of the land is usually expressed in percent, such as "50%". The slope gradient of cut- and fillslopes is often expressed as a ratio, such as 2-to-l. A 2-to-l slope means that for every two feet in the horizontal direction the land surface rises or falls 1 foot in elevation (two feet out for every one foot up or down). A 2-to-l slope is also said to have a gradient of 50 percent (50%). A 100% gradient would correspond to a 1-to-l slope pitch, and a 25% slope has a 4-to-l slope ratio. Less often, slopes are expressed in degrees (e.g. 30°).

Table 1 shows typical land and bank slopes, expressed as horizontal-to-vertical ratio (e.g., 2-to-l, or 2:1), percent (e.g., 50%) and degrees (e.g., 27°), and Figure 5 graphically depicts some of the more commonly expressed slopes. Fillslopes and cutbanks are also described using these slope measurement units.

Table 1. Relationship between ratio, percent and degrees as measures of slope steepness.		
Common Ratios	Percent	Degrees
	5.0	2.5
10:1	10.0	5.7
4:1	25.0	14.0
3:1	33.3	18.4
	35.0	19.0
	45.0	24.2
2:1	50.0	26.6
	65.0	33.0
1½1	66.7	33.7
	70.0	35.0
	80.0	38.6
	90.0	42.0
1:1	100.0	45.0
½1	200.0	63.4
¼1	400.0	76.0

Land slopes can be estimated from the contours on U.S. Geological Survey topographic maps, based on the scale of the map, the spacing between the contour lines and the stated "contour interval" for the map. Table 2 provides the needed data for determining land slope from a standard 1:24,000 scale contour map. Keep in mind, however, that the map shows an average slope between contour lines. In the field, land slope often varies considerably over short distances and is best measured using an instrument called a ***clinometer.*** A pocket-clinometer shows slope steepness, expressed in either degrees or percent, by looking either up or down the slope through the instrument.

Figure 5. Slope diagram graphically shows common cut and fill slope angles, and expresses steepness in both percent and slope ratio.



Roads should not be built directly up a slope that exceeds about 15%, unless it is for a short pitch of less than 500 feet with a road grade not exceeding 20%. This can help prevent serious drainage and surface erosion problems. Most roads traverse across the slope, and it is not difficult to" keep road grades to less than 3%-5%, even where the slope of the land exceeds 50%. Ridges, natural benches and gentle sideslopes far away from stream channels are usually the best places to build roads. Steeper pitches are sometimes required to avoid unstable areas or other obstacles.

Table 2. Land slope (%) as derived from a 1:24,000 scale topographic map

Contour interval of map (ft)	Measured distance (mm) between contours on topographic map (best if averaged along fall line over several contour lines)														
	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	2.0	2.5	3.0	4.0
20	51	42	36	32	28	25	23	21	20	18	17	13	10	8	6
40	102	85	73	64	56	51	46	42	39	36	34	25	20	17	13
80	203	169	145	127	113	102	92	85	78	73	68	51	41	34	25
120	304	254	218	191	169	152	139	127	117	109	102	76	51	61	38

b. Bedrock and soils: The stability and credibility of a road alignment is controlled by the underlying bedrock and soil material. Bedrock composition and the properties of soils vary dramatically along most road routes. Each soil and bedrock type reacts differently to road construction and road drainage.

Some important bedrock properties that influence slope stability and the ease of excavation for road building include rock hardness, direction and inclination of rock layering, amount of natural fracturing, amount of weathering or natural decomposition, and mineral composition. Highly fractured or weathered rocks, or rock layers that slope parallel to the hillside, are likely to result in erosion and stability problems during or after construction. These conditions often lead to high maintenance costs.

A number of soil properties will also influence how easy it is to build a road, how stable the road will be following construction, and how much erosion is likely to occur when the soils are exposed. Such properties include soil depth, credibility, texture, and compactibility. Soil texture is one factor used in determining the credibility or "erosion hazard rating" of a soil, and can be evaluated using simple field tests (Figure 6). The properties of soils in an area can generally be determined from soil survey maps and reports available from the local office of the U.S. Soil Conservation Service or from the California Department of Forestry and Fire Protection.

The responses of soils to road construction and use can often be anticipated from the information in these reports. In practice, where a road is to cross steep slopes, or portions of the route will traverse unstable areas, soil maps should be reviewed and a geologist should be consulted to evaluate the suitability of the site for the planned road building activities.

If soil maps do not exist or are not available, simple tests can be performed in the field to estimate the soil's most important properties. For example. Board of Forestry Technical Rule Addendum #1 for estimating surface erosion hazard rating can be used to estimate the erosional sensitivity of soils the road will pass through. However, this procedure only estimates the soil's susceptibility to surface erosion caused by rainfall and runoff. The likelihood of mass soil movement (landsUding) should be determined in other ways.

c. Drainage: "Drainage," refers both to subsurface drainage (groundwater flow) and surface drainage (runoff).

i. Subsurface drainage: Water held in the soil is called soil water or ground water. If too much water is in the soil (because of seasonal wetness or poor drainage) the weight of vehicles can deform the soil and turn it into mud, with lime form or texture. On a sloping road, the mud can become a safety hazard, the roadbed may be damaged, and sediment can flow into ditches and nearby streams, causing water quality problems.

Some soils are naturally wet and poorly drained, and should be avoided during road building operations. These are often indicated by pools and wet areas on the ground surface, especially during the wet winter months. Such sites can often be recognized during dry summer periods by noting changes in vegetation types. If you are unsure, obtain professional assistance.

Wet areas can sometimes be drained, but unless the source of the emerging ground water is eliminated, wetness may be a continual problem at the site. Once water has emerged onto the ground surface (on the cutbank, in the ditch or on the road surface), it should be directed away from the site and discharged onto a stable area. If the road must pass over a known wet area, modern subsurface drainage techniques can be used to drain the ground beneath the roadbed. Subsurface drainage techniques include the use of gravel-lined "French-drains," with perforated

pipes buried in ditches, and other combinations of gravels and overlying filter fabrics. Avoidance is the least expensive and most successful method for preventing subsurface drainage problems, and it is almost always best to re-route the road to avoid natural wet areas.

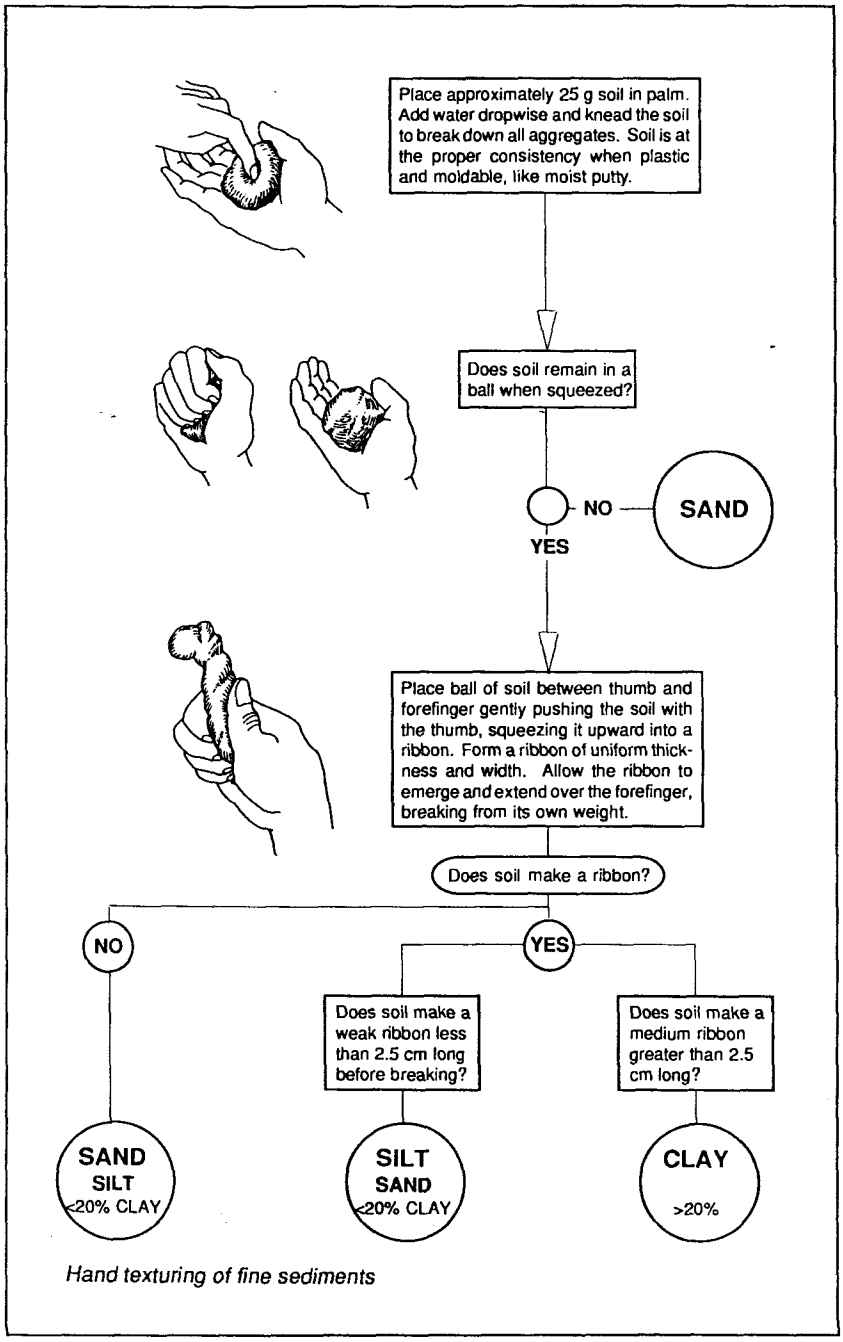


Figure 6. *The texture of fine sediments and soils, an important component used to evaluate soil credibility and erosion hazard, can be estimated using a simple hand-texturing field test (B.C.M.F., 1991).*

ii. Surface drainage: The key to successful surface drainage is to get the water off the cutslopes, fillslopes and road surface as quickly as is possible, before it has the opportunity to concentrate into a large volume of flow. The two most important rules for accommodating surface runoff are 1) get water off the road *rapidly* so it cannot erode or seep into the roadbed, and 2) get it off the road *often* to avoid large, erosive flows from developing in long, undrained ditches.

A simple method, called the 5-D test, can be used to measure the effectiveness of road drainage systems. This test relies mostly on visual information and analysis of road surface drainage. The 5-D's are:

1. Are <u>all</u> natural **DRAINAGES** conveyed (e.g., carried in dips, fords, culverts or bridges) across the road and released back into their natural channels (this includes both small and large streams and watercourses)?
2. Does the road drainage system actually **DIVERT** water off the road surface?

3. Is drainage quickly **DISCHARGED** from the road?

4. Is the energy of flowing water **DISSIPATED** onto non-erodible material at the point of discharge?

5. Is the **DISTANCE** between structures adequate to prevent erosion of the roadbed?

These five tests apply to all drainage methods, including road outsloping, waterbars, rolling dips, ditch relief culverts, stream culverts and bridges. The first four tests can be conducted by observation; the fifth test can be evaluated by published standards (Table 3) and by field observations for your area.

Table 3. Maximum distance between waterbreaks on roads and trails (feet)[1]

Erosion Hazard Rating (for surface erosion)	**Road or Trail Gradient (%)**			
	10%, or less	**11-25%**	**26-50%**	**over 50%**
Extremely high	100'	75'	50'	50'
High	150'	100'	75'	50'
Moderate	200'	150'	100'	75'
Low	300'	200'	150'	100'

[1] *from California Forest Practice Rules. This is the* <u>*maximum distance between waterbars:*</u> *when in doubt, reduce the spacing. Soils are non-renewable and waterbars are inexpensive.*

The use and correct placement of drainage structures such as culverts, rolling dips, diversion ditches, insloping, outsloping, inboard ditches, ditch relief culverts, waterbars and stream culverts are worth the initial cost of installation. Correction and repair may be 2-10 times more costly than the original installation, and damage to the land and nearby streams may not be correctable.

2. Control Points

The stability of a road and its impact on the environment are often determined by how the road is designed and located around physical points of control in the landscape. Efforts should be made to avoid as many obstacles and stream crossings as is possible when planning and locating a road alignment

a. Obstacles: Obstacles to a stable road include unstable slopes (slumps, debris slides, debris flows (torrents), and earthflows), hard rock outcrops, very steep slopes, highly erodible soils, ponds and lakes, swamps and property boundaries. These features should be precisely located during road reconnaissance since they constitute control points that will influence the final location of the road.

Agreements with adjacent landowners should be arranged when needed to prevent property boundaries from forcing roads to be built in unstable or unsuitable locations that could cause excessive erosion and damage in downslope and downstream areas. In addition, recognition of slope instabilities may sometimes be easy, but the skill and expertise of a trained geologist is often needed to determine the full extent of unstable areas and to choose a suitably stable alternate route which bypasses the obstacle. **In the long run, employing an expert to solve a technical problem is much less expensive than repairing a major road failure.**

b. Stream crossings: Stream crossings are particularly vulnerable to erosion and failure. For this reason, **the number and size of stream crossings that have to be constructed along a new road should be strictly minimized.** The more deeply incised a stream canyon is, the more excavation, soil disturbance and erosion are likely to occur during and after construction of the crossing. Therefore, stream crossings should be located where the channels are least incised, across natural benches, and where sideslopes are gentle and stable. In addition, stream crossings should be built at right angles to the stream channel, and, where possible, streams requiring a 48", or larger, diameter culvert or large volumes of fill should be bridged.

The use of prepared crossings is required wherever roads must cross a stream or watercourse. They may be permanent, including a culverted fill crossing, a bridge or a ford, or they may be temporary, such as a temporary culverted fill or a log crossing, that needs to be removed before the beginning of the following winter period (generally considered as beginning on October 15). All forest-land stream crossings that are to remain in place for one (1) or more winter periods must be designed to pass at least the 50-year storm flood flow. Crossings on older forest roads that need reconstruction must also be designed to current 50-year flood standards (methods for estimating the 50-year flood flow for a stream are included in Chapter 5 and in Appendix A). These standards are appropriate for all wildland roads, including forest and ranch land road systems.

Stream crossing installations often require a California Department of Fish and Game (CDFG) 1603 permit before any in-stream work can be undertaken. Many Class I, II and III watercourses not shown on the topographic maps will need 1603 permits, and all watercourses that are identified on maps, on photos or during field reconnaissance will need properly planned and designed stream crossing installations. If you need assistance, ask the Department of Fish and Game for their advice in preparing a stable stream crossing.

Some stream crossings require extra careful design to accommodate fish passage. These will require consultation with CDFG experts, to determine crossing type (ford, bridge, pipe arch or plate arch culvert or full round culvert), culvert length, the need for baffles, inlet and outlet location, acceptable culvert grade, resting and jump pools, and water depth. Preparing and installing the proper crossing in the first place is also much less expensive than having to modify a structure already in-place.

c. Road grade: The slope of the road is called "road grade." This is not the same as the slope of the land. Road grade is typically expressed in percent (%). A road that rises or falls 10 feet for every 100 feet of its length has a grade of 10%.

Steeper roads are more likely to suffer from erosion and vehicle damage if used when wet, and this leads to increased safety hazards compared to low gradient roads. Where possible, new road alignments should use grades of 3% to 5%, or less. According to the California Forest Practice

Rules, grades should be kept below 10% (try for a 7% maximum) except for short pitches of 500 feet or less where road grades may go up to 20%. These steeper road grades should be paved or rock surfaced and drained frequently if they are to be used during the wet winter months.

3. Other limitations on road construction and location

A number of physical limitations on road location have already be discussed, including obstacles and stream crossings. But other factors may also limit when and where a road can be built

a. Seasonal construction limitations: California's climate is generally one of wet winters and dry summers. The extremes of wet and dry limit the dme of year when construction activities can safely take place. However, there are a number of planning and reconnaissance activities that can, and should, take place during wet periods. Indeed, winter is the best period for field reconnaissance and to identify springs, seeps and small streams that might not be visible during dry periods.

Generally, construction and reconstruction activities should be dmed to minimize soil erosion, to give vegetation dme to take hold before heavy winter rainfall begins, and so heavy equipment will not have to work on wet soils. Late spring through middle summer is the best period for heavy equipment work in many locations. Some moisture is required and desirable for adequate compaction of fill materials, but road construction should not begin before the soil has had time to drain and dry.

Table 4 outlines activities that can be safely conducted during various times of the year. In some years there are extended dry periods during the winter months when some heavy equipment work can be performed. However, California Forest Practice Regulations require that erosion control work be kept current, that a winter period operating plan be prepared and filed (if necessary) to guide winter operations, and that work be immediately shut down ***before*** conditions begin to affect water quality.

Table 4. Timing of road planning and construction activities.

Season	Planning and design	Field Layout	Construction and re-construction	Inspection and Maintenance	Closure
Winter	+[1]	+	No	+	No
Spring	+	+	V (late)	+	-
Summer	+	-	+	+	+
Fall	+	-	V (early)	+	+

[1] *Key to symbols: + = good or excellent season/or this activity. "\/ = OK or good time to perform this work. - = not a very good season for this type of work. NO = this is not a good time for construction or closure -work using heavy equipment, unless there is an extended dry period. Each season has periods when work can be undertaken. Winter equipment work, if undertaken, should be planned and conducted carefully, with erosion control work kept up-to-date.*

b. Buffer strips and stream or watercourse and lake protection zones (SPZ; WLPZ): A sufficient buffer or filter strip of undisturbed vegetation should be left between road building and road maintenance activities and nearby streams. Road surface drainage should be sent through a filtering area with enough ground cover to catch any sediment coming from road runoff. Filter strips should be retained even for Class III watercourses and ephemeral streams that may not be flowing at the dme of road construction or maintenance. **Streambeds do not *make* good roads and should not be used for that purpose.**

Table 5 lists recommended minimum filter or buffer strip widths for protecting water quality, but these distances may have to be modified depending on vegetation cover and soil conditions. Where there is inadequate roadside vegetation, physical barriers (logs, brush, ditches, etc.) or small sediment retention structures/basins may be added to trap some of the sediment coming off the road surface or fillslopes. For example, the filtering effectiveness of buffer strips can be dramatically improved if slash is placed at the base of fillslopes along the road alignment These structures are called **filter windrows.** Inboard ditches and ditch relief culverts should be discharged onto vegetated slopes and ***never*** into natural stream channels or-watercourses.

Table 5. Recommended minimum widths for buffer/filter strips between wildland roads and streams[1]

Slope of land between road and stream (%)	Minimum width of vegetated filter or buffer strip (ft)
0	50
10	90
20	130
30	170
40	210
50	250
60	290
70	330

[1] *USDA, 1978*

c. Ordinances: County, state and federal ordinances regulate many aspects of road construction, reconstruction and maintenance. Some examples of these are listed below.

i. County - Department of Public Works and/or Building Departments often have grading ordinances that may apply in your area. These ordinances describe how private roads may be constructed and how these roads may connect with existing public roads. Permits may be required, and County Planning Departments may also want to review proposed roads that are being constructed for large and small lot splits and subdivisions, even in rural areas.

ii. State - State regulatory agencies with jurisdiction on road construction and related activities include the Department of Transportation, the Department of Fish and Game, the Department of Forestry and Fire Protection, and the Water Resources Control Board. Several other agencies have special jurisdiction. The California Department of Transportation controls private road connections with state maintained roads and highways. An application fee and bond or deposit may be required for this type of work. You should also check with the Coastal Commission when planning a road within the Coastal Zone. For new roads, archaeological clearance may be needed in areas where records show prehistoric activity or habitation. For developing rock pits and borrow sites over one acre in size, or exceeding 1000 cubic yards of overburden or rock material, the Department of Conservation should be consulted regarding development and reclamation requirements of California's Surface Mining and Reclamation Act (SMARA).

The Department of Fish and Game will need to review all road construction, road reconstruction or road removal jobs where the bed or bank of a stream or lake will be altered. This specifically applies to proposed stream crossings. A formal notification needs to be made to the Department, submitted on Form 1603, describing the proposed work and including an application fee (see Appendix B). The Department has 30 days to respond to the application and may propose mitigations and/or ask for a field review of the site. Most 1603 applications take about three weeks to clear before operations can begin, so paper-work needs to be submitted ahead of time. Check with the local warden to file a 1603 application and/or to set up a field inspection.

To build or rebuild a road for commercial harvesting of trees, firewood or other forest products, a licensed forester needs to file a timber harvesting plan (THP) with the Department of Forestry and Fire Protection. This includes any commercial timber or other saleable wood products from road building or reconstruction work. Specific regulations must be followed for planning, designing, constructing and maintaining these logging roads (Appendix C). Fire-safe road standards have also been developed for rural subdivision roads that require CDF review prior to construction.

The State Water Resources Control Board and the Regional Water Quality Control Board with jurisdiction in your area administer and enforce provisions of California's Porter-Cologne Water Quality Act, as well as the Federal Clean Water Act. Whenever water quality and the beneficial uses of water could be affected, these agencies need to be consulted. Sediment entering streams and watercourses is a serious pollutant and road construction, reconstruction and maintenance activities, if not performed properly and with care, can cause downstream pollution. Clean-up and correction actions ordered by the Board can be costly and cause significant delay, so it is always best to follow practices which are protective of water quality.

4. Keeping a stable road

Building a road should be viewed as a long-term commitment of both resources (cash and equipment) and personnel. If you are unable to make that commitment, then the road either should not be constructed, or it should be built as a temporary road with drainage structures that are removed after use. Many dead-end spur roads built during timber harvesting activities can and should be designated as temporary. If and when they need to be rebuilt in the future, stream crossings can be reconstructed and the road regraded.

A road built with drainage structures and stream crossings needs to be maintained during the winter period (as storms occur), during the summer period (as it is being used), and preceding each winter period (to prepare the road for winter). Periodic and storm maintenance inspections and activities need to be performed frequently and regularly during the first several rainy seasons as the road "settles in" and stabilizes. Each year that follows, the road and its drainage structures should be regularly checked'and, when necessary, repaired.

When the need for a road diminishes, it is not sufficient to close the road by simply abandoning it or by putting up barricades or a gate. If a road is not going to be maintained for one or more seasons, it needs to be proactively abandoned or "erosion-proofed." This is done by excavating stream crossings and removing culverts and by excavating potentially unstable fill material that might fail and deliver sediment to local stream channels during winter storms.

5. Where to find help...

Many people and references are available to help with development of wise decisions on planning, designing, locating, constructing, reconstructing, and proactively abandoning wildland roads. Table 6 lists some of the sources you can contact for guidance on plans for where, how and when to build a road. Don't hesitate to seek advice and assistance from other knowledgeable professionals with experience in your area.

Table 6. Sources of information for planning, constructing, maintaining and abandoning small private roads (modified from S.C.S. 1983).

Suggested source	Aerial photos	Weather reports	Vegetation	Permits	Technical assistance	Maps and Literature			
						Soils	Geology	Topo-graphy	Roads
Federal…									
Soil Cons. Service	X	X	X		X	X	X	X	X
Forest Service	X	X	X			X	X		
Bureau of Land Mgt.	X		X			X			
Extension Service	X	X	X		X	X	X	X	X
Geological Survey	X						X	X	
ASCS	X								
NOAA		X							
State...									
Dept. of Forestry	X	X	X	X	X	X	X	X	X
Div. of Mines and Geology	X				X		X	X	
Department of Transportation				X					X
Department of Fish and Game				X	X				
Reg. Water Quality Control Boards				X	X				

Table 6. (CONTINUED)

Suggested source	Aerial photos	Weather reports	Vegetation	Permits	Technical assistance	Maps and Literature			
						Soils	Geology	Topo-graphy	Roads
Universities (Depts. of Forestry, Geology and Engineering)		X	X		X	X	X	X	
University libraries			X			X	X	X	X
County...									
Public Works, Road or Building Depts.	X			X	X?				X
Timber Tax or Nat. Resource Depts.	X								
Planning Dept.	X			X					
County library			X?			X	X	X	
City & local...									
City library			X?			X	X	X	
Government				X					
Private...									
Consultants (forestry, geology, engineering, wildlife, etc.)	X		X		X	X	X	X	X
Outdoor stores								X	

CHAPTER II: PLANNING

A. Introduction to road planning

Good planning can minimize the impact of a road on the environment and provide low-maintenance, low-cost access for landowners. It will pay many times over to sit down and seriously plan for the road and road network before making irreversible decisions that cost extra money, waste time later and damage the environment

Two basic tenets of road planning should be followed. **First, minimize the number of roads constructed in a watershed through basin-wide planning.** If you don't own the entire watershed, consider meeting with other landowners to see how road network planning can benefit everyone by saving money and causing the least impact. Most landowners want to cause as little disturbance as is possible and to minimize costs. There is great economic and environmental benefit to developing a coordinated road plan and reducing road construction in a watershed. Roads should be minimized because they remove land from production and often cause erosion.

Second, existing roads should be used wherever possible, unless using such roads would cause more severe erosion problems than building a new alignment elsewhere. Existing roads might require some rebuilding or upgrading, but using them is usually much less expensive than new construction. Sometimes, because of property lines that divide ownerships, roads have been built close together on adjacent properties. Cooperative use of existing roads can prevent this kind of duplicate and unnecessary construction in the future.

Efforts should be made to develop easements or agreements that allow mutual use of roads on or near property boundaries. Written and recorded rights-of-way mutually benefit all parties concerned. Such agreements should define the road location, ingress and egress routes, road width, levels of use, maintenance responsibilities, monetary considerations, and any other pertinent points. A survey, properly recorded, may be needed to clearly identify the boundary line. It is suggested that an experienced local attorney be consulted to ensure that all legal and liability requirements have been addressed.

B. Need for a road

Two of the most important steps in planning for a road are 1) determining whether or not the road is actually needed and 2) deciding what standard of road is called for. Ask yourself these questions:

What will the road be used for? Will it be used for residential access, access for grazing or farming, timber hauling, fire control, or for recreation? What kind and size of vehicles or log yarding equipment will be used?

How often and when will the road be used? Is it a one-time use (e.g., for timber removal) or daily use (e.g. for residential access)? How fast do you expect to travel? Is it only to be used during the summer or will you need to use it during wet winter months (i.e., does it need to be an all-weather road)?

Is there an existing road, either on your property or on an adjacent property, that could be used or rebuilt? If the road is being built for timber removal, can an alternate harvesting or yarding method be selected that would either shorten the length of new road or eliminate the need for a new road altogether?

A sound, thoughtful review of the present and future needs for this road will assure that it will accommodate your needs. It is frustrating, and potentially costly, to build a road that cannot accommodate all the needed uses. At the same time, both forest and ranch roads should be built to the minimum standard necessary to accommodate all reasonably anticipated uses and equipment

C. Road size and standards

After deciding why a road is needed, you can determine the minimum size or standard that is appropriate to meet your requirements. Table 7 provides suggested minimum standards for single lane, packed gravel surface and dirt roads with traffic of less than 100 vehicles per day.

Horizontal curves occur where the road goes around a ridge, watercourse or other obstacle, and vertical curves are those where the road goes over the crest of a hill. Both kinds of curves require a minimum length of visibility at a given driving speed to assure safe stopping distances for trucks and other vehicles.

It is also important to provide passing lanes and turnouts on narrow, single lane roads, and turnarounds are needed at the end of all dead-end roads. Turnouts should generally be located so you can see from one to the next, and so oncoming traffic can safely pass without vehicles ever having to back up.

In some situations, long, straight roads may encourage excessive speeds. To discourage unsafe driving speeds, straight sections of road can be limited to 400 feet, or less. The road should be contoured to the landscape to minimize cuts and fills. Rolling dips, used for surface road drainage, also help keep travel speeds at a safe level.

Other considerations may also dictate road size. For example, in erodible, unstable or steep terrain, small narrow roads are often preferred because of their lower environmental impact. Spur roads and other low volume roads are often narrower and of lower standard than trunk roads that service large areas or serve as major connecting links in the road network.

Table 7. Suggested minimum standards for single lane gravel and dirt roads[1]				
Standards		**Design speed (MPH)**		
		10	**15**	**20**
Speed range (MPH)		5-15	10-20	15-25
Stopping distance (ft)		40	68	100
Horizontal curve radius (ft)	No sight obstruction	55	110	200
	obstructions 9 ft from road edge	100	300	600
Vertical curve length (ft)		200	200	200
Stopping distance for approaching vehicles, controlled by horizontal and vertical curves (ft)"		100	170	250
Travelling surface width (ft)		10	12	12
Road grade for heavy trucks (%)	Maximum sustained	7	4	3
	Minimum sustained	2	2	2
Maximum pitch (%) (<500 feet)		18	18	18

[1] *from USDA-SCS (1981)*
[2] *2½ times single vehicle stopping distance*

All other conditions being favorable, financial considerations and planned uses may play large roles in determining road standard and size. Costs are directly proportional to the standard of the road, and high standard roads are usually built where economic returns from land management (such as logging or mining) can pay for the added improvements, or where planned uses require high standard roads (e.g., for wet weather access to residential property).

For forest roads, standards and size may also be dictated by harvesting and yarding equipment needs, as well as the season of use. Other types of land use have their own special or unique requirements for standards. Features such as paving or rock surfacing, dual lanes, and oversized drainage structures can all add substantially to construction costs. If these features are not needed, given the planned use of the road and requirements for environmental protection, they should not be built into the project.

Road classification also indirectly affects road standard. Forest and ranch roads are often divided into classes called permanent, seasonal and temporary, in generally decreasing order of road standard and size. **Permanent roads** form the core of the all-season road network, and are surfaced to allow winter uses, such as log hauling (Figure 7). Permanent roads have watercourse crossings designed to accommodate at least a 50-year flood flow at all streams. **Seasonal roads** are a part of the permanent road network with drainage structures (or fords) designed to pass the 50-year flow, but they may not be of sufficient standard for heavy, wet-weather use or hauling. Both permanent and seasonal roads require regular, seasonal and storm period inspection and maintenance (Figure 8).

***Figure 7**. This well built permanent road is designed/or year-around use. It is contoured to the natural topography, has no inboard ditch, is slightly outsloped, has no outside berm, is occasionally rolled to provide continuous surface drainage and is rock surfaced for wet-weather traffic. This self-maintaining design will provide years of uninterrupted use.*

***Figure** 8. Seasonal roads are built to the same specifications as permanent roads, but are not surfaced for all-weather traffic. They typically provide summer or dry period access to watershed areas. The potentially credible road surface may be waterbarred before each winter (not shown), or outsloped with rolling dips to provide for rapid drainage of surface runoff.*

Temporary roads are lower standard roads with a surface adequate for use during the dry periods and drainage structures adequate for flows during the anticipated period of use, but that are removed before the beginning of the winter period (Figure 9). Temporary roads may remain in-place for several years before they are removed only if their drainage structures are designed to accommodate the 50-year flood event. Upon abandonment, all drainage structures and stream crossing fills are removed, and the road surface is permanently drained using outsloping rolling dips, waterbars and ditches.

Figure 9. Temporary roads are often spur routes constructed off permanent or seasonal roads that provide short-term access to watershed areas. They are usually outsloped, unsurfaced and used only during dry soil conditions. All stream crossings need to be physically excavated and removed upon the completion of operations or prior to the onset of the winter period (October 15 for forestry roads). In forested areas, the road bed can be planted with trees to return the site to productivity.

D. Road system layout

In forest and ranch road planning, the concepts "less is best" and "avoid the worst" generally describe the most economical and environmentally sound approach to planning for road building and road system layout. Some of these important concepts are listed below:

1. Minimize total road miles in your watershed,
2. Minimize new road construction by using existing roads,
3. Minimize construction of permanent and seasonal roads by using these standards only when absolutely necessary; use temporary roads to minimize long-term maintenance and reconstruction costs and reduce environmental damage,
4. Strictly minimize the number of watercourse crossings,
5. Minimize cuts, fills and vegetation clearing by contouring roads across the landscape,
6. Minimize road work near the WLPZ, and on unstable areas, inner gorges and steep slopes,
7. Minimize road width,
8. Minimize road gradient,
9. Minimize the concentration of runoff on and from the new road, and
10. Avoid problem areas and serious obstacles, when possible.

Road system layout is influenced by many factors, including topography, property lines, obstacles (rock outcrops, unstable areas, etc), and proposed landuse activities. Controls on the location of a road include both natural features and man-made elements (Table 8).

Table 8. Some man-made controls which affect road location[1]

Control	Comment
Legal	Boundary lines limit the location of a road. Talk with adjacent landowners and work out written right-of-way agreements to share roads and reduce road construction.
Specific location	The beginning and ending points of a road are often fixed. These represent major controls.
Safety	Each class of road and level of use have specific safety requirements. Common sense should be applied in setting speed, grades, curve radius, sight distance, and turnouts.
Pollution control	Roads should avoid problem areas. Allow ample room to trap sediment in a buffer before it reaches a stream. Do not allow any direct discharge points where road runoff flows directly into the stream. Avoid flood plains, landslides, credible soils, etc., as well as slopes over 40% wherever possible.
Design elements	Physical limits for curve radius, road grade, pitch grade, stopping distance and separation from streams are set by you! Design to reduce maintenance costs and pollution potential.
Migrating fish	Observe and maintain substantial buffers. Know what species use your streams, their habitat requirements, the susceptible periods of their life cycle, and their environmental tolerance limits. Permits may be needed from the Department of Fish and Game.
Approach road permits	Issued by California Department of Transportation or the County for roads connecting to public highways. Locations for intersections may be restricted.

[1]*modified from USD A-SCS(1981)*

1. Harvesting and yarding techniques: For timberland owners, road systems are often planned around the preferred method of timber harvesting and yarding for the terrain. Downhill tractor skidding, a common yarding technique in the past, require roads to be built in lower hillslope positions where slopes are often steeper, soils less stable and streams more incised into the landscape. These conditions can lead to greater erosion and soil loss from road construction, and higher long-term maintenance costs. Cable yarding allows most roads to be build near ridges and in upper hillslope areas where environmental impacts may be significantly reduced. Integrated planning for modem yarding techniques and road location and design will achieve the most economically and environmentally sound road system.

2. Road construction versus reconstruction: In the last 50 years, tens of thousands of miles of road have been constructed on private forest and ranch lands in California. Most of these roads were built to accommodate timber harvesting, ranching and rural development. Many of these roads are now abandoned and grown over with vegetation. Some were built in locations which would not be acceptable for new road construction today. As these areas are re-entered for additional logging and land use, decisions must be made as to whether or not it is better to use the existing abandoned road system, or to build a new road network in a better location using state-of-the-art techniques (Figure 10).

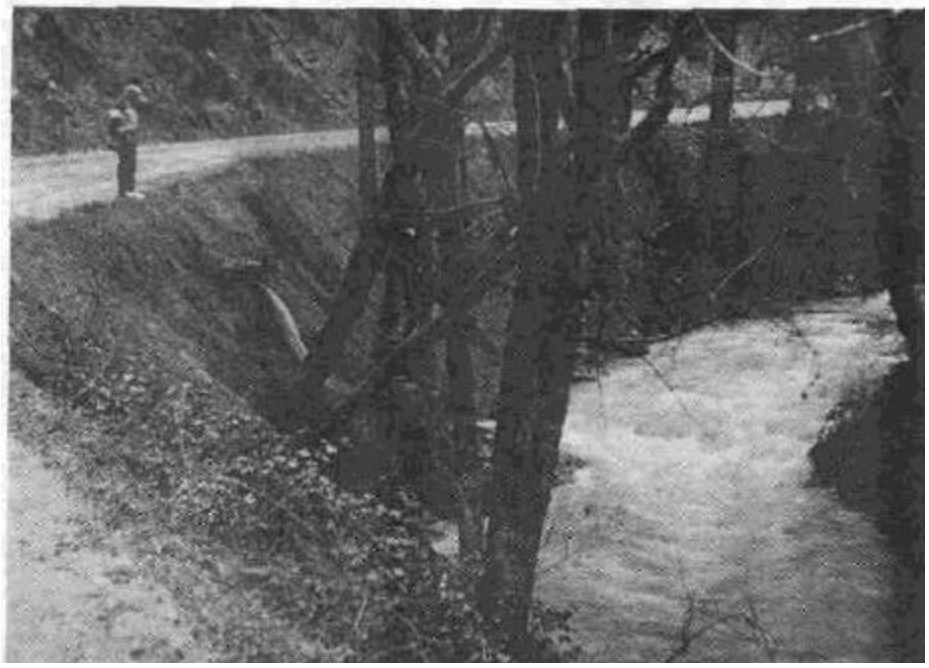


Figure 10. *Because of our increased awareness of the potential impacts to streams in a watershed, some roads which were built in the past would probably not be built in the same locations today. In this example, a side-cast-constructed road was built alongside a large, fish-bearing stream and ditch relief culverts still discharge muddy road runoff into the channel during storms.*

The answer lies in considering both economics and environmental impacts. In many instances, reconstruction can be viewed as an opportunity to cost-effectively improve watershed conditions and reduce the threat of long-term erosion, while providing the opportunity to economically access a previously harvested or managed area.

For example, in a final forest re-entry it is often possible to temporarily open an old road for forestry activities, and then to systematically and permanently close it upon completion of operations. This "road closure" would involve removing drainage structures, stream crossing fills, and unstable sidecast, and permanently draining and planting the road surface. In this way the old road can be **"erosion-proofed"** against future storm damage, and returned to forest or ranch-land production. At the same time, an economical temporary access to the site has been developed for at least one summer's work. Proactively planning for this option, where it can be used, is often both economically and environmentally advantageous.

In other circumstances, an old road system may be so deteriorated that only small portions of it can be safely used without causing extensive erosion. In this case, new roads may need to be planned and located at more stable, suitable hillslope locations. As this may be the only chance for rehabilitation work, efforts should be made to correct as many erosion problems along the old road network as is possible when the logging operation is being conducted.

Finally, an old, abandoned road system may be located in an environmentally suitable location, but because it has been abandoned for a number of years it is now overgrown with vegetation. In this case, reconstruction may cost significantly less than new construction, and result in little erosion. Sections of the reconstructed road network may have to be re-routed around unstable areas or areas where past slope failure has removed the road prism, but most portions of the road system may be useable with only minor earthwork.

When roads are planned for reconstruction, and to be a part of the permanent and seasonal road network, it is best to anticipate upgrading all drainage structures to current design standards (50-year flow) and redesigning road surface drainage to more modern standards (e.g., outsloping with rolling dips). ***Forest Practice regulations require replacement and upgrading of all undersized culverts on watercourse crossings that need reconstruction.***

3. Selecting favorable ground for new roads: In laying out a new road system in a watershed, the most favorable ground should be identified and utilized wherever possible. Favorable ground consists of ridges, saddles, natural benches and flatter natural slopes. Less excavation is needed if the road is built in comparatively low gradient areas and utilizes natural benches. Terrain to avoid includes hard rock areas, inner gorge slopes, steep slopes, watercourse and lake protection zones, highly credible soils, wet areas and swamps, areas of unstable soils and sensitive wildlife habitat

4. Road routing through difficult terrain: Avoidance is almost always the best solution to road-building in difficult terrain. Indeed, the recognition and avoidance of unstable slopes is without doubt the most effective and cost-efficient method of managing landslide-prone terrain. When possible, all serious obstacles to road construction should be avoided through complete realignment or by locally changing grade and circumventing problem spots as they are encountered. **It is far better to plan for a route containing fluctuating grades than to build a straight road which ignores the landscape through which it traverses.** Construction and maintenance costs will be minimized by sticking to the most favorable terrain.

In order of priority, the road planner and designer should consider:

1. Avoiding	unstable slopes or soils,
2. Preventing	destabilization, using special road building techniques, when potentially unstable slopes cannot be avoided,
3. Stabilizing	slopes which show signs of instability using special techniques developed by a trained engineer/geologist,
4. Protecting	downslope resources when an unstable area cannot be physically or economically avoided, prevented or stabilized.

If it is impossible to move the alignment to avoid serious obstacles, construction costs and maintenance requirements are likely to climb sharply as special construction techniques (such as endhauling) are employed to build a stable road bench and to minimize post-construction erosion.

E. Preliminary road location

The road should be plotted and located by a person with some knowledge of the area to be served by the road and of the terrain where the road is to be built. A tentative road location should first be roughly plotted on aerial photographs and topographic maps. At this stage, several alternate routes should be developed and plotted for investigation during later field reconnaissance. These alternative locations should be visually fitted to the topography (paralleling the contour lines) as much as possible to minimize cutting and filling. Aerial photos are useful for identifying natural features on the landscape that don't show up on the topographic map.

One procedure for plotting an alignment on topographic maps is shown in Figure 11. Using the known contour interval printed on the map, together with a set of measuring dividers, you can easily plot a tentative course for the road while keeping within the allowable grade limits. By combining this method with observations from aerial photographs, some of the recognizable obstacles and control points can be located, and a route with a suitable average grade can be identified and plotted on the topographic map.

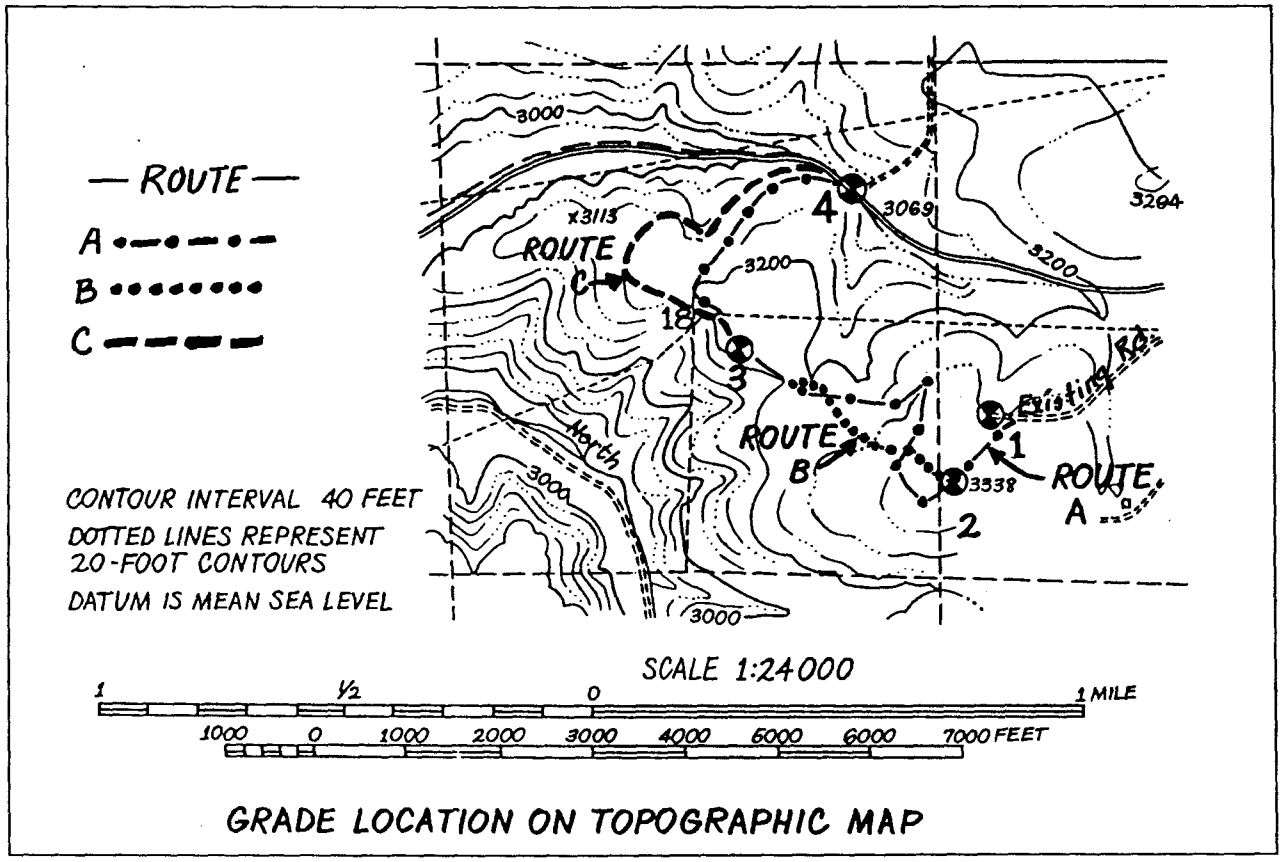


Figure 11. *On this topographic map, three preliminary road routes across a hillside have been identified. Identifying possible alternate routes on maps and photos can save time and money when the next step of field reconnaissance is performed. Several alternate routes should always be identified in the planning process since field conditions may require minor or major adjustment of the route (USDA-SCS1981).*

Table 9 shows the computations for the example in Figure 11, including three possible alignments for a road to be built from point "1" to point "4." A simple, 6-step methodology can be followed to arrive at these "paper alignments."

Table 9. Control section and grade computations for three possible road routes (see Figure 11)[1]

Route	Road reach	Elevation diff. between control points (ft)	Est. road dist. between control points (ft)	Estimated avg.road grade (%)	Caliper dist. setting	Meas'd road dist. (ft)	New est. road grade (%)	Comment
A	1 to 2	+58	800	+7	290	800	7	route is too long; try again
	2 to 3	-128	3200	-4	500	3200	4	
	3 to 4	-150	2400	-6	330	2200	7	
B	1 to 2	+58	800	+7	290	800	7	route OK; field check
	2 to 3	-128	2000	-6	330	2100	6	
	3 to 4	-150	2400	-6	330	2200	7	
C	1 to 2	+58	800	+7	290	800	7	route OK; field check
	2 to 3	-128	2000	-6	330	2100	6	
	3 to 4	-150	3000	-6	400	2600	6	

[1] *USDA-SCS (1981)*

1. Mark the beginning (1) and ending points (4) of the road.

2. Mark other known control points along the route (control points are natural features that dictate road location, such as a stream crossing, rock outcrop or saddle in a ridge).

3. Compute the elevation difference between each control point

4. Compute the estimated average grade of each road segment between control points (dividing the difference in elevation between two points by the length of road between them gives the sustained or overall grade of the road segment).

5. On a divider, set the scale distance equal to the contour interval divided by the decimal percent grade (distance = C.L/grade). Then, simply mark the primary and alternate road alignments using the dividers as set, and move from one contour line to the next

For example:

Contour interval = 40 feet

Max. desired grade = 8%, (or .08)

Computation: 40/.08 = 500 feet

In this example, you must go 500 feet before climbing 40 feet to keep the grade to 8%. The dividers should be set at a spacing equal to 500 feet on the map. Then the dividers can be used to mark where the proposed road will cross each contour line on the map (at 500 foot intervals).

6. If any road segment fails to reach the identified control points or endpoints, or if the required grade between these points would be too steep, then either individual segments or the whole road needs to be re-routed until each alternative segment and grade is satisfactory.

With several alternative alignments available, at least on paper, several other tests can be made *before* going out in the field to scout the routes. You can overlay the routes with soil maps to identify potentially unstable or erodible sites. Aerial photos can be viewed to identify possible landslides or rock outcrops that lie in the path of one or more of the routes. Ownership boundaries can be identified and, if necessary, permission can be secured to scout possible alignments that lie on adjacent property.

For most roads, half a day spent in the office can save much wasted time in the field trying to identify possible alignments for the road. Remember, topographic maps are not always accurate in the small details of the landscape, so no alignment is satisfactory until field reconnaissance is performed. Most small benches, streams and unstable areas will not show up on the standard 1:24,000 scale topographic sheet. However, general routing of the alignment, from starting point to ending point, can be performed ahead of time and then be used to guide subsequent field work.

NOTES:

CHAPTER III: FIELD RECONNAISSANCE AND LOCATION

A. Scouting the alignment

Now it's time to walk proposed routes on the ground, to scout, measure and record the actual field conditions, and to determine the feasibility, advantages and disadvantages of each alignment. If another route looks good in the field, don't hesitate to walk it, flag it, record observations and grades, and plot its position on the map. **Remember, road building is the main destabilizing activity carried out in forestry and wildland management, and avoidance is the most cost-effective means of dealing with unstable terrain.** Steer clear of sensitive obstacles such as unstable slopes, credible soils and steep stream canyons.

First, the entire length of the proposed road is walked to become familiar with the topography and ground conditions and to identify important features that were not visible on the aerial photos or topographic map. Items and conditions to identify and locate on the map in this first reconnaissance include:

1. favorable topography (especially benches and low gradient areas for landings, turnouts and spoil disposal),
2. control points (the beginning and ending points, saddles and other sites),
3. obstacles (especially unstable or erodible soils, large rock outcrops and wet areas),
4. stream channels (including their degree of incision),
5. inner gorge locations,
6. areas of steep slopes and
7. any other obvious hazards or controls.

It is important that all control points be noted at this time, with only a minimum of marking (flagging) necessary to indicate the route traveled, along with any other important features to either utilize or avoid.

B. Recognizing hazards and obstacles

Identifying many "obstacles" or hazards in the field can be fairly simple. Streams, surface wet areas (springs and seeps), rock outcrops and steep slopes are usually readily apparent. Other potential obstacles to a stable road may take training and experience to identify. These include sensitive wildlife habitat, archaeological sites, and a variety of "hazardous" hydrologic and geologic conditions (Table 10). Final identification of these potential problem areas should be left to trained specialists.

Table 10. Some natural controls which affect road location[1]

Control		Comment
Saddles		Major control for road location
Ridges		Major control and often a satisfactory road site.
Stream crossings		Major control. Seek locations with gentle side slopes and locations wide enough to accommodate the road. Good sites for bridges or culverts are needed. Evaluate for migratory fish where needed. Will need Fish and Game 1603 permit.
Benches		Often a good location for road junctions, switchbacks, landings, turnouts, etc.
Cliffs or rock outcrops		Cross above or below at a safe location. Rock which can be ripped is less costly to remove than hard rock needing blasting.
Slides		Major control. Avoid or cross at the safest point. Ask for professional geotechnical assistance.
Wetlands (bogs, swamps, wet meadows)		Major control. Avoid where possible or cross quickly at best point. May need Fish and Game clearance.
Valley floor	wide	Low gradient, desirable road location if above the flood line. If crossing, cross and get out of floodplain quickly. Little excavation required. Fish and Game permit may be required.
	narrow	Poor location because of flooding, erosion and pollution potential and high costs to cross the stream if it meanders. Keep road above floodplain. Fish and Game 1603 permit may be required.
Slopes	>40%, but <60%	Avoid sidecasting and sliver fills (thin blankets of fill placed on steep slopes) in which large bare areas arc exposed to erosion. This loose sediment may be difficult to control because of long buffers needed.
	≥60%	Construction in unstable areas should be avoided. Full bench road construction and endhauling material may be needed where slopes remain steep alongside stream channels. **Proceed only with extreme caution.** Avoid road construction on these steep slopes if possible.
	ridge crest	Good alignment and little excavation. Good drainage. Few culverts required. Adverse grade encountered on uneven ridges. Spur roads will have an adverse grade.
Aspect		Maintenance requirements in moist climates can be minimized by placing roads on south-facing slopes to promote drying and snow melt. In dry climates, (he north-facing dopes have more vegetation and may have less erosion. Extremely wet or dry climate negates this effect.
Rock slope (dip)		Place roads on (he hillside where rocks dip (slant) into the hillside, not parallel to or out of the hillslope. Consult a geologist for other problems and advice.
Soils		Where possible, avoid road building on naturally erodible soils. Check soils maps for potential problems and ask extension agents or the SCS for advice. Frozen soils require special care; ask for assistance.

[1] *modified from USDA-SCS (1981)*

For example, a geologist may be needed to locate unstable subsurface geology, soft or weak bedrock materials, contact zones and faults, rock layering that is susceptible to failure when undercut by road construction, existing and potential landslide areas, potentially unstable stream banks and stream crossing sites, and the suitability of local spoil material for use in road fills and stream crossings. Many of these conditions may not be apparent to the untrained observer. It is important to identify all the unstable areas along the proposed alignment and treat them as control points. Avoid unstable areas and poor stream crossing sites by linking up all the stable slopes and suitable crossings locations.

When a final alignment has been identified, a trained wildlife biologist may be required to investigate the alignment and the surrounding terrain for endangered species or species of special concern. An archaeologist may occasionally be needed to identify cultural sites that have to be avoided or mitigated before construction can begin.

If you are unsure whether or not you need specialized advice, ask the Department of Fish and Game (for wildlife issues), the Soil Conservation Service (for reading activities on private non-timber lands), and/or the Department of Forestry and Fire Protection (for reading activities on private timberlands). They won't do the technical consulting work for you, but they can give you pointers, provide advice about the need for additional help and describe where to find it.

Specialists identify problems, suggest alternate alignments to avoid many of these problem areas, and design mitigations for problems areas that cannot be avoided. The expense of these professional consultations is, in most cases, well justified and quickly repaid by lower construction and maintenance costs over the first few years of the road's existence. Benefits are also gained from minimizing impacts to watercourses along the alignment So called "low-cost" roads can be very expensive if they are poorly planned and constructed, while roads which initially cost slightly more to build often end up costing far less in the long run when lower maintenance and rebuilding costs are accounted for.

C. Marking the proposed alignment

First, a preliminary traverse of the approximate route(s) is conducted. For this, and later detailed field layout, the following tools and materials should be carried:

1. a hand-held clinometer or abney level (to measure road grades and hillslope gradients),
2. a measuring tape, range finder or hip-chain (to measure distances),
3. an altimeter (to measure elevations),
4. colored flagging (for marking the alignment, hazards and obstacles),
5. a hand compass (to check bearings), and
6. a map and/or aerial photos (showing the alternative alignments plotted earlier).

Next, a preliminary road location survey is conducted, using one or two people. Based on the first traverse, and the identification of obstacles and hazards, a tentative route is identified on the ground. Beginning at one end, the center line of the route is roughly marked with flagging along a pre-selected grade line (the average grade of this route was determined in the 6-step map procedure described earlier). Grade between each flag is measured using a clinometer or an abney level. Ragging, by convention, may be hung on the approximate centerline, or they may be hung to mark the top edge of the cutbank (so they aren't destroyed during construction). If the predetermined fixed grade does not exactly meet the desired ending point, you can work back from that endpoint and connect the two surveys at a convenient location.

Once this preliminary alignment has been established, you should "stand back" and examine the route to determine where adjustments in grade and alignment could be made to take advantage of benches and gentle ground, while avoiding unstable sites, wet areas, incised stream channels and rock outcrops. Some steep pitches may be necessary to reach the best ground for the road. For example, efforts should be made to identify and utilize the most suitable, stable and least incised stream crossing sites, and potential WLPZ areas should be avoided. Broad ridge crests and benches should be identified and flagged as possible locations for landings, road turnouts and spoil disposal sites (Figure 12). Nearby rock outcrops should be identified and evaluated for potential rock aggregate for road surfacing materials. After evaluating all these factors, several additional grade surveys may be needed to identify and mark the final and best location for the road.

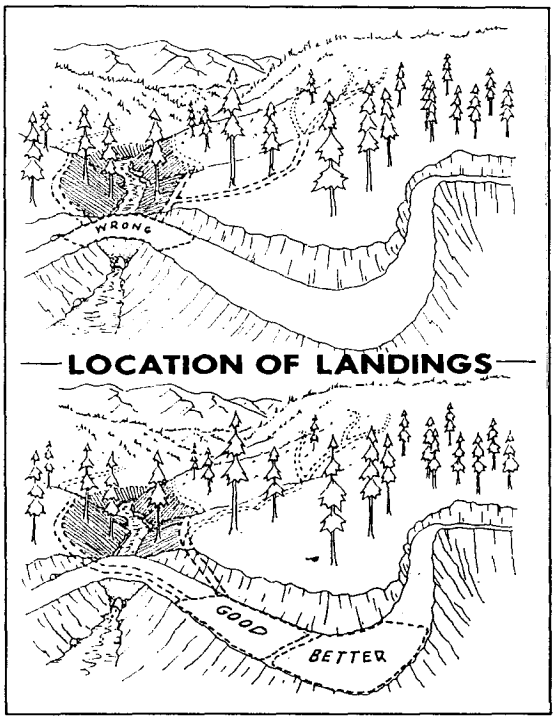


Figure 12. Log landings on forest road systems should be kept to the absolute minimum size necessary to accommodate yarding, loading and hauling equipment and the minimum number needed to remove timber resources. Landings constructed on gentle ground and broad ridge crests far removed from stream channels are least likely to cause water quality problems, whereas landings built on steep slopes and near watercourses can result in severe impacts (USFS, 1963).

The marking of curves and switchbacks requires a little more thought and care during road layout. Each turn should be of sufficient radius for trucks and the anticipated equipment to negotiate easily and safely. The radius should be no less than 35 feet for standard pickups and field vehicles, and 55 feet for tractor trailers (such as log trucks). A minimum horizontal curve radius of 200 feet is suggested for roads supporting 20 mph traffic (Table 6).

Where curves are short and gentle, they can be located by eye to follow the topography and the flagged grade location. Sharper curves and switchbacks require some surveying. The center stake method is one of the simplest methods for marking these curves during the road survey. First,

decide on the radius of the curve (see Table 11). Then, using a string or a tape that is the length of the desired radius (or using a range finder), simply identify and stake the center of the curve and stake the centerline in an arc extending out from the center stake (Figure 13).

Table 11. How to convert horizontal distances to true "slope distances" measured on hillslopes needed for marking road curves and switchbacks[1]

When the land slope is this steep in the direction you're looking (use a clinometer)...	...true slope distance is determined by multiplying horizontal distance by the following correction factor...
10%	1
15	1.01
20	1.02
25	1.03
30	1.04
35	1.06
40	1.08
45	1.10
50	1.12
55	1.14
60	1.17
65	1.19
70	1.22

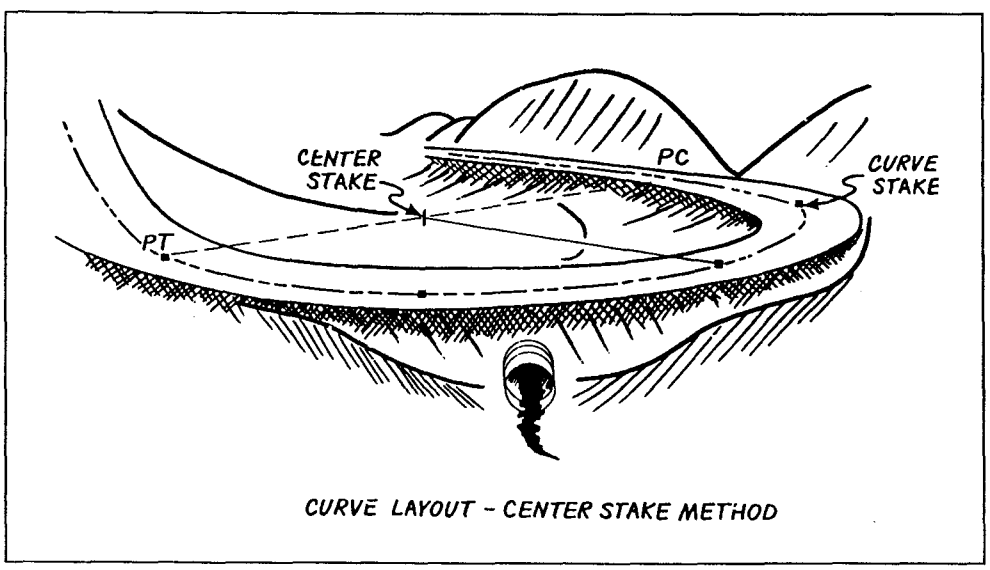


Figure 13. *Staking and identifying simple curve layout using the center stake method (USDA -SCS, 1983).*

The Center Stake Method assumes the ground is flat as you're marking the arc. This isn't usually true, so some adjustment of the lengths marked in the field is needed to compensate for the slope of the hillside (see Table 11). To use the center stake method, true horizontal distances need to be marked on the ground. To get the slope distance, multiply the horizontal distance (desired curve radius) by the correct multiplier shown in Table 11. For example, to switch back across the slope above with a 110 foot horizontal radius on a hillside with a 65% slope, the curve should be marked 131 feet upslope (110' x 1.19 = 131') and 131 feet downslope from the center stake. Straight ahead, on contour, the stake is marked at 110 feet.

Ideally, the road within a switchback should have little or no grade so that trucks and equipment can pass safely and so they won't tear up the road surface while turning the comer and continuing up the road. This may require increasing the average grade of the road coming into and leaving the switchback. Depending on the curve radius, the grade of the road should at least be reduced through the curve to provide for safe handling of vehicles and equipment (Table 12). Where longer curves are needed, the Stick Method of curve layout may be more convenient (see Appendix D).

Table 12. Suggested reductions in road grade through curves of different radius[1]

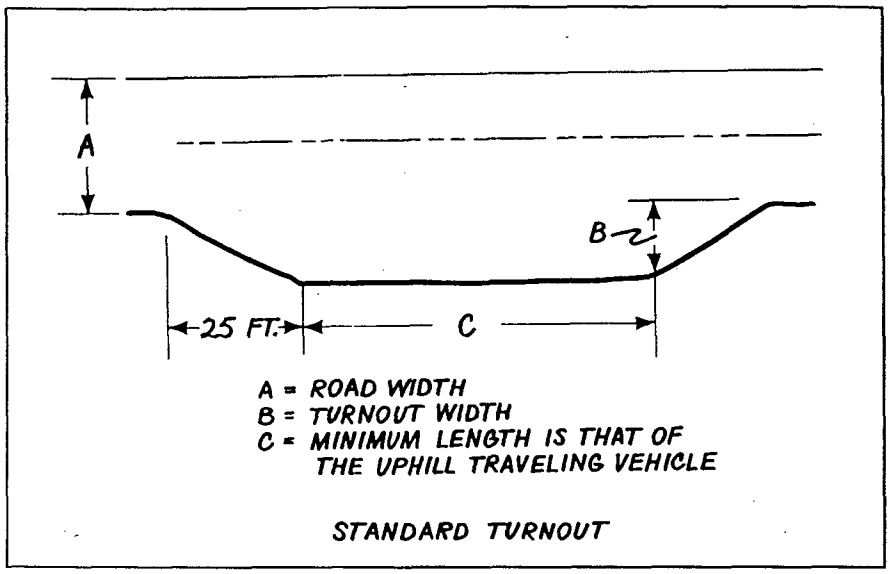
Curve radius (ft)	Reduction in % road grade
150 to 460	1%
90 to 150	2%
65 to 90	3%
50 to 65	4%

[1] *USDA-SCS (1981). It is suggested that road grades through switchback curves be flat (0%), or very low.*

Landings and turnouts should be identified and staked at the same time curves are staked. Typically, turnouts should be intervisible and located where a minimum of excavation will be required to increased the road width (Figure 14). Landings should be the minimum length and width necessary to accommodate the yarding and loading equipment. Some mobile yarders can work directly off a single lane road or at turnout locations, and landings need not be built On roads to be reconstructed, existing, stable landings should be re-used and landing enlargement or expansion should be avoided wherever possible.

For situations that require a more highly engineered road than can be marked using a centerline location survey (e.g., where slopes are very steep, or where sidecasting is not permitted), it may be necessary to set grade and slope stakes. In this procedure, stakes are placed at 50- to 100-foot intervals along the alignment, depending on topography. For sidecast constructed roads, grade stakes are first placed at points in the cross section of the road where the cut and fill sections meet and are reduced to zero. A follow-up survey is then run to set cut and/or fill stakes marking points on the ground that will be at the top of the cutbank or the toe of the fill, respectively. Grade surveying may then be used to obtain accurate estimates of cut and fill volumes.

re 14. Standard turnouts allow for les to pass each other by safely ıg off and back onto a single lane Turnouts and landings should be ed to take advantage of benches and 1 ridges where the additional road can be developed with a minimum of 1 excavation. Turnouts should be isible (USDA-SCS, 1983).



Notes:

CHAPTER IV: DESIGN

A. Introduction to road design

Road design is often a combined result of economic and environmental factors that influence construction, operating and maintenance costs. Unfortunately, because construction costs are felt immediately, they are often the sole consideration employed in choosing a road's final design. However, excessive hauling expenses and difficulty of travel on a road, as well as high road maintenance costs, may have a far greater effect on the long-term economics of forest or ranch operations than the savings in initial construction of a low standard or inadequately designed road.

Over-design can also be a costly mistake. For example, construction costs for a 12-foot wide road on a steep side slope may be as much as 30% higher than for a 10-foot wide road in the same location, because of the large volume of earth that must be moved from the inside of the road bench to obtain an additional two feet of road width. Long-term maintenance costs are also likely to be higher for the wider road. For this reason, it is important to determine the main types of vehicles and the expected volume and speed of traffic so that the required road standards can be established well before actual construction begins.

Both road length and road width should be designed to minimum standards for the anticipated uses of the road. Narrow roads dramatically reduce excavation and sidecast volumes, thereby reducing cutbank height and decreasing the likelihood of slope failures (Table 13).

Road design begins with planning for the road's location. Selection of the final route will constrain many future design decisions. Two important design questions that need to be answered early in the planning process are 1) road prism design and 2) road surface design. Routing the alignment through or around various obstacles and hazards calls for the use of certain road prism designs. In addition to these, there are special situations that often arise and require special road design considerations.

Table 13. Excavated soil volume for full bench roads with various road widths and hillslope gradients (yds^3/ft)				
Hillslope gradient (%)	Excavated volume to construct a full bench road (assumes ½ : 1cutbanks) (yds^3 excavated per ft of road)			
	Road width 12 feet	Road width 14 feet	Road width 16 feet	Road width 18 feet
30	0.94	1.28	1.62	2.17
35	1.13	1.54	2.01	2.55
40	1.33	1.82	2.37	3.00
45	1.55	2.10	2.75	3.48
50	1.78	2.42	3.16	4.00
55	2.02	2.81	3.60	4.55
60	2.28	3.11	4.06	5.14
65	2.57	3.50	4.57	5.78
70	2.87	3.91	5.11	6.46
75	3.20	4.36	5.69	7.20

B. Road prism design

Road prisms may be designed to be **full bench, partial bench** (part cut and part fill, including designs employing sidecasdng) or **full fill** (Figure 15). Roads which are constructed without endhauling are **partial bench** roads where spoil generated during initial grading is used to widen the roadbed and fill depressions and stream channels crossed by the road. This has been the most commonly used construction practice for rural forest and ranch roads. The fill is either placed and compacted, or (more commonly) sidecast loosely into the desired location. However, there are many circumstances where sidecastmg is no longer acceptable and alternative designs and methods are needed and required to reduce environmental impacts and to provide a stable road bed.

Roads may need to be **full bench** on steep slopes (those over about 60%), in watercourse protection zones, or where water quality could be impacted by road work (Figure 16). Full bench construction requires that all the spoil generated by cutting into the hillside must be either used in filling local stream crossings and low spots in the new road, or endhauled to a stable storage site where spoil has no risk of entering a watercourse.

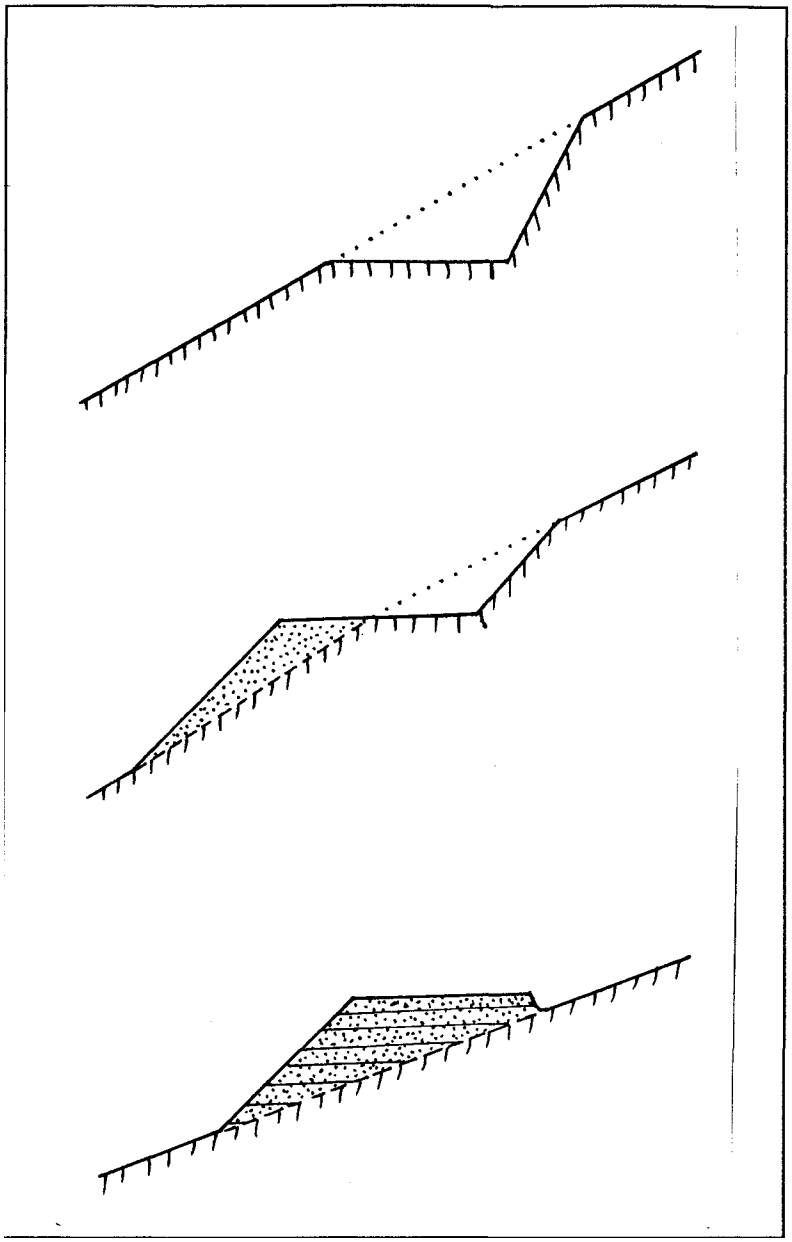


Figure 15. *Idealized diagrams depicting a full bench road (all material endhauled - no sidecasting)(top); a partial bench road (with both cut and sidecast)(center); and-a full fill road (no cut - all fill placed and compacted in shallow layers)* ***(bottom).***

Road segments constructed with **full fill** techniques are somewhat uncommon at the present time, but growing in importance. Roads using this technique are usually confined to short reaches where slopes are potentially unstable and cuts into the slope could trigger soil movement Full fill sections of road are often supported by structurally engineered fills with near-vertical fill faces. Full fill road construction is also used where roads cross incised stream channels and the road is built entirely on fill material.

Cut-and-fill design: For most forest- and ranch-land owners, use of cut-and-fill road construction has been preferred because it minimizes the amount and cost of earth moving. In other words, less soil moved generally means less expense (Figure 17).

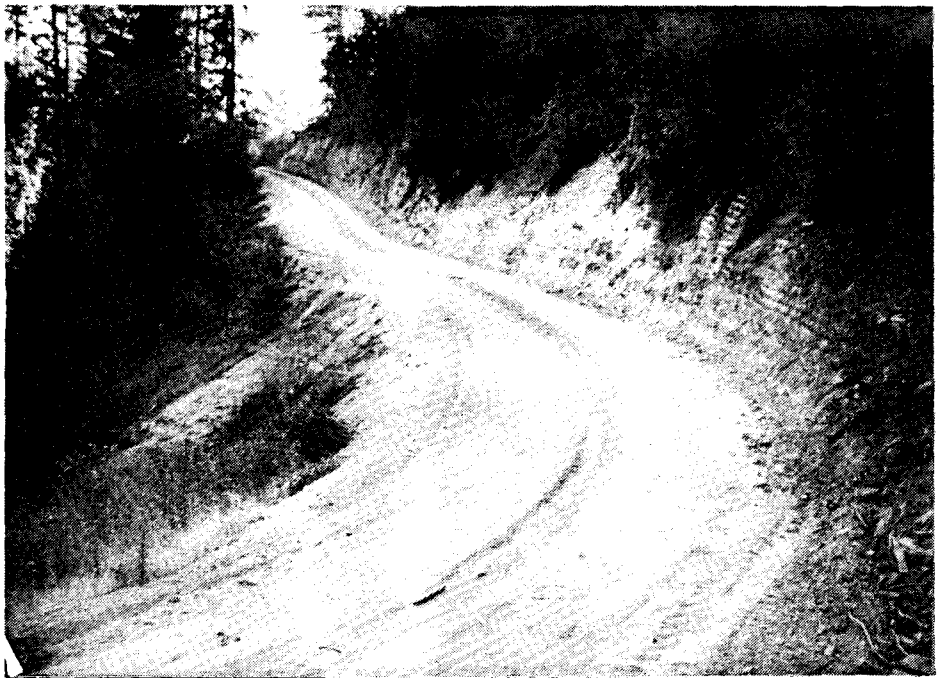


Figure 16. *Full bench road. The height of the cutbank, the slope of the natural hillslope and the small amount of sidecast indicates that this road is full bench and cut entirely into native hillslope materials. Note that the road is outsloped with rolling dips and no inboard ditch.*

***Figure** 17. In contrast to the road in Figure 16, this partial bench road was built by extensive sidecasting. At least half the roadbed is built on fill materials.*

However, the indiscriminate use of sidecast road construction (the simplest method of cut-and-fill construction) has probably caused more problems for landowners than any other type of road building. Sidecasting construction techniques should not be used on slopes over 55 percent because this results in fillslopes of about 67 percent, the average angle of repose (stability) for most loose soil materials (Figure 18). For this reason, sidecast construction should be limited to gently sloping areas where streams are far from the road prism. Cut-and-fill construction techniques can be used on slightly steeper slopes *if* proper compaction techniques are used.

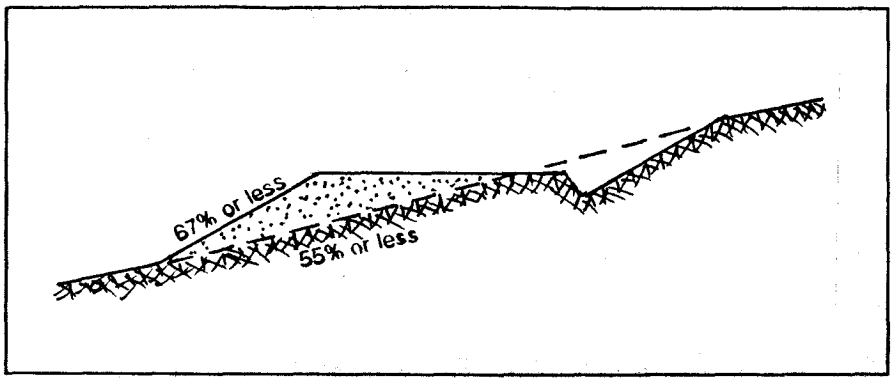


Figure IS. *For most earth materials, sidecasting on natural slopes over about 55% **in** steepness will result in steep, loose, unstable sidecast slopes that are easily eroded or prone to sliding. The face of a sidecast slope should not exceed about 67%, the maximum angle of stability for most uncompacted, sidecast soil material.*

In general, cuts should equal the needed fill volume, plus about 20 percent to allow for settling of loose fill. That is, the loosened, excavated soil will take up about 20% more space than when it was "in-place." During the process of cutting and filling, it is critical to avoid letting sidecast or waste material enter streams or watercourses, or placing it on unstable or steep slopes where it might erode.

The angle or steepness of both cut and fillslopes is very important in building stable roads. There is a tradeoff in determining the optimum cutslope angle (Table 14). Cutbank slopes should be designed to achieve maximum stability as well as a minimum exposure of bare soils. On balance, cutbanks should be as steep as the soils and bedrock will permit without becoming unstable.

Table 14. Advantages and disadvantages of steep cutslopes[1]

Advantages of steep cutslopes	Disadvantages of steep cutbank
1. Less right-of-way	1. Difficult to revegetate
2. Less excavated material	2. Prone to ravelling
3. Less sidecast	3. Prone to tension cracks and failure
4. Shorter slope exposed to surface erosion	4. Slightly greater risk of a rotational slope failure.

[1] *B.C.M.F. (1991)*

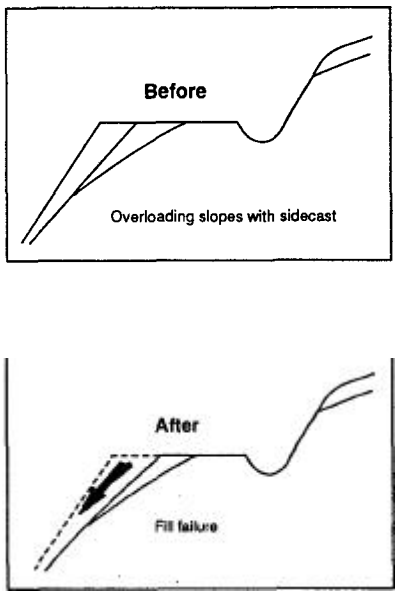
Cut and fillslopes are usually expressed as ratios, such as ½: 1 or 1:1 (Table 1). Road banks can be cut as steep as the stability of the material will permit, ranging from ¼ : 1 for very stable rock materials to 3:1 for erodible or unstable soils (Table 15). A general guide for the maximum steepness of road cuts in various rock and soil materials is shown below. Note that wet slopes, unstable or erodible soils, and highly fractured or bedded rocks may require gentler slope cuts.

Cut height and cut angle also affect the stability of the final cutslope. Cuts which are stable at ½: 1 at a 6-foot height may not be stable when the cut height is twice as high at 12 feet. Higher cuts lead to increased gravitational force and reduced stability at the face of the slope. Tall (deep) cuts are also more likely to intercept emerging soil water that can weaken the cutslope and cause failures that block the road or result in persistent ditch and roadbed maintenance problems.

Table 15. Generalized maximum cut and fill steepness for different earth materials	
Slope ratio	**Earth material**
¼ to l	Rock cuts
½ to l	Hardpan & soft rock cuts
¾ to 1	Clay
1 to l	Clay, sandy or gravel alluvium
1 ½ to 1	Fillslopes, lake deposits
2 to l	Unstabilized, uncompacted soil
3 to l	Unstabilized soil
Near vertical to sloping: use only where such cuts are working locally	Some sandy or granitic soils; some hard bedrock exposures

Fillslopes can be built to a variety of angles depending on the properties of the material used, the amount of properly applied compaction, soil moisture and the type and density of vegetation that is established on the surface. In general, thick accumulations of loose, dry, side-casted soil that is not compacted will not usually hold a slope over about 65 percent, whereas many fill materials that are placed and properly compacted in thin, 1-foot layers may be stable at slopes well over *1 ½* to 1 (67%). While a thin veneer of sidecast may hold on a slope steeper than 65%, a thick wedge of loose sidecast may not be stable even at a 50% slope (Figure 19). Stable road fills can be built on moderate and steep slopes by using layered compaction methods. Here, a bench is excavated at the base of the proposed fill, and layers of compacted soil are built up on this stable bench. The stability of the fill can be further increased by starting with an insloped bench that helps "key" the fill to the slope.

Figure 19. *Overloading steep slopes with uncompacted sidecast material can result in landsliding that damages streams hundreds of feet downslope(B.C,M-F.,1991).*



In critical areas, engineered fills that utilize reinforcing fabrics or other internal supports can be constructed with nearly vertical faces. These are especially useful in short road sections where other fills would be unstable or erode and sediment could enter a watercourse. In such cases, it may be necessary or prudent to employ a geotechnical engineer to design a stable cut and fill road. Depending on the stability of the cutslope rock and soil materials, it may be simpler and cheaper to construct a full bench road where all the excavated material is simply endhauled off-site and deposited in a stable storage site.

C. Road surface design

Road surface design is really ***road surface drainage design,*** and should be chosen based on both maintaining safety for the intended uses and minimizing erosion and sediment pollution in streams. Road surfaces can be designed as **insloped, crowned, or outsloped.** It is critical to properly design road surfaces to minimize erosion from the road bed, ditch, cutbank and fillslope surfaces.

1. Insloped and crowned roads

Insloped and crowned roads drain surface runoff to the inside of the roadbed, often into a ditch, where it is combined with flow from the cutslope and upslope hillside areas and discharged through culverts. Insloped roads are often used where an inside ditch is needed to keep soil water emerging from the cutslope off the road surface (Figure 20). To keep ditch flow to a minimum, it is also possible to build an outsloped road with an inside ditch to carry away water from the cutbank and from upslope areas. Crowned roads drain water both ways from the center of the road, but an inside ditch is still required.

Well constructed and maintained ditches are a real key to long-term stability of an insloped road. Backhoe and excavator constructed ditches are often superior to bladed ditches built by a bulldozer or grader because they can be cut out of the subgrade rather than gouged into the cutbank. The ditch cross section should be designed to accommodate expected storm flows, with the base of the ditch at least 12 inches below the roadway in order to prevent water from entering the road surface material and removing the fines. A relatively deep ditch also allows for faster drainage of the subgrade and helps maintain high soil strength.

Ditch gradients on insloped roads should be steep enough (generally over 1.5%, and ranging from 2% to 6%) to prevent sediment deposition and allow rapid drainage, but not so steep as to result in ditch erosion. When inside ditches are used, frequent ditch relief culverts should be installed to minimize the concentration of runoff in the ditch and to disperse runoff to downslope areas. It is recommended that a minimum 18 inch diameter pipe be used for ditch relief culverts. A general rule-of-thumb is to install the culvert at a grade 2% steeper than the ditch grade, and to skew the culvert at a 30° angle to the ditch line to minimize inlet erosion and to transport sediment through the culvert. Culvert outfalls should be protected with slash and/or rock armor to prevent erosion of the fill. Where sedimentation at the inlet occurs because of over-steepened cutbanks, drop inlets can be installed to prevent culvert plugging. On steep roads over about 10%, even small volumes of ditch flow may have high enough flow velocities to cause erosion of the ditch. In this case, it may also be necessary to armor the ditch to prevent erosion.

The capacity of ditches should also be planned and designed to accommodate flood flows from large storms. If stream crossing culverts along the road are designed to accommodate a 50-year flood flow, the ditches should probably be designed to the same standard. Flat-bottomed ditches (which are easily cut by backhoes and excavators) are less subject to scour than V-bottom ditches that are commonly created by bladed tractors and graders. A 1-2 foot bottom-width is recommended.

2. Outsloped roads

Outsloped roads are typically less expensive to construct and less difficult and expensive to maintain than insloped roads. For example, building a 12-foot wide insloped road with a 3-foot wide inside ditch requires moving almost 60 percent more material during construction than if the road were outsloped with no ditch (Table 13). Clearly, if conditions permit, roads should be constructed with an outsloped surface, no ditch and no berms along the outside edge of the road.

Outsloped roads also disperse and drain runoff along the entire outside edge of the road. Rolling dips and a smooth road surface are key to maintaining a well drained, outsloped road. The frequency of rolling dips and grade breaks, and the amount of "outsloping" needed to drain the road surface, depends on the grade of the road, as well as the road surfacing. Table 16 shows design criteria for the degree of outsloping needed to drain road surfaces on differing grades.

Table 16. Outsloping "pitch" for roads up to 8% grade[1]

Road grade	Outslope "pitch" for unsurfaced roads	Outslope "pitch" for surfaced roads
4%, or less	3/8" per foot	1/2" per foot
5%	1/2" per foot	5/8" per foot
6%	5/8" per foot	3/4" per foot
7%	3/4" per foot	7/8" per foot
8%, or more	1" per foot	1 ¼" per foot

[1] *CDF(1984)*

Where fillslopes are stable, roads should be designed and constructed with minimum width and with a mild outslope (3-4%) (Figure 20). However, on most roads, especially those with grades in excess of eight percent (8%), outsloping is not always enough to get surface flow off the road quickly. Here, in addition to outsloping, waterbars (for seasonal or temporary roads) or rolling dips (for permanent and seasonal roads) are necessary to divert surface runoff.

Waterbars and rolling dips should be spaced along the road close enough together that the road surface is not gullied. It is important to use rolling dips, rather than waterbars, on roads with even infrequent use because traffic will quickly break down and/or breach the waterbars (Figure 21). Waterbars should be reserved for roads that are to have little or no winter use.

Appropriate spacing of surface drainage structures depends on soil credibility and runoff rates. Look at local roads to determine the maximum spacing that will work in your specific area. Suggested design criteria for drainage spacing (waterbars and rolling dips) is listed in Table 3 and, alternately. Table 17. Design dimensions for rolling dips are shown in Table 18.

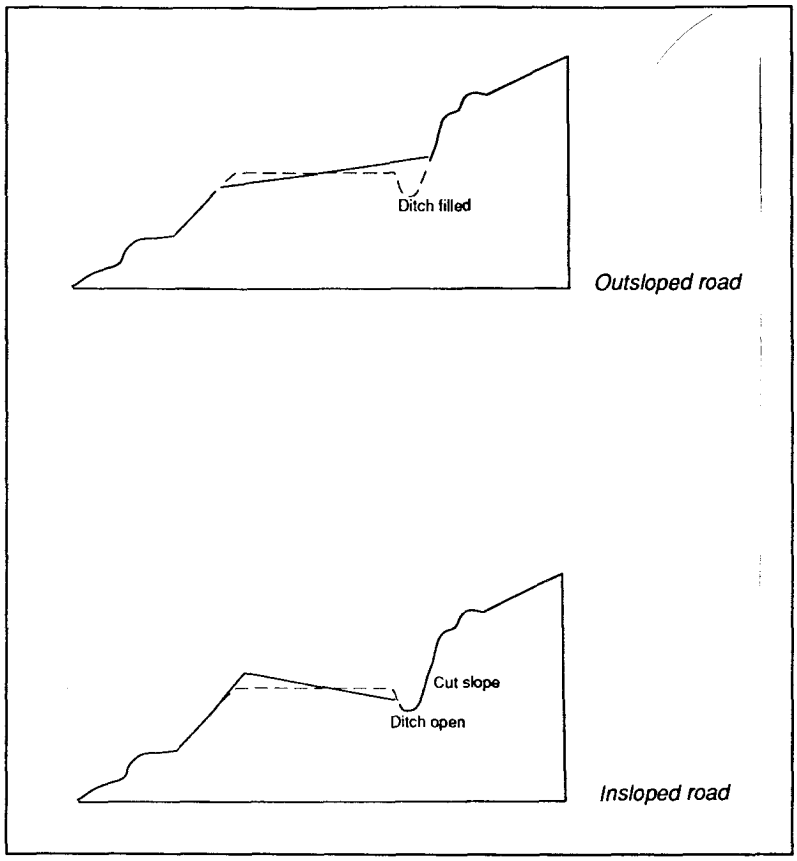


***Figure** 20. Outsloped road with no ditch (top), and insloped road with the ditch open (bottom). Outsloped roads are generally preferred because they disperse and drain surface runoff across the outer edge of the road prism. Insloped roads collect and concentrate road runoff into an. "inboard" ditch that is drained across the road in ditch-relief culverts. Outsloped roads are superior except where seeps and springs necessitate short segments of inboard ditch to collect and remove runoff.*

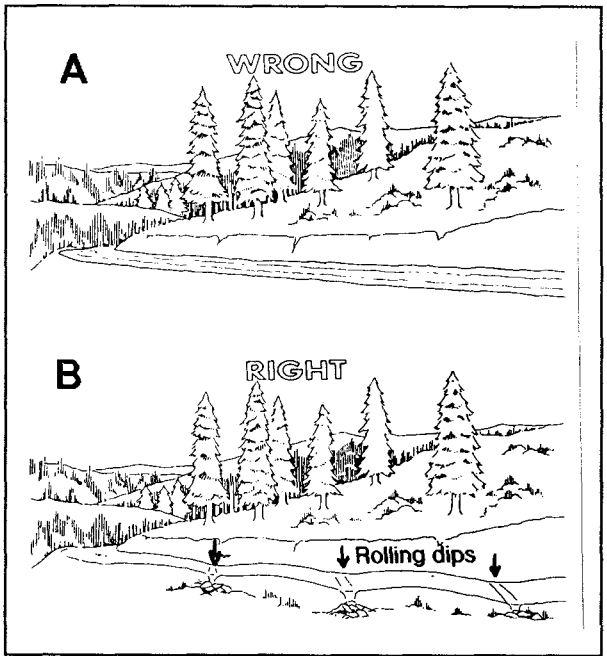


***Figure 21.** Installing rolling dips, or "rolling the grade" of an outsloped road helps guarantee that surface runoff will not concentrate on the road surface and erode the roadbed.*

Table 17. Maximum suggested road surface drainage spacing based on road gradient and soil composition[1]			
Soil composition	Road gradient (%)		
	2% - 4%	5% - 8%	9% -12%
Granitic or sandy	400	300	200
Clay or loam	500	400	250
Shale or gravel	600	500	300

[1] *MSS1,. (1991). Distances used. only to show importance of soil type in influencing drain spacing. Forestry operations are required to employ distances outlined in the Forest Practice Rules (Table 3) as a minimum.*

Table 18. Table of rolling dip dimensions[1]				
Road grade (%)	Upslope approach[2] (distance from up-road start of rolling dip to trough)(ft)	Reverse grade[2] (distance from trough to crest) (ft)	Depth below average road grade at discharge end of trough[2] (ft)	Depth below average road grade at upslope end of trough[2] (ft)
<6	55	15-20	0.9	0.3
8	65	15-20	1.0	0.2
10	75	15-20	1.1	0.1
12	85	20-25	1.2	0.1
>12	100	20-25	1.3	0.1

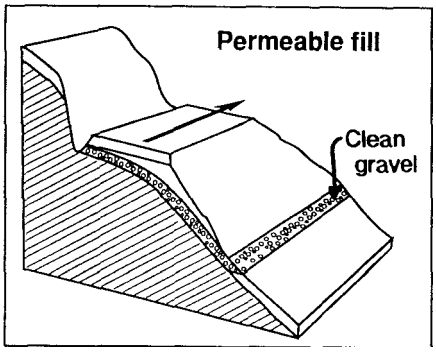
[1] *USDA-SCS(198l)*
[2] *See also Figure 28*

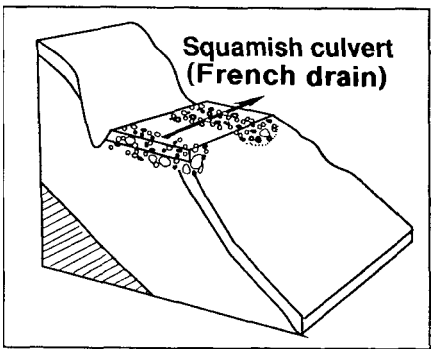
D. Subdrainage requirements and design techniques

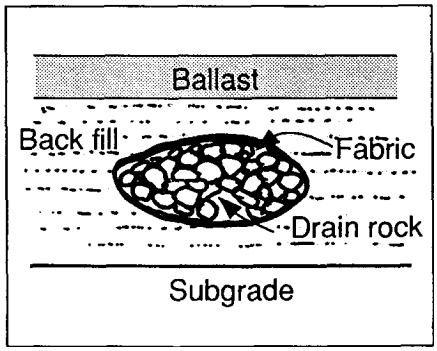
Subdrainage is used to carry subsurface or emergent subsurface water from the roadway. Seepage can occur along the cutbank, beneath the roadbed and/or beneath the road fill along the outside edge of the road. This can cause several problems if subsurface water is not drained from the road prism and construction area, including 1) excessively wet fills and subgrade materials, leading to road surface rutting or the need for large quantities of rock as base-course, 2) cutbank slumping, 3) mass wasting of the fill due to unrelieved pore water pressures, and 4) continual mud pumping at the road surface, leading to failure of the surfacing and the need for regular re-surfacing.

Use of special subdrainage measures is not typically required on forest and ranch roads. However, when needed, some relatively simple techniques can be used to get rid of water (Figure 22). Ditches and French drains excavated along the inside edge of the road, at the base of the cutbank,

are common methods of draining emergent, upslope ground wa^er. Horizontal drain pipes can be installed to drain water from the cutbank, but this stabilization technique is expensive and not always effective.







French drain

Figure 22. *Roads which are built across small springs or seeps can be kept dry and stable by the use of subsurface drainage techniques. Drainage blankets (a) and "french"drains (b), using graded rock and synthetic fabrics (geotextiles), are two common methods for draining subsurface soil and rock materials. Figure lie details a close-up of the modem french drain design using a geotextile lining (B.C.M.F., 1991).*

If the roadbed crosses an intermittent or perennial spring, soils beneath the road surface may need extra drainage. For water which will emerge beneath the road, gravel drainage blankets can be used to drain the water laterally to the toe of the fillslope. Filter fabrics (geotextiles) are used to maintain separation between the native hillslope materials and the I gravel. Where fills are thin, and where surfacing is placed directly on native soils, geotextiles can also be used at the base of the subgrade to maintain soil separation and prevent soil pumping into the surfacing materials.

E. Landing design and layout

Log landings built along forest roads vary tremendously in size and frequency from one landowner to the next, but their design requirements differ lime from other sections of a road system (Figure 23). Newer, mobile cable yarding machines can operate on narrow sections of road, with lime more than a turnout required for their swing. Other yarders, including towers, may require an entirely separate "yarder pad" be constructed on a spur road above the main haul road where logs are landed and then loaded onto trucks. However, such large yarding machines are becoming less commonplace.

Tractor yarding requires moderate size landings that, over the years, often grow larger than needed as spoil and debris is carried down the converging skid trail network and then sidecast over the outside edge of the landing.

The frequency of landings that need to be constructed is controlled, or influenced, by the type of yarding equipment, the slope of the land and the density of harvestable trees along the route. For

example, on very steep slopes, stable landings might only be constructed on broad ridge crests. **In general, landing construction should be limited to the fewest number and smallest size that are absolutely needed for yarding operations.**

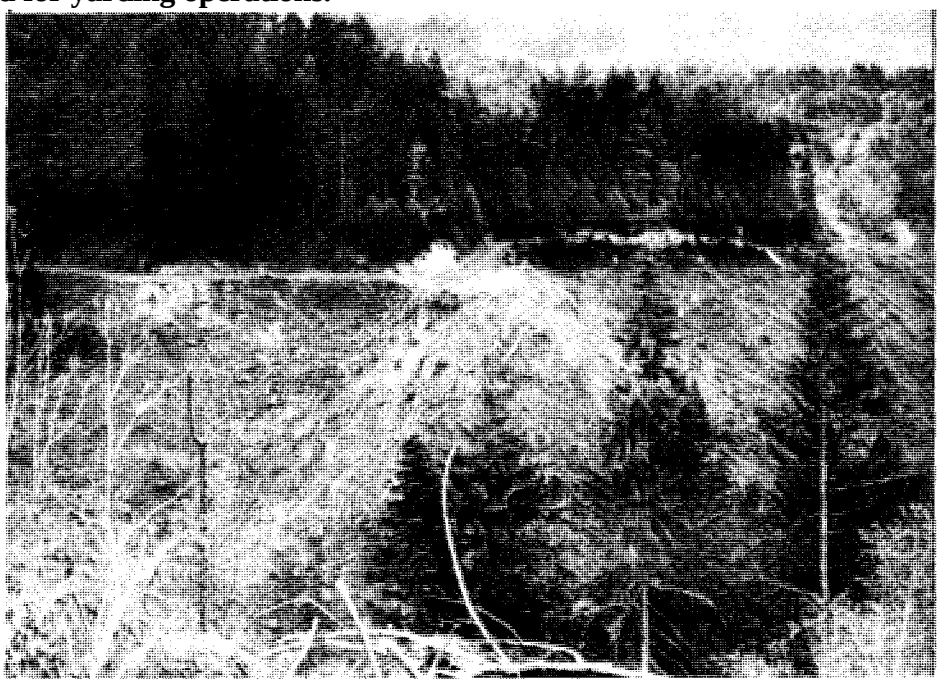


Figure 23*. Landings should be built on the nose of ridges and above the break-in-slope defining the steep inner gorge slopes above a stream channel.*

Landing fills that are placed on steep slopes or near watercourses should be "keyed" or benched into the hillslope and compacted in shallow (1 foot) lifts from the bottom up. **Sidecasting should be avoided. In addition, older landings which are being rebuilt or reused should not be enlarged by sidecasting of spoil or organic debris.** Where roads are located far from the stream, maximum hillslope gradients for building small landings using sidecasting methods should be the same as for road construction: about 55 percent. It is recommended that keyways or benches be constructed for catching sidecast and fill where landings are built on slopes steeper than about 40%.

The following terrain conditions should be avoided as sites for landings: 1) unstable slopes and soils, 2) open slopes steeper than 30 degrees (55%) with no natural benches, 3) steep headwater swales and inner gorge slopes, 4) narrow ridges between headwater swales, 5) any steep slopes (>50%) which led without flattening to a watercourse and 6) areas underlain by steeply dipping sedimentary rock or highly fractured rock.

Constructing full benches for landings on steep slopes produces tremendous volumes of spoil material. Although full benching might be necessary so that fills can withstand equipment vibrations and weight loads, spoil that is disposed of as sidecast can destabilize the hillside below. Gully headwalls and swales are already naturally unstable sites and have little room for landing debris. Sidecasting into these steep headwater swales can trigger debris flows and torrents (Figure 24). Although steep, narrow ridges adjacent these steep headwater channels provide good deflection for yarding, the sides of these ridges are often unstable and unsuitable for sidecasting.

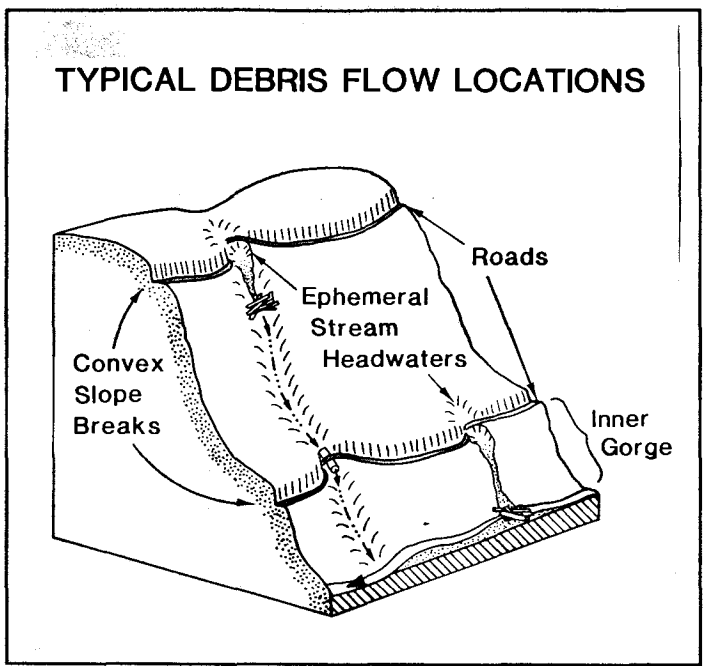


Figure 24. *Recent research has shown that many destructive debris flows and debris slides caused by the construction of wildland roads occur at specific sites on the hillside. The most sensitive sites, and therefore those to avoid during road construction, are steep inner gorge slopes, steep headwater stream areas, and steep slopes immediately below a convex bread-in-slope.*

F. Special design considerations

In both the forest and ranch-land setting, special design considerations may be required where roads cross unstable slopes, wet areas, watercourses and other potential hazards or obstacles. Some of these might involve using new, state-of-the-art subdrainage materials and methods. Other special designs may simply involve the application of time tested methods of equipment exclusion, excavation, endhauling, bridge installation, road surfacing or additional requirements to provide increased protection to water quality. Guides for special road design are often available from private geotechnical firms specializing in road construction, or from suppliers of materials and supplies used in erosion control and road engineering.

Converging roads on steep slopes is one special case of road construction that commonly produces erosion and sediment problems. In this situation, a lower road may undercut and remove support for the upslope road. In addition, sidecast from the upper road can extend downslope to the lower road, with continuing sidecast from the lower road then extending the blanket of bare soil downslope even farther. These bare soil areas are notably difficult to stabilize and revegetate.

The best planning and design solution for converging roads is to locate road junctions on gentler slopes, or to plan for them to occur on broad ridges separating steep gradient slopes. If steep slopes cannot be avoided, it is recommended that the upper road be constructed as a full bench road with all spoil endhauled to a stable location, and the lower road be built with an engineered fill to limit uncontrolled sidecasting. The road junction should be located sufficiently far upslope from watercourses such that water quality will not be affected. Full bench construction with endhauling, or other creative engineering solutions that minimize sidecast, may be designed for these "unavoidable" settings where the potential for sedimentation or slope failure is relatively high.

G. Equipment needs for construction and reconstruction

Construction is the application or implementation of road design on the ground. How well the design is followed during construction depends both on the skill and understanding of the equipment operators and the type and size of heavy equipment used for each task. For example, constructing a full bench road with endhauled spoil material requires suitable excavating equipment. A tractor will not work, especially on moderate or steep slopes. Similarly, without a skilled equipment operator, there is a much higher chance of making expensive mistakes or causing environmental damage.

In steep or mountainous areas, it is often a serious mistake to design the road around the types of equipment you own or have to work with. Roads should be designed for stability as a primary concern, and then constructed using the types of equipment called for by the road design and the environmental setting. Similarly, operators should be used who are experienced with the equipment and with implementing similar design requirements.

The bulk of road reconstruction may consist of vegetation removal and grading performed by tractors on abandoned roads that have been overgrown for many years. As with road construction, however, it is very important to use the proper types of heavy equipment when the more complicated situations are encountered (Table 19). Thus, excavating equipment is often specified for road reconstruction, especially where the old road has been built next to a stream or within a watercourse protection zone (Figure 25). Where stream crossings have partially or completely washed-out, hydraulic excavators may be needed to reinstall upgraded culverts and to place and compact fill. Loaders and dump trucks may be needed for spoil removal where the road is blocked by cutbank failures.

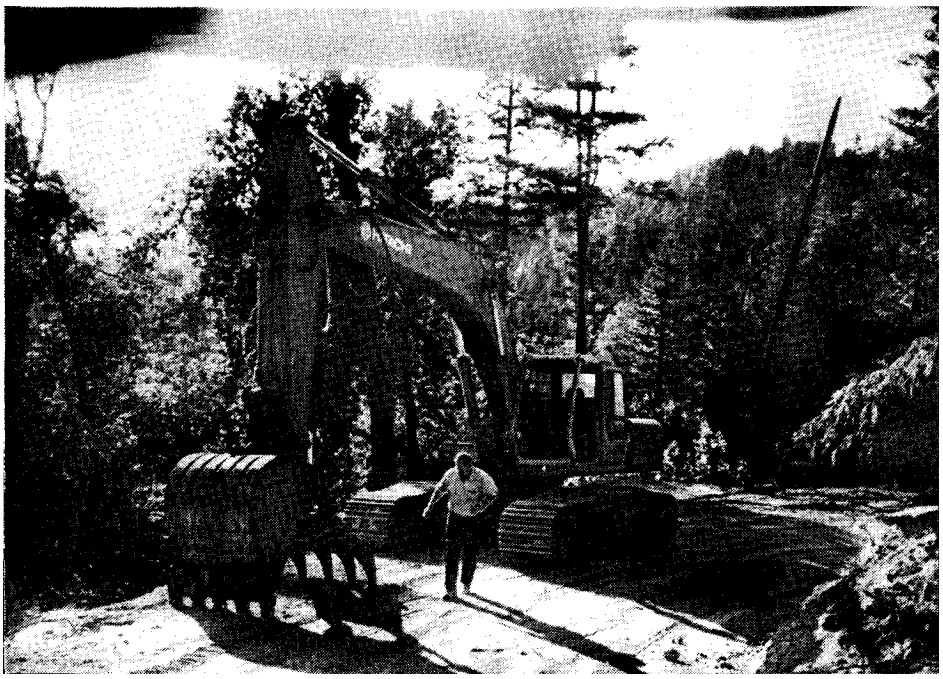


***Figure** 25. Perhaps the most versatile of road building equipment today is the hydraulic excavator. Low impact roads can be built quickly and efficiently using this now-common type of earth moving equipment. Roads constructed exclusively using bulldozers to cut-and-sidecast soil material are best confined to hillslope gradients less than about 35 percent and to areas where incised stream channels are not common.*

Table 19. Settings and equipment combinations suitable for various types of road construction methods.

Generic road type	Hillslope characteristics	Typical equipment types
Sidecast (cut-and-sidecast)	Gentle (<35%); stable, far from streams	tractor; grader; water truck
	Moderate (<55%), stable, far from streams	excavator and tractor, or tractor; grader; water truck
	Moderate (<55%), close to stream	excavator and tractor; grader; water truck
Cut-and-fill (with compaction)	Gentle (<35%)	excavator and/or tractor; grader; water truck
	Moderate to steep (35-55%)	excavator, or excavator and tractor; grader; water truck
Full bench (cut)	All slopes	excavator, dump trucks, some tractor, grader, water truck
Temporary fill (cribbed)	Moderate to steep	excavator and tractor
Reconstruction	All slopes	excavator, tractor; loader; dump trucks; grader

Notes:

CHAPTER V: DRAINAGE

A. Introduction to road drainage

It is impossible to over-emphasize the importance of drainage in maintaining stable roads and protecting water quality. Roads should be designed and constructed to cause minimal disruption of natural drainage patterns. Provisions for two components of road drainage should be included in every road project: 1) road surface drainage (including drainage which *originates* from the cutbank, road surface and fillslope) and 2) hillslope drainage (including drainage from large springs, gullies and streams which *cross* the road alignment).

B. Road surface drainage

Road surface drainage is accomplished by insloping, outsloping or crowning the roadbed. Without adequate cross-slope, the road surface will either pond water, or concentrate runoff down the roadbed and create surface erosion. Roads with springs along the cutbanks are often insloped with an inside ditch, roads with smaller cutbanks or dry cutslopes may be outsloped for most of their length, and some larger roads are crowned to most rapidly drain runoff from their surfaces. For seasonal roads, insloping can occur with or without an inside ditch.

1. Outsloped roads

It is generally recommended that most forest and ranch roads be constructed as single lane (minimum width), outsloped roads with minimal cut-and-fill, where conditions are suitable (Figure 26). These roads are likely to cause the least disturbance and soil movement, create less environmental impact and have lower maintenance costs than other designs. All-season roads built high on the hillside, or wherever the surface can be kept dry, can generally be outsloped. Conditions that might limit road outsloping include, 1) steep road grades (which may make adequate outsloping difficult), 2) winter use of an unsurfaced road (snow or muddy conditions on a steep, outsloped road may be hazardous), or 3) upslope runoff or excessive spring-flow from the cutbank or road bed (which makes an inside drainage ditch necessary).

Figure 26. *Well built outsloped road displaying minimum cut, smooth free draining surface, no outside berm and rolling dips to help disperse surface runqff.*

Even on roads which are outsloped for much of their length, some sections can be insloped to deal with local conditions. For example, short sections of insloping, in combination with an inside ditch, can be used to drain local wet areas. The road can be either insloped or outsloped through stream crossings. Finally, while some wet cutbanks may require the construction of an inside ditch (or French drain) for drainage, the roadbed itself may still be a worthy candidate for outsloping. Outsloping will minimize flows in the inside ditch and reduce the potential for erosion and sediment delivery to the next culvert

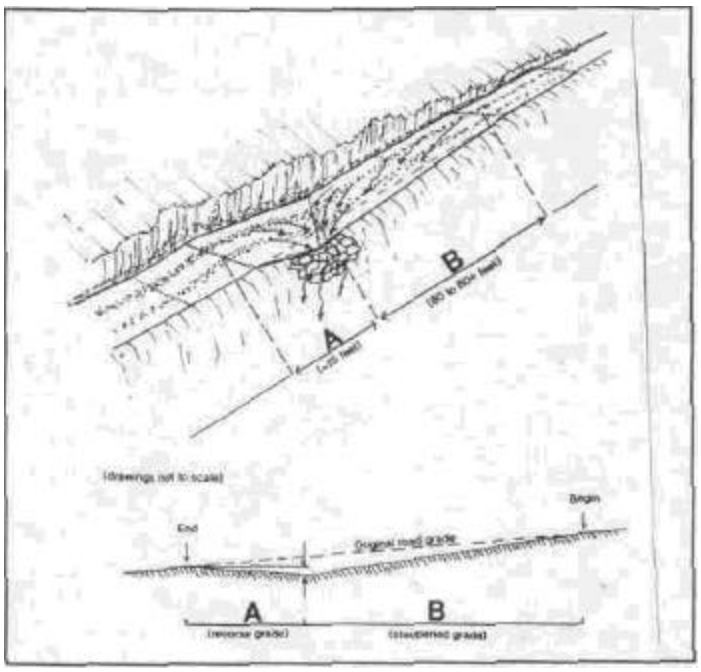
On climbing (or falling) roads, the road surface can be drained using rolling dips or waterbars. Rolling dips are smooth, angled depressions constructed in the roadbed (Figure 27). Dips should be constructed deep enough into the road subgrade so that traffic and subsequent road grading will not obliterate them. Their length and depth should provide the needed drainage, but not be a driving hazard.

***Figure** 27a. Rolling dip constructed on a rock surfaced forest road (a). The rolling dip represents a change-in-grade along the road alignment and acts to discharge water that has collected on or is flowing down the road surface.*

***Figure** 27b. A side view (b) shows that the rolling dip does not have to be deep to reverse road grade and drain the road surface.*

In general, broad rolling-dips are built at a 30 to 45 degree angle to the road, with a cross grade of at least 1 percent greater than the grade of the road. Some are built nearly perpendicular to the road alignment. They are built with a long, shallow approach on their up-road side and a more abrupt rise or "lip" on their down-road side (Figure 28, Table 10). They are usually used on outsloped roads to drain road surface runoff to the outside of the road, but may be built on either insloped or outsloped roads to drain in either direction. Rolling dips should be placed at intervals frequent enough to prevent road surface rilling and erosion (Tables 3 and 17), yet broad enough to permit uninterrupted vehicle travel. They may be designed and constructed into new roads, or they may be built into older, existing roads that are being reconstructed.

Figure 28. The up-road approach to the rolling dip (B) is several percent steeper than the approaching road and extends/or 60 to 80 feet to the dip axis. The lower side of the structure (A) reverses grade over approximately 15 feet, and then falls down to rejoin the average road grade. It must be deep enough that it is not obliterated by normal grading, but not so deep that it is difficult to negotiate or a hazard to normal traffic. The outward cross-slope of the dip axis should be at least 1% greater than the original road grade so it will drain properly.



Waterbars (also called waterbreaks) can also be used to drain a road surface. These are shallow, abrupt excavated dips or troughs with an adjacent, downslope hump or mounded berm, that are built at an oblique angle across the road. **Waterbars are useful only on low standard seasonal or temporary, unsurfaced roads where winter use will not occur, because traffic easily cuts through the soft berm and fills the adjacent dip.** Waterbars should be constructed at proper spacing according to the grade of the road (Figure 29; Tables 3 and 17). Waterbars are usually regraded (smoothed out) at the beginning of each operating season, and then reconstructed at the beginning of each winter period.

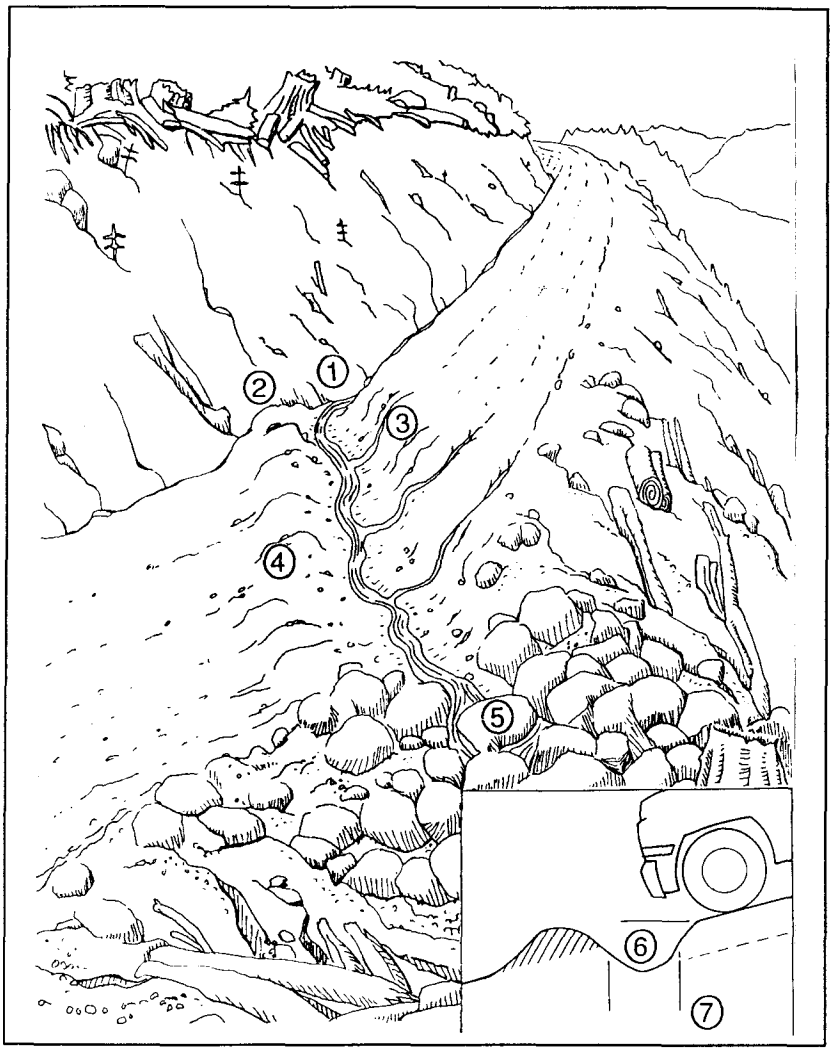


Figure 29. Waterbars are constructed on unsurfaced forest and ranch roads that will have little or no traffic during the wet winter period. The waterbar should be extended to the cutbank to intercept all ditch flow (I) and extend beyond the shoulder of the road. A berm (2) must block and prevent ditch flow from continuing down the road during flood flows. The excavated waterbar (3) should be skewed 30° to the ditch-line with the excavated material bermed on the downhill grade of the road (4). Water should always be discharged onto the downhill side on a stable slope protected by rip rap or vegetation (5). The cross ditch depth (6) and width (7) must allow vehicle cross-over without destroying the function of the drain (B.CM.F., 1991)

Waterbars are high maintenance drainage structures that are prone to failure if not properly built and maintained. Unauthorized winter traffic is likely to break down waterbars and result in serious road surface erosion and water pollution.

On outsloped roads, a narrow berm can be locally constructed along the outside edge of the road to divert road runoff away from erodible fillslopes (Figure 30). This technique of road surface drainage control may be used where road fills are especially steep, erodible or located close to watercourses, such as at stream crossings. Collected runoff can then be funnelled to protected areas or discharged across the fill through a fabricated, sheet metal berm-drain that is located at a designed break in the outside berm. This practice, however, adds a high risk and high maintenance feature to an otherwise low-maintenance drainage design. Unfortunately, repeated annual grading on many wildland roads has created widespread outside road berms that collect road surface runoff and create rill and gully erosion on roads and fillslopes. **Generally, outsloped roads should *not* be built with outside berms.**

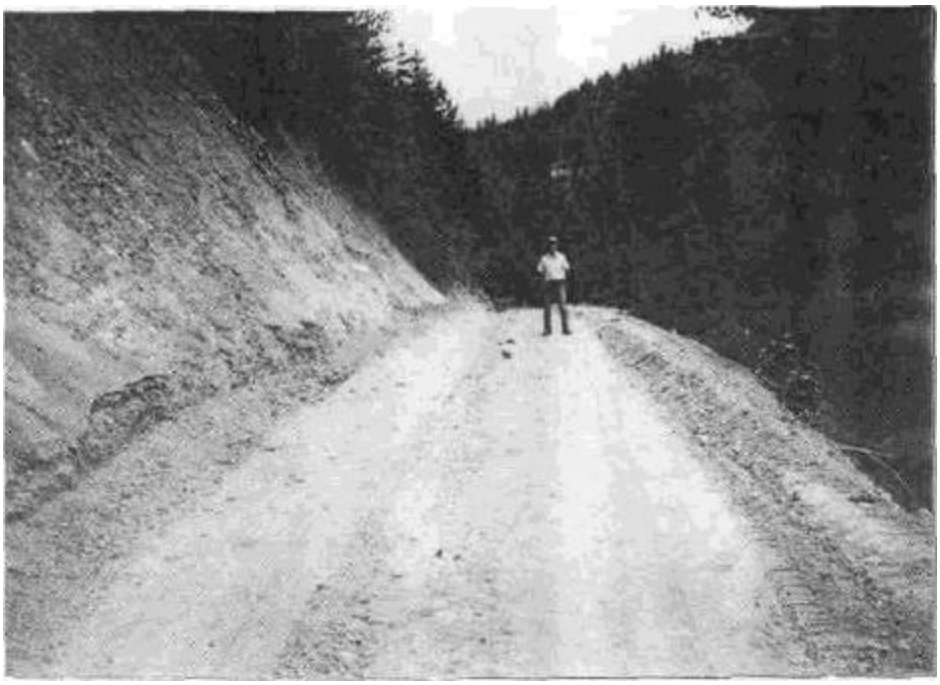


Figure 30. Short road reach where a soil berm has been constructed along the outside edge of the road prism, to prevent surface runoff from flowing over the highly erodible fill. To prevent the road surface from accumulating too much runoff and eroding, the berm can be intermittently breached and a wooden or sheet metal berm-drain used to carry runoff dawnslope past the base of the erodible fillslope.

Open top box culverts can also be used to drain the road surface, but they may fill with soil and rock, are difficult to grade over, and require higher levels of maintenance. Recently, experimental rubber-waterbars have been installed on forest roads in Oregon. These structures are located in the same position and orientation as dug waterbars. Their base is buried into the roadbed, and a thick, stiff rubber flap sticks up above the road surface to capture and direct surface runoff. The flap bends down as vehicles pass over the waterbar and then immediately springs back to deflect runoff. Unlike the dug waterbar, which tends to break down with continued vehicle use, the rubber waterbar should remain functional in traffic. The rubber waterbar will be most useful on rocked roads or on seasonal roads where frequent road grading is not necessary.

2. Insloped roads with ditches

Insloped roads should be constructed only where road surface drainage discharged over the fillslope would cause unacceptable erosion or discharge directly into stream channels, where fillslopes are unstable, or where outsloping would create unsafe conditions for use. It is generally preferable to outslope road surfaces in order to disperse road surface runoff before it has a chance to concentrate.

Insloped roads should be built with an inside drainage ditch to collect and remove road surface runoff (Figure 31). Roads steeper than about 8 percent may be too steep for an inside ditch because of the potential for gullying in the ditch. Inside ditches should also be drained at intervals sufficient to prevent ditch erosion or outlet gullying, and at locations where water and sediment can be filtered before entering a watercourse. "Filtering" can be accomplished by thick vegetation, gentle slopes, settling basins, or filter windrows of woody debris and mulches placed and secured on the slope.

Figure 31. *Rock surfaced, insloped road with* ***an*** *inboard ditch. A ditch relief culvert carries ditch/low beneath the road at location "A."*

As with outsloped roads, steep insloped road surfaces may be difficult to quickly drain. Rolling dips (for permanent, surfaced roads and seasonal roads) or waterbars (for seasonal or temporary, unsurfaced roads) should be constructed at intervals sufficient to disperse road surface runoff from steep road segments (Tables 3 and 17).

Ditches and culverts need occasional maintenance to operate correctly and to carry the flows they were designed to handle. The most important type of maintenance is annual and storm period inspections which can prevent small problems from growing into large failures. When ditches become blocked by cutbank slumps, they need to be cleaned and the spoil deposited in a stable location. However, excessive maintenance (mostly grading) can cause continuing and persistent erosion, sediment transport and sediment pollution to local streams during storm runoff. It may also remove the rock surfacing.

Ditch relief culverts should be designed and installed at intervals along the road that are close enough to prevent erosion of the ditch and at the culvert outfall [1], and at locations where collected water and sediment is not discharged direcdy into watercourses (Table 20). On new roads, ditch flow should be culverted and discharged into buffer areas and filter strips before it reaches a watercourse crossing (Figure 32). Ditches should neither be discharged directly into the inlet of a watercourse crossing culvert, nor should ditch relief culverts discharge into a watercourse without first directing flow through an adequate filter strip. In addition to installing ditch relief culverts on either approach to watercourse crossings (Figure 32), it is also advisable to consider installing ditch drains before curves, above and below through-cut road sections, and before and after steep sections of the road.

[1] California's Forest Practice Rules do not prescribe the maximum or proper distance between inside ditch relief drains. Instead, they state that adequate drainage must be provided. Indicators of inadequate relief drain spacing include: 1) gullying of the inside ditch, 2) gullying or sliding of the slope below the culvert outlet of a cross drain, 3) direct transport of sediment along an inside ditch to a watercourse, or 4) loss of capacity of culvert cross drains due to filling with sediment.

Figure 32. Where a road approaches a stream crossing (B), ditch flow should be adverted across the road (A, D) and discharged into a vegetative buffer that can filter the runoff before it reaches the watercourse. If the stream culvert plugs with debris or is topped by flood flows, flow will spill over the road at the change-in-grade at location "C" and back into the stream channel (modified from MDSL., 1991).

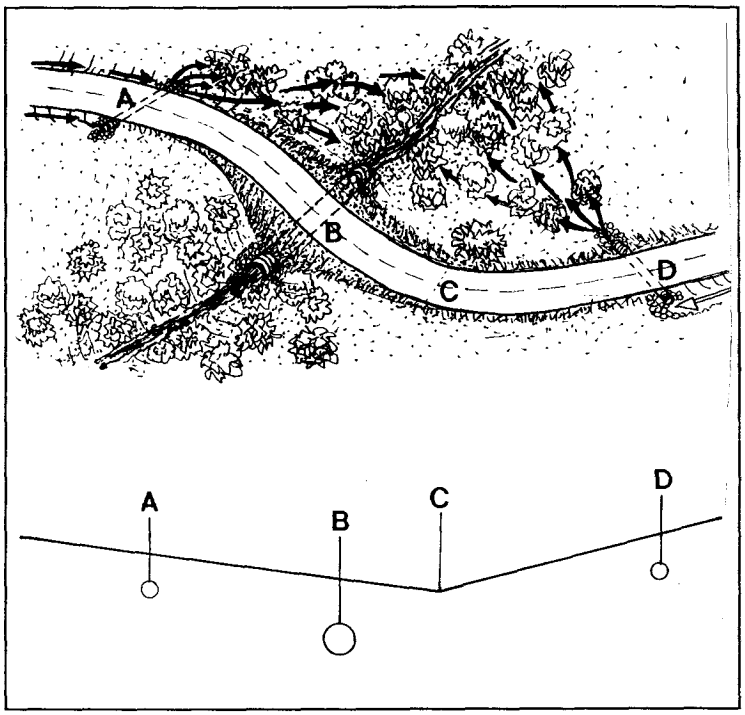


Table 20. Maximum suggested spacing for ditch relief culverts[1] (ft)

Road grade (%)	Soil credibility				
	very high	high	moderate	slight	very low
2	600-800[2]				
4	530	600-800[2]			
6	355	585	600-800[2]		
8	265	425	525	600-800[2]	
10	160	340	420	555	
12	180	285	350	460	600-800[1]
14	155	245	300	365	560
16	135	215	270	345	490
18	118	190	240	310	435

[1] *Adapted from Transportation Handbook USDA Forest Service, R-6, 1966. Culvert spacing may be too great in locations where ditch runoff is accumulated and discharged onto steep hillslopes that are prone to gullying. Spacings are designed to control ditch erosion, not culvert outfall erosion, and are based on 25-year storm and precipitation rate of 1-2 in/hr for 15 minutes. If less, multiply by the intensity 0.50, 030, etc. If 2-3 in/hr, divide distance in table by 1.50; if3-4 in/hr, divide by 1.75; and if 4-5 in/hr, divide by 2.00. The U.S. Forest Service also publishes abundant information on preventing and controlling gully erosion below culvert outfalls.*

[2] *Even with stable ditches, ditch relief culvert spacing greater than about 600 to 800 feet is generally not recommended due to the large volume of road surface and cutslope runoff that would be discharged through the culvert and onto lower slopes during peak runoff periods. Culvert outlet erosion may occur with less than 800 feet of contributing ditch line, so observe local conditions to determine the upper limit of acceptable spacing in your area.*

If a ditch is capable of transporting and delivering sediment to a Class I or Class II watercourse during a flood event, it can be said to function the same as a Class III watercourse. It has a bed and a bank, and it can transport sediment Ditches which drain directly into watercourse crossing culverts should be treated and protected from disturbance and erosion, just as is a Class III watercourse. Ditch relief culverts should be installed across ditched roads before watercourse crossings so that water and sediment can be filtered before reaching the stream.

Ditch relief culverts do not need to be large, since they carry flow only from the cutbank, springs and a limited length of road surface. **In areas of high erosion and/or storm runoff, minimum ditch relief culvert sizes should be 18 inches, but ditch relief culverts should never be less than 12 inches diameter.** Smaller culverts arc too easily plugged.

Generally, culverts should have a grade at least 2 percent greater than the ditch which feeds it to prevent sediment buildup and blockage. Where possible, ditch relief culverts should be installed at the gradient of the original ground slope, so it will emerge on the ground surface beyond the base of the fill. If not, either the fill below the culvert outlet should be armored with rock, or the culvert should be fitted with an anchored downspout to carry erosive flow past the base of the fill. Culverts should never be "shot-gunned" out of the fill, thereby creating highly erosive road drainage "waterfalls."

A 10 percent grade to the culvert will usually be self cleaning. The culvert should be placed at a 30 degree skew to the ditch to improve inlet efficiency and prevent plugging and erosion at the inlet (Figure 33). The pipe should be covered by a minimum of 1 foot of compacted soil, or to a depth of 30% of its diameter, whichever is greater. Finally, inlet protection, such as rock armoring or drop structures, can be used to help minimize erosion, slow flow velocity and settle-out sediment before it is discharged through the pipe (Figure 33).

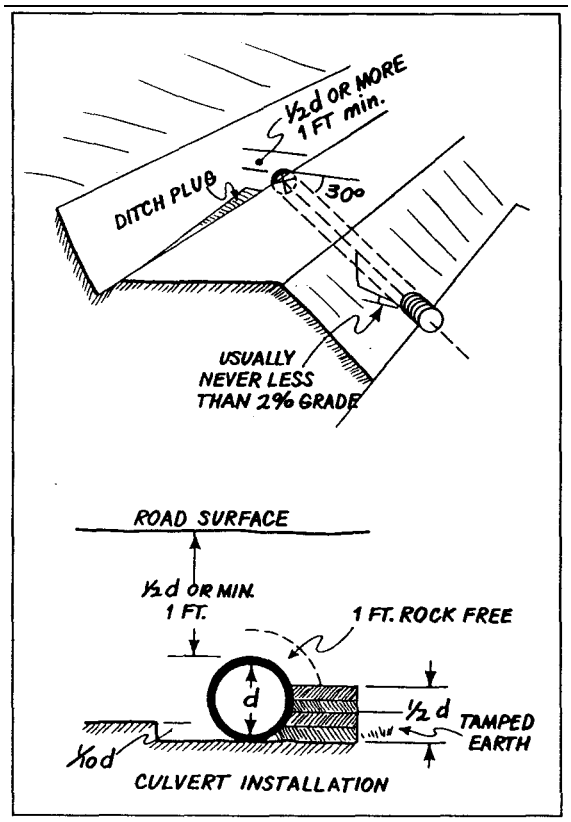


Figure 33. *The elements of a properly installed ditch relief culvert. The culvert is angled at about 30 degrees to the road alignment to help capture flow and prevent culvert plugging or erosion of the inlet area. It is set at the base of the fill (ideally) or with a grade slightly steeper than the grade of the contributing ditch (but never with a grade less than 2 percent) (USDA-SCS, 1983).*

C. Hillslope drainage (stream crossings)

Where a road crosses a natural watercourse, provision should be made to carry the water under the road. Streams can be crossed with bridges, culverts or fords. Culverts are the most common stream crossing structure. Bridges are best for large streams or where there is a lot of floating wood and debris in flood flows. Bridges also have less effect on fisheries than other methods. Fords work well on small to medium sized streams where there is a stable stream bottom and vehicle traffic is light. Compared to a culverted fill, they have the advantage of little fill to wash out during flood flows. Unless wet fords are constructed of poured concrete, they are less desirable in high traffic areas because continued disturbance to the streambed can cause persistent downstream turbidity and fine sediment pollution problems. Dry fords on seasonal roads can often be installed and used with minimal impact to the channel system.

1. Legal requirements

All private landowners constructing temporary or permanent stream crossings need to obtain proper permits and follow applicable laws and regulations of state and federal agencies. Prior to conducting road building or timber operations, or to modifying the bed or banks of a stream channel for *any* purpose, it is important to determine the legal requirements of your work.

Under the provisions of section 1603 of the Fish and Game Code, ***any activity that would result in the diversion or obstruction of natural stream/low, or in physical modification of the bed or banks of a stream or lake, is <u>unlawful</u> to perform without first formally notifying the Department of Fish and Game.*** The Department of Fish and Game will act on your 1603 proposal within 30 days (or sooner), and may request a field Visit to the site and/or propose measures deemed necessary to protect fish and wildlife. Permanent or temporary stream crossing structures, fords, rip-rapping or other bank stabilization measures, culvert installations, bridges, or skidding across temporary crossings are some of the projects which are subject to the 1603 notification process (Appendix B).

Forestry operations and road activities near watercourses are also subject to the California Forest Practices Act and to rules and regulations developed by the State Board of Forestry and administered by the California Department of Forestry and Fire Protection (Appendix C). These apply to any forest operation involving commercial wood products. The rules include culvert sizing requirements, requirements for removal of temporary stream crossings, limits on equipment operations near stream channels, road construction standards, and a variety of other road building and erosion control requirements. Information on the Forest Practice Act and Rules can be obtained from Ranger Unit offices of the California Department of Forestry and Fire Protection.

Federal and state water pollution regulations are administered and enforced by the California Water Resources Control Board, through their Regional Water Quality Control Boards. Information about requirements pertaining to road building work can be obtained from the Regional Water Quality Control Board with jurisdiction for your area. A wrong choice in stream crossing method can result in major damage to both the immediate site and to downstream water quality. There are strict legal requirements for protecting water quality. ***Stop-work orders, clean up and repair orders, and penalties for pollution can delay your project and be very expensive. Do it right the first time!***

Ask your local California Department of Fish and Game warden, a forester from the California Department of Forestry and Fire Protection, and your Regional Water Quality Control Board inspector for assistance and information about requirements for your project. Prevention is always the best course of action.

2. Stream crossing design

Classifying the stream (Class I, II, III or IV) and the road (temporary, seasonal or permanent all-weather) is the first step in defining the type of crossing to be installed. Stream crossings should be designed for adequate fish passage (where fish could be seasonally present), minimum impact on water quality, and to handle peak runoff and flood waters. Stream crossings can be classified as either "permanent"[2] or "temporary." There are three basic subcategories of both permanent and temporary stream crossings: 1) bridges, 2) fords, and 3) culverts. Culverts include not only the traditional corrugated metal pipe (CMP), but also "Humboldt" log crossings, and other temporary structures that pass streamflow through the road fill.

The type of crossing facility selected will depend on a number of factors. Each of these elements should be considered before selecting the final design or location for the stream crossing installation. Design considerations include:

1) whether or not fish use the channel at the crossing site,
2) whether the crossing will be temporary (used for only a single entry) or permanent (to be used for a number of years),
3) the type of vehicles that will use the crossing,
4) the slope, configuration and stability of the natural hillslopes on either side of the channel (soil foundation conditions),
5) the slope of the channel bed,
6) the orientation of the stream to the proposed road,
7) the expected 50- or 100-year flood discharge (i.e., stream size),
8) the amount and type of sediment and woody debris that is in transport within the channel,
9) the installation <u>and</u> subsequent maintenance costs for the crossing,
10) the expected frequency of use, and
11) permits and other legal requirements.

These and other site-specific factors play a role in determining the best crossing location and most suitable type of stream crossing to be used.

[2] There is really no such thing as a "permanent" culverted stream crossing. Culverts are subject to a variety of processes which guarantee their eventual failure unless they receive periodic and storm maintenance, and they are replaced and rebuilt at the end of their normal life span. Metal culvert pipes have a limited life span and will eventually wear down and fail. In addition, since culverts are designed to pass a "design flood," a larger flood will eventually occur which exceeds culvert capacity and washes out the stream crossing.

3. Fail-safe and "fail-soft" drainage designs

Culverted stream crossings are naturally susceptible to failure. That is why it is somewhat of a misnomer to call culverted stream crossings "permanent." In reality, a fill crossing is really an earthen dam, placed across a stream channel, that has a small hole (culvert) in the bottom. Plug the hole with sediment, vegetation or wood, and the dam will wash out. That's why culverted crossings need to be properly designed, constructed and maintained to prevent loss of the fill and discharge of large volumes of soil into the stream.

Washed-out stream crossings are a common occurrence on abandoned, poorly maintained and/or improperly designed forest and ranch roads. However, culvert plugging can result in much more damage than a washed-out stream crossing fill. If flow from a plugged culvert is diverted down the adjacent road (instead of flowing over the fill and immediately back into the stream channel), the diverted streamflow can create large gully systems or trigger landslides as it flows over nearby unprotected hillslopes.

Stream crossings with a **high diversion potential (DP)** occur wherever the road climbs through the crossing and one approach slopes away from the stream crossing (Figure 34). If the culvert plugs on a crossing with a high DP, backed up flood waters will be diverted down the road alignment (Figure 35). If the crossing has no DP, backed up flood waters will flow onto the road surface, over the fill and back into the natural channel. The fill may be washed-out, but streamflow is not diverted out of the channel and onto adjacent, unprotected roads and slopes.

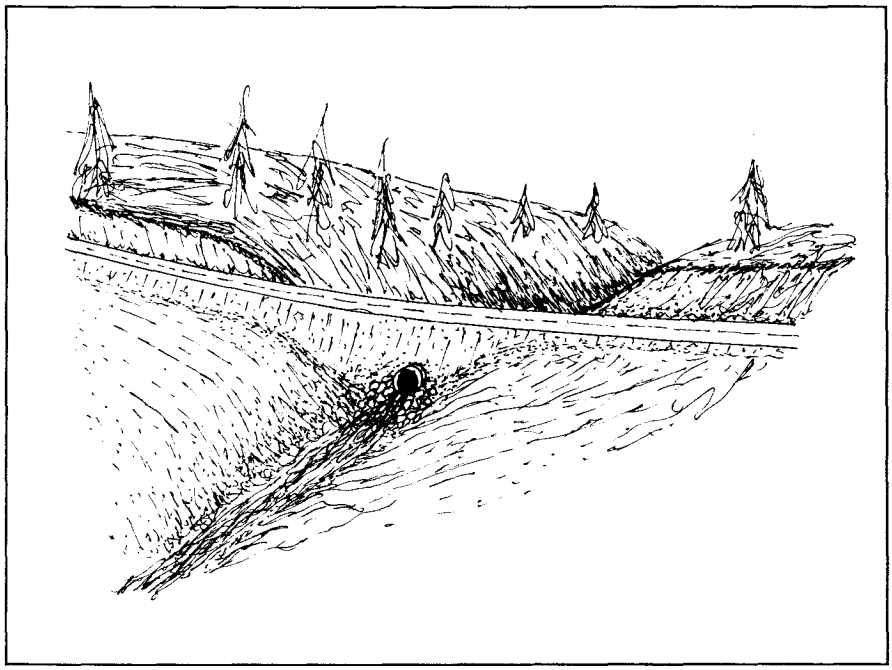


*Figure **34a.** Stream crossing with diversion potential (a) and with no diversion potential (b). In Figure 34a streamflow would be diverted down the road toward the right side of the picture.*

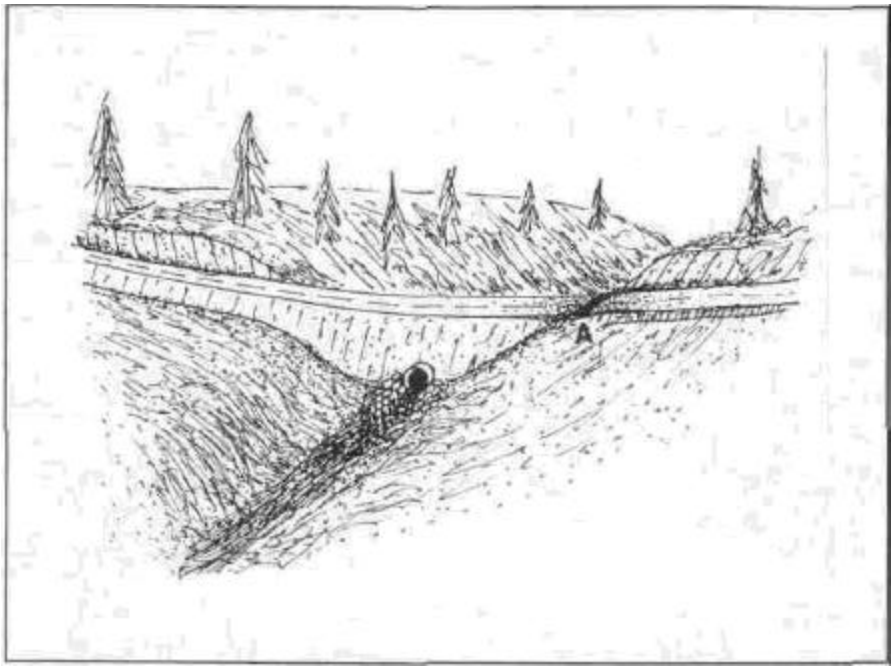


Figure 34b. *In Figure 34b flow would reach the road surface and flow back into the channel at location "A," where the road changes grade.*

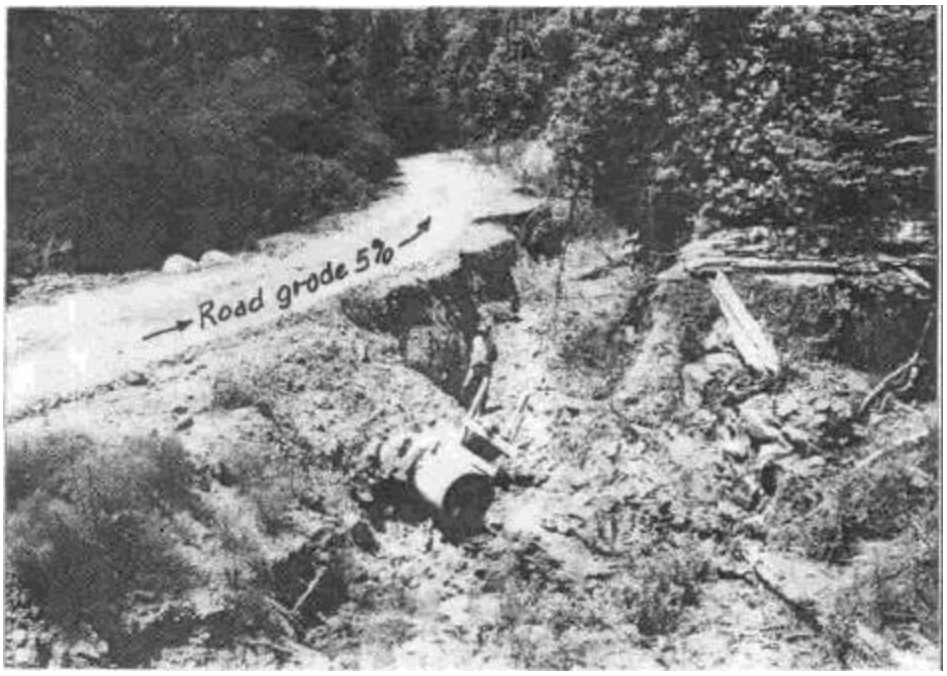


Figure 35. *Double culvert stream crossing showing the result of a stream diversion that occurred during a winter storm. The road slopes to the distance at about 5 percent, so when the culverts plugged with debris, water flowed down the inboard ditch and created the large diversion gully.*

A very large number of existing stream crossings on private forest and ranch land have been constructed with a high diversion potential (Figure 36). During road reconstruction, these high DP crossings should be corrected by constructing a broad rolling dip over or immediately down-road from the fill. New stream crossings should be constructed to prevent stream diversion of flood overflow if the culvert were to become plugged. This can be done by designing the road to "dip" into and out of the stream at the crossing site (a dipped crossing), or by installing a broad rolling dip on the down-road side of the crossing, so that flood overflow will be directed back into the natural stream channel (Figure 37). **Stream crossings on all newly built or reconstructed roads should not be constructed in a manner that gives any opportunity for future stream diversion.**

Stream crossings with no diversion potential are said to be designed as **"fail-safe"** because a dip in the road grade prevents flood flows from ever flowing down the road. Fail-safe stream crossings are also said to be **"fail-soft"** if the dip in the road bed is located over the edge (not the center) of the fill, so that erosion from an overflow event will be less likely to erode and wash out the entire fill.

Figure 36. *Steeply climbing road crosses a stream channel without changing grade, creating a crossing with a high diversion potential.*

Figure *37. A gradually climbing road changes grade over the stream crossing, thereby eliminating the possibility for future stream diversions.*

4. Stream crossing culverts

To function properly, culverts should be installed at a stable grade (preferably at or slightly below the bed of the original stream channel). It is best for the road to cross at right angles to the stream channel, but regardless of the road alignment, the culvert should be placed parallel to the natural channel so that the inlet will not plug and flow from the outlet will not erode either of the channel banks (Figure 38).

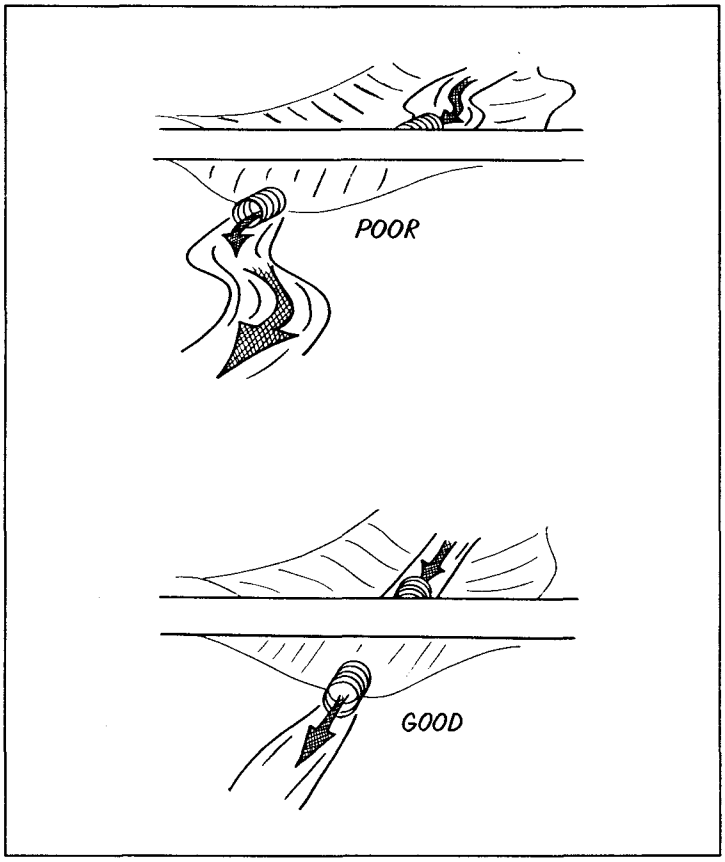


Figure 38. *Culverts should be aligned with and placed in the bed of the natural channel so that flow enters and exits the culvert without having to turn (USDA-SCS, 1983).*

On fish-bearing streams, fish passage must be designed into all watercourse crossings (Figure 39). Most obstructions can be prevented if the potential for fish passage is recognized during road planning. Culverts should be placed at or slightly below grade (so fish don't have to jump up into the culvert). If flows are rapid, the culvert diameter should be increased and the culvert grade reduced. Resting pools should be designed immediately below and above the culvert. Maintaining a stable stream bottom through the culvert-influenced area is essential. Avoid installation of round culverts where fish passage might be difficult. Instead, use either open arch culverts or bridges. **In order of decreasing desirability, bridges, structural plate arch culverts, corrugated pipe-arches, and corrugated round metal culverts can be used for fish passage.** Bridges should be used on all larger, faster streams (Figure 40).

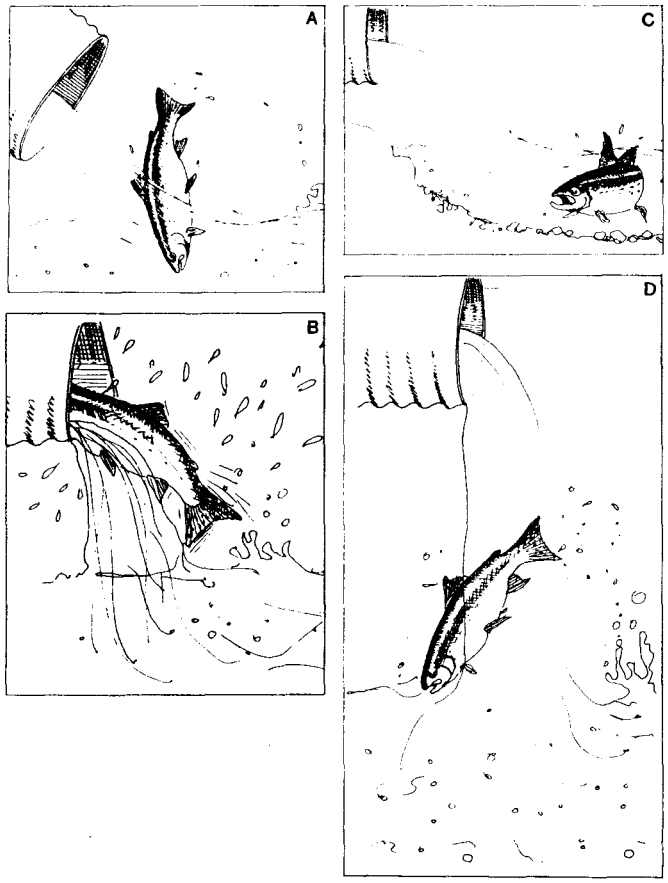


Figure 39. *Incorrect culvert installation can impede or prevent fish passage through a stream crossing. Culvert conditions that block fish passage include: A) water velocities too great, B) water depths too shallow, C) insufficient resting area or jumping pool depth at culvert outlet, and D) culvert outlets that are too high above the streambed (Furniss, et.al., 1991).*

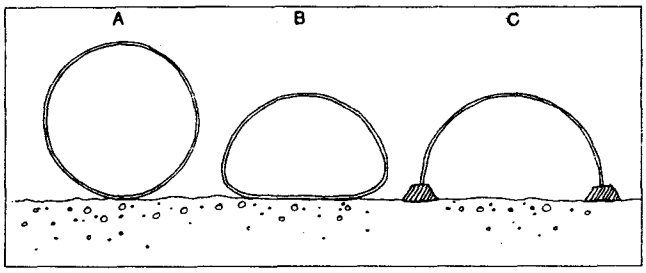


Figure 40. *Three common types of stream crossing culverts are used in forest-land and ranch-land road construction: A) round culvert, B) pipe arch culvert and C) plate arch "culvert." For stream crossings where fish passage must be accommodated and a bridge cannot be installed, plate arch culverts are preferred. Round culverts are the least preferred culverting method where fish passage is important.*

Debris control structures (trash racks) at culvert inlets, and energy dissipators at culvert inlets and outlets, are key components of stable culvert design (Figure 41). The design of these protective structures has been varied, and there are as many successful designs as there have been failures. Debris control is best obtained by some type of grate or "filtering" structure of inclined poles built across the channel just ***upstream*** from the culvert inlet Creativity and experience can be used to develop a successful design. Drop inlet "trash racks" have proven to be effective in trapping debris without allowing the culvert to plug. If constructed incorrectly, wooden crib boxes built around the culvert inlet can become clogged with debris and plug the culvert, or significantly reduce its capacity to pass flood waters. The most common problem with trash racks placed over the culvert inlet is that small debris is often trapped rather than being allowed to pass through the culvert. This small debris can clog the trash rack and actually cause the inlet to plug.

Figure 4la. *Trash racks at culvert inlets and energy dissipation at culvert outlets are methods of preventing erosion of the stream crossing fill. The most effective trash rack is one placed across the channel just upstream from the culvert inlet.*

Energy dissipation (rock armor is most common) may be needed to prevent high velocity culvert flows from eroding the channel bed or banks at the culvert outlet. Rock should be sufficiently large to resist erosion and transport. If the culvert outlet emerges mid-fill, a downspout or flume will be needed to carry streamflow down past the base of the fill and to the natural channel.

Flow capacity is one of the most important factors in stream crossing culvert design. Culverts need to be large enough to meet flood-stage requirements, not just normal flows. Stream crossings to be built as a part of forestry operations are now required to pass at least the 50-year flood flow for that channel, even if they are to remain in the channel through only one winter season. However, even a 50-year design does not mean that a culvert will not fail (Table 21). Woody debris and sediment transported down a stream channel can also substantially increase the risk and likelihood of culvert plugging and failure. Stream crossing design should account for the possibility of culvert failure from both overflow and from plugging.

The Rational Method is one simple technique commonly used for estimating flood discharges from small watersheds. This method for estimating the 50-year flood flow, and for determining the appropriate culvert size, is included in Appendix A.

Except for the very smallest of crossings, it is generally <u>not</u> sufficient or adequate to estimate (guess) culvert sizes for stream crossings along forest and ranch roads. Most field personnel have little personal experience or expertise with which to correctly estimate or visualize a 50-year flood flow, and many stream channels may no longer display evidence of the most recent large floods, which may have occurred more than a decade ago.

Figure 4 Ib. *Limbs and branches floating down the channel are caught before they can plug the culvert inlet.*

Figure 41 c. *Culvert trash racks which are constructed right over or against the culvert inlet should be avoided because they can plug and, in turn, prevent streamflow from entering the culvert inlet. Culverts that are not set into the bed of the original channel and would discharge runoff onto the road fill need to be extended with an elbow and full round culvert extension, or with a flume (in this case a half-round culvert) past the base of the erodiblefill.*

Culvert length should also be estimated so that correct quantities of pipe will be available on the job site when stream crossings are being installed. Culvert length can be estimated based on the slope of the stream channel/hillslope and the designed width of the road. A procedure for determining the correct length of culvert needed for stream crossings or ditch relief drains is outlined in Appendix E. Culverts that are too short for the crossing cause erosion of the fill and severe sediment pollution in the stream channel.

Figure 41d. *Culverts and flumes carry high velocity stream flow and outlet areas often need to be protected against erosion by the use of rock riprap .*

Table 21. Risk of Hows exceeding flood design for a culvert[1]	
Planned useful life of road	Risk of exc eeding 50-year flood flow
1	1%
5	8%
10	18%
15	27%
20	35%
252	40%
30	45%
35	51%

[1] *WDN.R. (1982)*

[2] *For example, if you plan on using a road for 25 years before closing or reconstructing it, there is about a 40% chance that pipes desig ned/or a SO-year flood along that road will overflow in that time period. Designing for a 100-year flood flow would reduce the risk of failure to about 22%. These figures do not account for plugging by floating organic debris, which would likely increase the risk of plugging and failure considerably for some streams. If you feel these risks are too high, use a larger culvert.*

5. Bridges

Bridges usually have less an environmental impact than culverted stream crossings. They provide much better clearance for extreme floods and floating debris, and bridges are the ideal crossing structure for fish passage requirements. The cost of portable bridge installation is now highly competitive with the installation of medium to large size culverted (filled) stream crossings. For temporary crossings, the quick installation and removal of reusable bridges makes them the method of choice for many crossings that would otherwise require extensive filling and re-excavation.

Bridges may be temporary or permanent. Temporary bridges can be constructed across a stream channel, and then removed upon the completion of operations. Because little soil is disturbed in or along the stream channel, the crossing site can easily be returned to its original condition. Railroad flatcars are the most common, low-cost alternative to conventional bridge construction used for forest and ranch roads. They can also be easily hauled on low-boy trailers from site-to-site and require little preparation prior to installation (Figure 42).

***Figure** 42. Low cost railroad flatcar bridges can be used for temporary crossings of incised stream channels, or they can serve as permanent watercourse crossings.*

Railroad flatcars can also be left in-place and used as permanent bridges. The bridge abutments may be made more permanent by the use of precast or poured concrete supports. Other permanent bridges can be made out of log stringers (large diameter logs extended across the stream channel) or steel I-beams with a driving surface and supporting mechanism. **Bridges used for hauling and vehicle traffic require an adequate engineering design** (Figure 43).

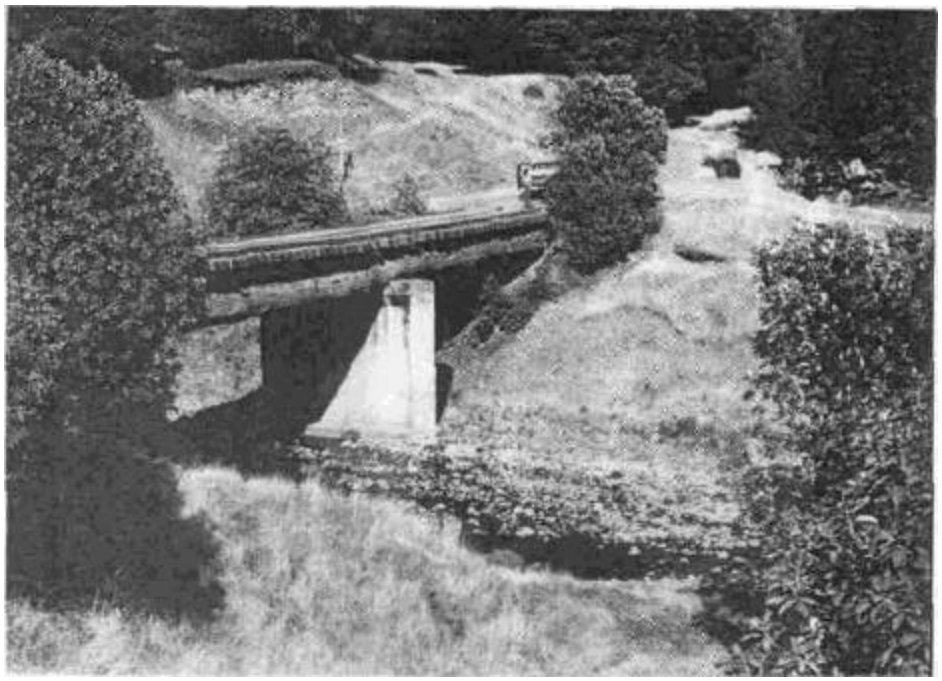


Figure 43a. *Log stringer bridges and railroad flatcar bridges can span •wide channels if they are supported with mid-channel piers.*

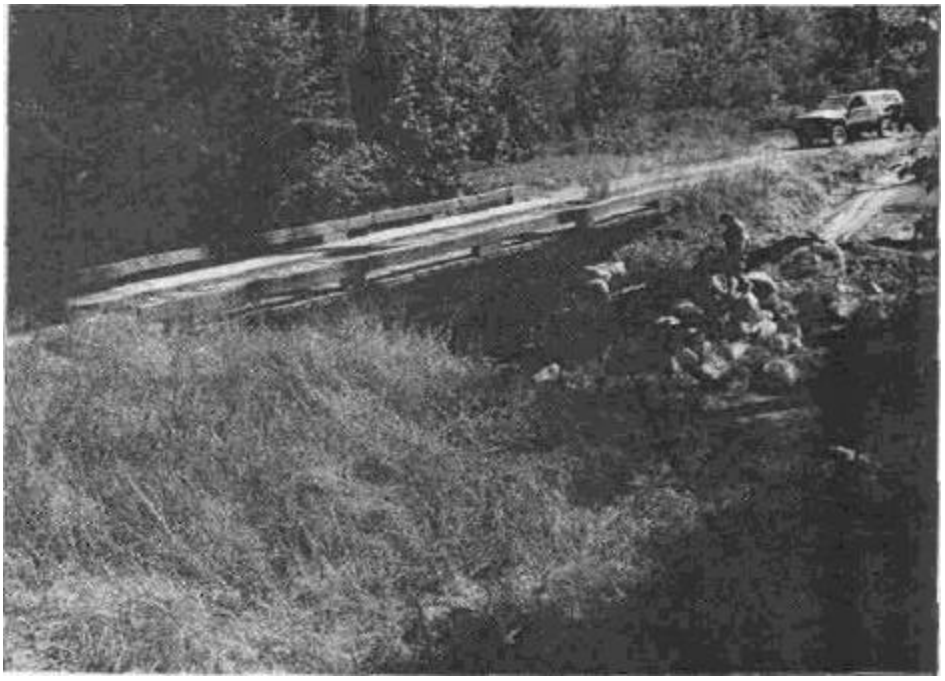


Figure 43b. If possible, it is usually best to span the channel without using center supports and to build abutments well out of the flood zone of the channel. Abutment areas exposed to flood waters should be armored to protect them against erosion. In practice, abutments should be built up and out of the flood zone so they do not restrict channel flood capacity.

Not every stream crossing is equally suited to bridge installation. Generally, bridges should be installed at right angles to the channel with enough clearance beneath the structure to pass the design flood flow (including organic debris). Incised stream channels with relatively flat or low gradient approaching slopes are well suited to bridges. Because bridges are generally straight and fairly narrow, all the turning needed to cross the channel must be incorporated into the approaching road segments. Thus, deeply incised stream channels with steep sideslopes may require extensive excavation (and endhauling) of the approaches before a bridge can be installed across the channel. One method of avoiding some excavation is to install dual, side-by-sidc flatcar bridges so that some vehicle turning can be performed on the deck of the bridge, or to utilize special construction techniques which allow some turning on the structure (Figure 44).

Figure 44. This railroad flatcar bridge has been structurally modified to allow for some truck turning on the bridge deck. Deeply incised stream channels with steep sideslopes would require extensive hillslope excavation if a straight approach was utilized. The underside of this bridge can be seen in Figure 65.

The simpler, less expensive bridges are usually less than 100 feet long. For example, railroad flat cars generally come in standard lengths of about 55 feet and 90 feet. It is important to be sure the bridge is able to support the design loads that will be passing over the road. Longer bridges may require added superstructure supports, or a center pier to support the extra length (Figure 45). Where such complications are present, an engineer should be consulted before fabricating a bridge structure.

***Figure** 45. It is important that all bridges used to transport vehicles and equipment be properly designed or evaluated by a structural engineer before they are put into use. This large, reinforced bridge was fabricated from four railroad flatcars with a center pier support that can be folded up under the bridge during winter flood flaws.*

6. Fords

Fords work well on small to medium sized streams where there is a stable stream bottom and traffic is light. However, "construction" of fords and other unimproved stream crossings on well traveled roads should be avoided where water is flowing because of their potential to impact water quality. In certain situations, where flash floods, high seasonal flood peaks or floating debris are problems, fords may be a practical answer for crossing a poorly incised, shallow stream.

Fords of live streams, called "wet fords," are typically composed of streambed gravels, fill, or concrete structures built in contact with the streambed so that vehicles can cross the channel (Figure 46). If possible, a stable, rocky (or bedrock) portion of the channel should be selected for the ford. Fords can be made of permeable trench drains of coarse cobbles and boulders. Low summer flows seep through the fill, and high water discharges flow over the top. During extreme events, however, the ford may be completely washed-out. Permeable fords may be a barrier to migrating fish and installation will require approval by the Department of Fish and Game.

Paving fords across live streams may be necessary to maintain water quality if there is to be regular traffic. Paving consists of a concrete, slightly dish-shaped slab across the watercourse, and a discharge apron or energy dissipator on the downstream side to prevent scour during high flows. The structure should be designed to pass both sediment and debris during high flows. Unfortunately, concrete fords are often plagued by scour around their edges, leaving the ford elevated and impassable. Ford structures are sometimes even moved downstream by large flood flows.

A ford crossing is vulnerable to erosion and can create pollution from several sources. High traffic levels and/or high water flows can cause erosion of both natural and artificial streambed materials. Material placed in the stream or moved about by vehicle traffic can create a barrier to fish migration. Deep water crossings can cause oil products to be released from vehicles as they

pass through a wet ford. Streams with high stream banks require the excavation of substantial ramps to get vehicles down to the streambed. These through-cut ramps are often sites of substantial surface erosion and rilling that enters the stream during periods of winter rain.

Figure 46. *Wet ford on Class II perennial stream. Clean rock aggregate has been imported for the travelling surface and coarse rock armor protects the outer edge of the road bed. It is important that rock aggregate used in a ford be large enough to resist transport during winter flows. Fords should not be used if high winter flows would cut off access to inspect and maintain drainage structures further out the road.*

On small, poorly incised, ephemeral or intermittent streams a ford may be needed if there is insufficient channel depth to install a culvert. In fact, a rock lined rolling dip with a rock apron face is generally desirable to permanent culverts on these swales and small watercourses. Fords have the advantage, over culverted fills, of never plugging.

Fords on small streams should be rock armored to prevent erosion of the road surface and fill during periods of runoff. The fill face on the downstream side of the fill can either be protected with rock armor or fitted with a large overside drain (berm drain) to prevent erosion. **Unimproved fords, which consist of a stream channel that has been filled with a substantial quantity of soil and left unprotected by armor or surfacing is a hazard to water quality and should not be constructed.**

7. Temporary stream crossings

Temporary stream crossings are used to provide short term access to an area. Temporary crossings should be installed wherever a proposed temporary road crosses a Class I, II, III or IV watercourse. Any stream channel or water source that would be fitted with a drainage structure on a permanent road should receive a temporary drainage structure on a temporary road. The structure should be capable of passing the expected discharge of the channel during the season(s) that it is to remain in place. **If a stream crossing used for forestry operations is to remain in-place after October 15, it must be designed and constructed to pass flood flows from the 50-year runoff event.** Specific techniques for constructing temporary stream crossings are discussed in Chapter VI.

For temporary roads, only temporary crossings are acceptable. Dry fords that are removed following operations are appropriate for dry channels. For live streams, a more substantial crossing is needed. They can be constructed of a variety of materials, including: culverted fills; logs (Humboldt crossings); combinations of logs and pipes; straw bales over pipes and logs; and temporary log or railroad flatcar bridges. Where channels are wet or incised, temporary culverts, temporary log fills or temporary bridges should be used. Log fills (with or without culverts) and portable bridges can often be installed, used and removed with little damage to the stream banks or channel bed.

It is important that the original base level of the stream channel be maintained when a temporary crossing is removed following operations. For this, a "marker" consisting of several inches of straw placed in the bed of the channel is often used to mark the natural channel bed ***before*** any logs or fill is placed in the channel. Re-excavation of the crossing is then relatively simple.

A special category of temporary stream crossing is the low water crossing that is often installed to provide for summer vehicle traffic across large perennial streams during summer low flow conditions (Figure 47). These crossings are typically composed of streambed gravels that have been ramped up on both approaches to the low flow channel with one or more culverts used to carry streamflow. Only clean gravels are used in its construction and no new soil or fine sediment is introduced into the channel. The low flow crossing and culverts are then removed prior to the first fall rains which would raise flows in the river. Fish passage should be considered and designed into the low flow crossing so that juveniles and adults can pass through the structure. A temporary flatcar bridge may be required in some settings.

Figure *47. Summer low-water crossing of a Class I perennial stream. Coarse, clean streambed material has been used to ramp up over the flowing water. Two culverts have been installed at water level to allow for uninterrupted flow and the migration of young fish. A temporary bridge crossing should be used where migrating adult fish need to pass beneath the crossing. Low water crossings should be removed before the first fall rains.*

Notes:

CHAPTER VI: CONSTRUCTION

A. Introduction to construction

The construction phase of a road project is when planning and design decisions are carded out on the ground. To achieve the intended road standard, and to result in minimal impact to the environment, each phase of road construction should be carried out according to the formulated plans. Poor execution of plans, no matter how well designed, can result in a poorly constructed road that causes serious impact to the watershed and environment Such substandard results are most often caused by untrained supervisors or unskilled operators. Thus, the skill and experience of supervisors and equipment operators selected to complete the road project will play a large part in determining its success.

Plans and designs may need to be modified during construction as changing conditions are encountered in the field. Minor changes in the proposed work can be accomplished in the field by experienced supervisors and equipment operators. However, substantial changes in road alignment or in road and drainage design should only be made by qualified personnel.

B. Timing

While planning, design and field reconnaissance work can be conducted at any time of year, the timing of each phase of road construction is critical to a successful project. **Roads should be constructed during the time of year when the best results can be achieved with the least damage to the environment** (Table 4). The time varies when each of the activities (clearing, grubbing, burning, excavation and grading, compaction, stream crossing installation and surfacing) can best be conducted. For example, scheduling road building activities in steep slope areas for the drier months can be an effective landslide control measure.

Clearing (cutting and removal of trees and brush from the right-of-way) can be performed anytime weather permits ground crews to cut the vegetation and equipment to pile or yard it to a storage site. Often, felling crews will cut vegetation along the alignment up to a month before equipment is on-hand to remove the material. Yarding results in soil disturbance and should be limited to reasonably dry soil conditions when rain storms are unlikely. Likewise, grubbing (the removal of organic material from the soil surface, including stump removal) should only be performed when the threat of erosion from the disturbed areas is minimal.

Grading (the excavation and creation of the road bench) creates large expanses of bare soil, and should therefore be performed only during dry spring, summer or early fall conditions. To achieve proper compaction of fill materials used in stream crossings, landings, and along cut-and-fill road benches, most soils will require adequate moisture. Rocky, coarse-textured soils may be placed during relatively dry conditions. Overly dry or very wet, fine textured soils often cannot be compacted enough to produce the soil strength needed to support loaded trucks or to remain stable on steep slopes. If the soils are too wet, they should be allowed to dry, and if they are too dry, they should be watered to achieve adequate compaction. Local problem *areas* are likcJy to be encountered that will need to be treated by drying or watering. An engineer or geologist can recognize improper soil moisture conditions by using simple field tests.

The timing of stream crossing installation is critical to maintaining and protecting water **quality.** Timing is also important to fisheries in many watersheds. Work should be performed as quickly as possible during the dry period of summer, when streamflows are at a minimum (or the channel has dried up) and there will be minimal soil disturbance and risk of sedimentation.

All road construction activities, including the installation of stream crossings and erosion control work, should be completed before the onset of the rainy period (October 15 for forestry operations). Final grading and proper installation of road drainage structures are critical to keeping erosion from the new road to a minimum during the first winter. Likewise, all temporary stream crossings should be removed and all erosion control measures installed before the winter begins. There are additional rule requirements in effect for forestry operations conducted anytime during the winter period. These include developing a "winter period operating plan" that includes the details of proposed landuse and erosion prevention activities. For example, the plan may require all bare soil areas be adequately drained and protected with suitable erosion control measures concurrent with the conduct of timber operations.

C. Clearing and grubbing

The road centerline, or the cut and fill staking, should be marked on the ground prior to clearing. The upslope and downslope boundaries of the right-of-way should also be flagged or staked to mark the limits of vegetation removal for work crews and equipment operators who will be performing the clearing. This will help prevent over-clearing.

Trees and other large vegetation should be felled and bucked. In addition to right-of-way clearing, hazardous snags and unsafe trees should also be felled at this time. **Trees and shrubs** should **be left growing at the base of the proposed fillslopes, and the right-of-way should be kept** to **the minimum width necessary for the planned use of the road.**

During grubbing of the surface, stumps should be removed from within the road prism and anywhere fill or sidecast material will be deposited (Figure 48). **Mixing stumps and other vegetative debris into the road fill should *always* be avoided** because the voids which form when the wood decomposes reduce the stability of the fill. Fine slash and small limbs are usually not a problem, but all chunks, logs and slash over approximately 3 inches in diameter and 3 feet in length should be removed and safely disposed. **For slopes over 35 percent in gradient, (the organic layer on the soil surface should be substantially disturbed or removed prior to fill placement or sidecasting.**

Figure 48. *Hydraulic excavators are rapidly becoming the preferred equipment for wildland road construction. Here one is grubbing and clearing the alignment for a new forest road.*

Cull logs and coarse slash can be piled in a row ("windrow") parallel to the road at the base of the proposed fill. When performed ahead of road construction, this practice can effectively control sediment movement from sidecasting and provide an economical, environmentally sound way of roadway slash disposal. This is especially useful when the road is being built near a stream channel. The height, width and length of these slash piles should be limited to allow for wildlife migration through the road corridor.

If an excavator is used to perform clearing and grubbing work, merchantable logs can be placed on top of windrowed slash piles for collection and loading when the road is passable to yarding equipment and log trucks. This practice reduces yarding costs. If some of the accumulated slash is to be burned, state fire regulations must be followed and permits obtained from the California Department of Forestry and Fire Protection and/or your local fire department.

D. Grading and compaction

Most forest and ranch roads are built by excavating a road bed out of naturally sloping ground. Thus, grading is when the bulk of soil excavation and disturbance occurs. **For a given road width, the steeper the ground the greater will be the volume of soil that is excavated or displaced during road construction** (Table 13). Road design and layout (flagging and stakes on the ground, together with plans and maps to look at) show equipment operators the correct alignment and the proper cutslopes and cutslope steepness to be developed along the new road. Operators may be asked to either construct roads using sidecasting methods on gentle terrain, to use cut-and-fill (with true compaction) on moderate slopes, or to employ full bench construction techniques on steep slopes or where the road is near stream channels.

1. Sidecast construction

In sidecast construction, the bulldozer starts at the top of the proposed cutslope, excavating and sidecasting material until the desired road grade and width is obtained. Material is pushed or "drifted" in front of the blade to areas where fill is needed (Figure 49). Road fill is used to cover culverts, and build up flat or low areas along the alignment. Since fill must support traffic, it needs to be spread and compacted as much as is possible to develop sufficient strength. Unfortunately, this common method of sidecast or "top-down" road construction does not lend itself to standard, engineered compaction methods where fill is placed and compacted in thin layers.

Figure 49. *Road constructed by cutting and sidecasting. A row of slash and organic debris along the base of the sidecast slope can help catch and filter soil eroded from the loose slope. Soil should only be sidecast onto* ***gentle or*** *moderate slopes that have been cleared and grubbed of vegetation, and where material cannot be eroded and delivered to a* ***stream.***

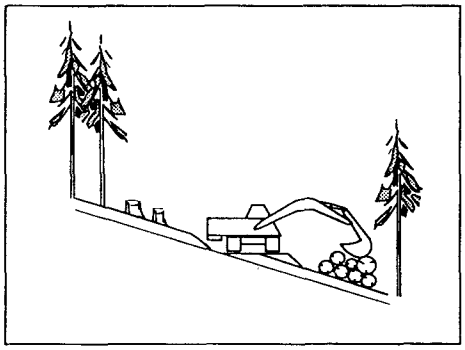
In sidecast construction, much of the spoil material moves down the slope below the final road bed and cannot be adequately compacted or contained. For this reason, **sidecasting construction methods are not suitable on steep or moderate slopes near stream channels where loose material could saturate during wet weather and slide further downslope. During sidecast construction, it is critical to avoid letting sidecast or waste material enter streams or placing it where it could erode and be delivered to a watercourse.**

Road construction can increase landslide risk by:
Oversteepening the slope with sidecast material
Overloading slopes by adding sidecast and fill material
Altering hillslope drainage by blocking or redirecting surface or subsurface water movement onto fillslopes or unstable soils
Removing material or undercutting the toe of a steep or potentially unstable slope

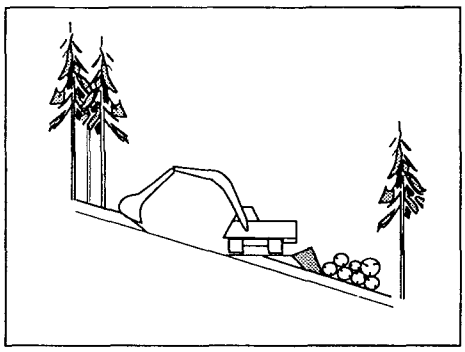
A general rule-of-thumb for moderately and steeply sloping lands is to keep sidecast everywhere less than about three feet deep, measured perpendicular to the original ground surface. Within about 400 feet of a watercourse, the sidecast should feather out within 30 feet of the road edge. This will minimize the risk of shallow landsliding, and of slope failures delivering sediment to stream channels. Roads built within a WLPZ, or roads constructed across moderate or steep slopes that extend, without significantly flattening, all the way downslope to a stream channel, should not have sidecast more than about 1 foot thick and it should feather out within about 10 feet of the road.

Overloading and oversteepening already steep or wet slopes with sidecast material during road construction is the single largest cause of road-related landslides. Sidecast failures are usually associated with ground slopes of 65% or steeper, although springs and seeps can cause failures at much gentler slope angles. To avoid surface ravelling and severe filling on sliver fills, 55-60% is the maximum ground slopes for stable sidecasting. A good rule-of-thumb is to not side cast on ground slopes of over 55%, and to not develop sidecast slopes exceeding about 65%. Road-related failures on lesser slopes occur mainly where breakdowns in the road drainage system redirect water onto the fillslopes.

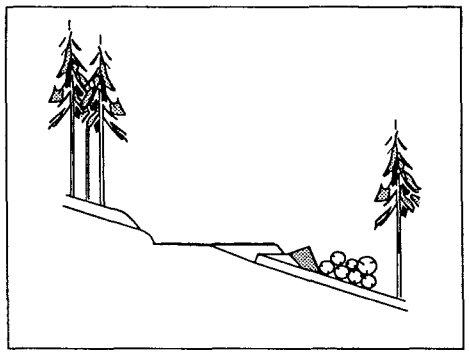
A relatively new, more protective method of "sidecast construction" is gaining popularity with many road builders. This method utilizes a hydraulic excavator, instead of a bulldozer, to pioneer the road bench. The excavator is able to cleanly remove slash, stumps and logs and place them at *the*. base of the fillslope so they are not incorporated in the fill (Figure 50). It then grubs or cleans off the organic layer, excavates mineral soil and places it, bucket by bucket, beginning at the base of the slope (Figure 51). The powerful hydraulic system of large excavators permits them to partially compact the fill as it is placed. Spoil carefully placed using this method is more stable and less susceptible to failure than pushed or sidecast material. A fill face of about 65% is generally the steepest angle material can be placed at unless the fill is "engineered" using standard compaction methods, as described below.



First Pass *- Log and stump removal*



Second Pass *- Overburden removal*



Third Pass *- Completed subgrade*

Figure 50. Excavators can perform a simple three step process of clearing and grubbing, excavating and subgrade development during construction of a balanced bench road. Using an excavator minimizes the volume of sidecast material. In the first pass an excavator operating from a pioneered bench removes logs and stumps, grubs the slope and installs a filter windrow of slash material at the base of the proposed fillslope. The second task is for the excavator to remove the overburden and place and compact the fill downslope above the windrowed slash. Thirdly, the uncovered, unweathered material is used to construct the bearing surface of the road(B.C.M.F., 1991).

Figure 51. *Each step of the way, the excavator clears vegetation and grubs the slope surface in front of it before it excavates and extends the road bench. Excavated soil from the new segment of road bench is placed and compacted on the grubbed slope below the new segment of road bench. Cleared vegetation placed along the base of the future fillslope helps contain erosion from the exposed fill.*

Filter windrows of slash material are easily formed and placed at the base of the fill by the excavator to contain surface erosion following construction. The excavator or a bulldozer then follows up on the pioneered road bench (Figure 52) to develop the final road width and surface shape, using the uncovered, unweathered material to construct the bearing surface of the road (Figure 53), which can then be surfaced for all-weather use (Figure 54).

Figure 52. *Behind the excavator, a bulldozer is used to prepare the final subgrade, surface shape and width of the new* ***road.***

Figure 53. *New road constructed by excavator and bulldozer. Logs harvested from the right-of-way have been placed on top of the filter windrows and will be hauled away later.*

Figure *54. Rock surfaced, outsloped forest road constructed by hydraulic excavator. Note the absence of an outside road benn which would otherwise collect and concentrate surface rwwff on the road prism.*

2. Compacted cut-and-fill and benching construction

A variety of road benching techniques may be employed on moderate and steep slopes to improve the road's stability. These include balanced benching (using the excavator), sliver fills, backcasting, multi-benching, and full benching with endhauling. These techniques each utilize construction methods that can lend added stability to the road prism, compared to sidecasting. Each is also suitable for a specific soil and slope type, and should not be used in other situations.

Backcasting and multi-benching construction employs a technique called "bottom-up compaction" which adds stability to fill material placed along the outside of the road prism. ***Multi-benching*** **is not often used, but it is a good way to develop a stable footing with a minimum of**

sidecasting. First, a bench is cut at the proposed base of the fill, about 30 feet below the elevation of the proposed road grade (its exact location depends on the slope of the hillside and the width of the final road). It may be necessary to excavate and endhaul material from this first cut so that it is not sidecast downslope. Next, the operator moves slightly upslope to create another bench, casting the spoil material onto the first bench downslope where it is then compacted. After the second bench is completed, the process is repeated upslope to the final road elevation. The result is a fill that is keyed into the hillslope on multiple, small benches, with little sidecast (Figure 55).

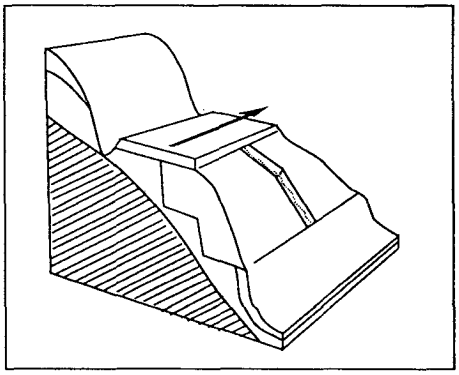


***Figure** 55. Multi-bench road construction.*

Single benching **is a more popular technique employing the same basic methods** as multi-**benching.** After the first (lowest) bench is cut, a bulldozer or an excavator may be used to cut into the hillslope above the bench to widen and raise the road bed. As cutting progresses in the upslope direction, the road bed is widened and layers of spoil material are added to the bench in thin "lifts" that are compacted as they are laid down. Cutting, filling and compaction of the road bed continues until the road reaches the final design grade and width (Figure 56).

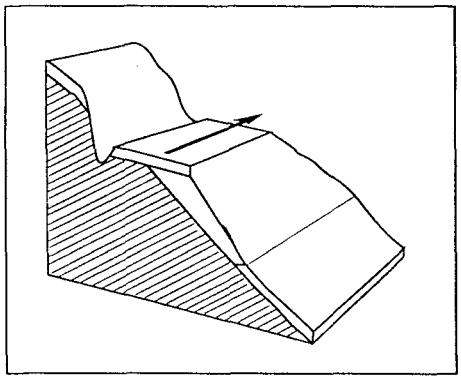


Figure 56. Single or "balanced bench" road construction, where the volume of cut material is balanced (equals) the volume of fill material that is placed nn the outside of the road bench. In most instances, a bench is excavated at the base of the proposed fill slope and layers of fill are placed in lifts and. compacted until the desired road level has been attained.

Remember, bulldozers and loaders are ***not*** efficient compactors. In critical situations where fill compaction is necessary to ensure that the material will not fail, true compactors should be used. Check with an engineer to select the correct equipment for the job. Compactors include grid, sheeps-foot, pneumatic, vibratory and tamping foot machines. Grid and vibratory compactors are appropriate for materials coarser than coarse silts and sands, while the others are preferred for sand and finer sized soil particles. Ask for advice.

Backcasting is a **method of producing a full bench road with no** endhauling. The soil must be medium to coarse grained and well drained, and the slopes cannot exceed 80%. It may not be a suitable technique on approaches to incised stream channels where emerging groundwater is commonly found. The surface immediately in front of the excavator is cleared and grubbed, and organic debris is either sidecast or windrowed at the base of the proposed fillslope. Then, a deep full bench is cut in front of the excavator about 25 to 30 feet wide and 8 to 10 feet deep at the road center line (again, depending on the slope of the land and the width of the road). The earth materials excavated from this cut are "backcast" and piled on the subgrade behind the excavator. Once the bench has been constructed, the piled subgrade material is leveled and graded by a bulldozer or the excavator, with little or no sidecasting (Figure 57). Because the roadbed materials are all excavated and placed, with little compaction, they should be allowed to settle and drain before the surface is outsloped or final ditches and ditch relief culverts are installed. On steep slopes, the fill will have to be reinforced or retained, and subdrains will be needed for springs and wet areas.

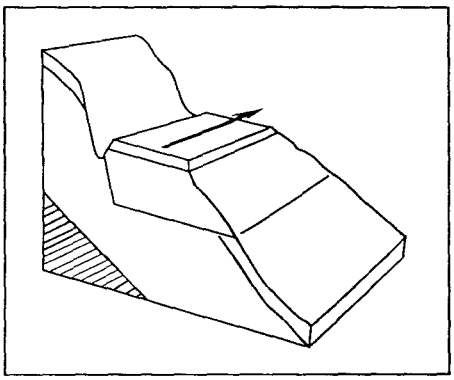


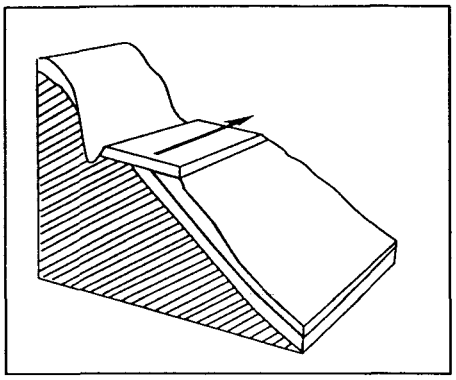
***Figure** 57. Backcasted bench road construction.*

Sliverfill construction is a potentially hazardous method that can result in slope failures and water quality problems if material and site conditions are not correct. Sliverfills are thin fills lying parallel to the underlying hillslope, rather than as wedges used in normal cut and fill. Sliverfills cannot be compacted on slopes exceeding about 35%. On gentler slopes, sliverfills are small and relatively stable. As slopes increase, the fills become thicker and more susceptible to failure.

Sliverfill construction should be used only in special situations where 3/4 to full bench roads are constructed through rock or coarse alluvium and there is nowhere to dispose of the excess material. The rationale is to avoid producing an oversteepened slope by placing or spreading a thin veneer of coarse material on the ground surface at a slope less than its angle of repose (Figure 58). An excavator with a normal 35-foot reach can usually control and drape a sliver fill up to 40 feet downslope from the road bench.

Sliverfill construction should be a method of last resort, because the potential for failure is high, and a large amount of forest slope is taken out of production. Ravelling from the fill can also create a dangerous condition if there are roads or buildings downslope from the sliverfill. **Sands, silts and clays are completely unsuited for sliverfill construction. Sliverfills are not constructed by sidecasting, because uncontrolled sidecasting on steep slopes produces highly unstable deposits that ravel and/or fail by debris sliding.**

Figure 58. Sliver fill road construction, in which a thin veneer of fill is "placed" (not sidecast!) over the slope below the road. Sliver fills should only be used in specific situations, usually with free draining broken rock materials where slope gradients are below the material's angle of repose, and there is no other place to put the material. Silts, clays and other fine grained soils are completely unsuitable for sliver fill construction.

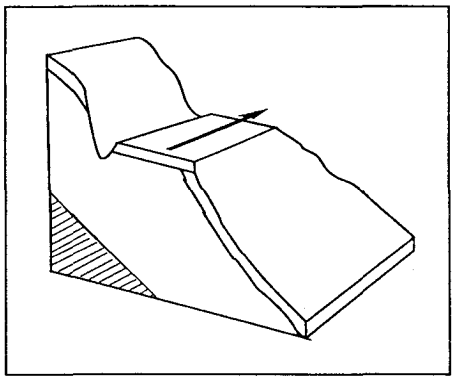


3. Full bench construction

***Full bench* construction, the final method described here, typically involves excavation of the road bed using a hydraulic excavator.** A bench is cut into the rock or soil equal to the width of the road. No material is sidecast and spoil is used to fill low areas or stream crossings along the road alignment. Excess material can be hauled off-site to a stable storage location, while only a very minor amount can be safely drifted or feathered over and compacted on the road bench (Figure 59).

Full bench road construction is typically reserved for moderate or steep slopes, or where a road approaches or parallels a stream channel that could be impacted by sidecasting. Endhauling can be expensive, and full bench construction can cost four to seven times more than cut and fill methods. However, full benching without endhauling on steep slopes is a sure recipe for sidecast failure on many sites, as well as resultant impacts to downslope stream channels.

Figure 59. Full bench road construction, in which all excavated material has been truck-endhauledfrom the site and deposited in a stable storage site.



Full bench roads often result in tall cuts. Several rock and soil types may not support these large cutslopes. Unstable rock, including soft or highly fractured sedimentary rocks, or rocks with layering dipping steeply into the road cut, may not be suitable for full-bench cuts. These deep cuts can remove critical toe support and initiate upslope failure. Deep, soft clays, lake deposits and other earth materials with similar physical properties may also be unsuitable for tall cuts because of their susceptibility to rotational failure. Although balanced benching or backcasting may be better construction techniques for such soft and unstable soil and rock materials, it still may not be possible to build the road where slopes are steep and the rock is weak.

Excess spoil should be endhauled and stored at a stable location where it will not erode or fail and enter a watercourse. In addition, spoil should not be placed on unstable slopes, where the added

weight could trigger land movement Excessive loading of clay or silt soils at an endhaul dump site could also cause a bearing capacity failure in the subsoil. Rock pits, wide, stable sections of road, ridges, benches and the inside edges of landings are typical locations where fill can be stored. All proposed fill sites should be field examined before construction. Those with emerging ground water or thick organic layers could experience slope failure after loading and should not be used.

For most situations, endhaul material is directly loaded into dump trucks by the excavator and hauled to the storage site where it is spread in layers that can be reworked by a bulldozer. In some cases, bulldozers can economically cany (push) spoil material to stable storage sites for distances up to 500 feet. The resulting spoil pile at the storage site should generally conform to the local topography to provide for natural drainage, and should be mulched and planted to control erosion (Figure 60).

Figure 60. *Typical spoil disposal site (uphill side of road) for endhauled spoil materials from a full bench road construction site. Spoil disposal site is located on a broad, gently sloping, dry ridge. Material is dumped, spread, compacted (by bulldozer) and seeded, mulched and planted.*

E. Constructing on wet soils

The application of coarse rock surfacing is a time-tested method for solving wet road surface conditions on forest and ranch roads. Rocking allows trucking and hauling on many roads during periods of wet weather. From 6 inches to over 18 inches of clean, graded rock may be needed to provide a stable, wet weather surface. While surfacing can double the cost of a road (Table 22), the rock or gravel cover provides a stable surface that can be used to extend the operating season without damaging water quality. However, if water is reaching the road bed from subsurface flow beneath the road fill (rather than from rainfall), measures in addition to surface rocking will likely be required to maintain surface stability and control erosion.

Table 22. Estimated cost distribution for constructing a typical forest road[1]	
Construction phase	**Average cost (%)**
Equipment and material	10%
Clearing, grubbing, slash disposal	20-25%
Excavation	20-25%
Culverts	10%
Rock surfacing	30-40%

[1] *USDA-SCS (1981)*

If small springs and seeps cannot be avoided when laying out the road alignment, special construction materials and techniques can be used to minimize wet soil problems. Established techniques for constructing clean gravel drains and surface rocking have been dramatically improved by the use of new, synthetic geotextile materials. These fabrics and engineering materials often come with detailed manufacturer's instructions that should be followed to achieve best results. Many companies provide free consultations to help in specific user applications.

Water emerging from road cutbanks can be controlled using a French drain or vertical drainage trench. The trench is excavated, lined on both sides and the bottom with a geotextile fabric, back filled with open graded, clean gravel and topped with fabric and soil. The fabric keeps fine soil materials from entering the trench and plugging the drain. The trench is then drained across the road prism in an outflow trench or subsurface drainage pipe situated down the ditch line.

Water emerging beneath the road bed can be controlled by installing a drainage blanket beneath the fill. This provides an easy path for the emerging water to flow out from under the road without saturating the road bed and overlying fill materials, thereby preventing rutting, rilling, muddy surface conditions or fill failures. In the field, a permeable geotextile blanket is laid down over the wet zone prior to road construction, and a gravel layer is backfilled over the top. This gravel blanket should slope to the outside edge of the road and "daylight" near the base of the fill to ensure proper drainage. Another geotextile layer is then laid on top and native soils are spread and compacted over the top until the desired road bed level is attained.

The above examples provide a brief introduction to the inexpensive and highly successful engineering methods now available to solve problems of subsurface drainage. Additional reading and research is highly recommended before using geotextiles for subdrainage. Assistance may be obtained from an experienced road engineer who has had success using these products, or from the field representative of a company that manufactures or distributes geotextiles designed for these applications.

F. Constructing on unstable slopes

The first rule of road construction is to stay away from unstable areas and landslides. However, there may be times when all other options have been exhausted and road construction in unstable zones is the least damaging alternative. **If road construction must occur on unstable slopes, it is highly recommended that an engineering geologist or geotechnical engineer be consulted to develop plans and construction methods for the specific road segment.** In situations where water quality would be seriously threatened by operations on unstable slopes, road construction or reconstruction projects may have to be deferred or entirely avoided. **Unstable slopes that threaten water quality must be recognized and considered *unsuitable* for road building.**

Some preventative measures can be applied to compensate for expected decreases in slope stability that often accompany road building. These include: 1) don't oversteepen or overload the slope with sidecast material, 2) don't alter the hillslope drainage by blocking or redirecting surface or subsurface flow onto the slide mass or by ponding water, and 3) don't remove material from the toe of the unstable slope or slide. These preventative measures should be applied when operating on slopes steeper than 50% to 55%, and may be necessary on some soil types at lesser gradients.

Most road-related failures are the direct result of excessive fill and sidecast on steep slopes, or concentration of runoff on road fillslopes. Narrow roads can significantly reduce the amount of material that must be excavated during road construction in these areas (Table 13). Thus, on steep slopes (over about 60%), sidecasting should be avoided. In addition, unstable soil types or the presence of springs and seeps may limit the use of sidecasting on slopes as low as 45% to 50% in order to minimize the potential for sidecast or "fill" failures.

It is especially important to avoid sidecasting on steep slopes in headwater swales, where hillslopes converge into a narrow, steep channel. These locations are prime sites for generating debris slides which can move thousands of feet downslope, scouring steep channels and depositing large amounts of sediment and debris that severely impact fish-bearing streams and domestic water supplies. Professional judgements and recommendations are critical for the identification of debris flow hazard and can best be made by a trained geologist or engineering geologist.

Debris avalanches on steep slopes can also be triggered by ground motion from heavy blasting during road construction or quarry excavation, especially during wet conditions. This suggests that the potential for initiating a landslide in the vicinity of blasting can be reduced by conducting blasting in the dry summer period. On steep slopes, excess blast material should be endhauled and not allowed to accumulated on the hillslope below the road.

The overall risk of slope failure can also be reduced by reducing total road length, especially for roads built across steep slopes. For example, using long-line or helicopter yarding systems can reduce road construction on unstable hillslopes by up to 50%, or more. Steep road gradients and pitches can also be used to reduce road mileage, and may be more cost-effective than full bench, end-haul construction across unstable areas or steep slopes. Employing locally steep road grades and pitches can be used to get your road onto low-maintenance, stable ridge-top areas and benches within the watershed. However, steep sections of road will often require

outsloping, better ditching, more surfacing, and improved surface drainage compared to low gradient roads.

Knowing the boundaries of an unstable area (slide mass) is essential in selecting the type and location of cut and fill construction to be used. Cuts and fills can be located across some landslides with little effect on their stability, or even a net increase slope stability. For example,, the toe of some existing or potential rotational slides can be loaded with weight, or the head can be unloaded, without decreasing slope stability (Figure 61). Thus, a full fill road (using endhauled material and little or no cutting) at the toe or a full bench road (with endhaul) at the head of tills type of slide will not reduce stability and may even improve conditions (Figure 62). However, in spite of employing state-of-the-art road building techniques, slide movement may still continue. As a general rule, landslides and unstable areas should not be crossed with roads.

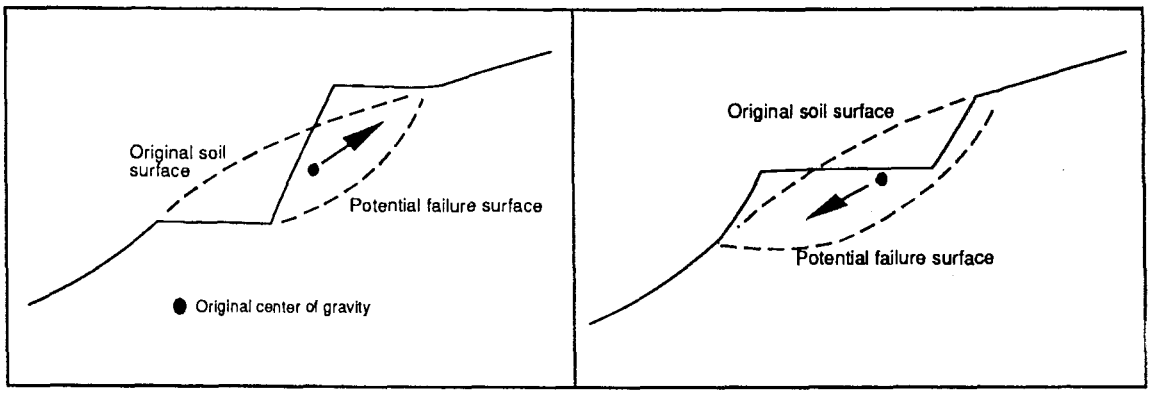


*Figure **61.** In general, the toe of a rotational slide should be loaded, whereas the head should be unloaded. Loading the head anal or unloading the toe (left diagram) acts to raise the center of gravity and actually decreases stability. Loading the toe anal or unloading the head shifts the center of gravity downward and can increase slope stability. This strategy does not work for other landslide types, where road building should be avoided.*

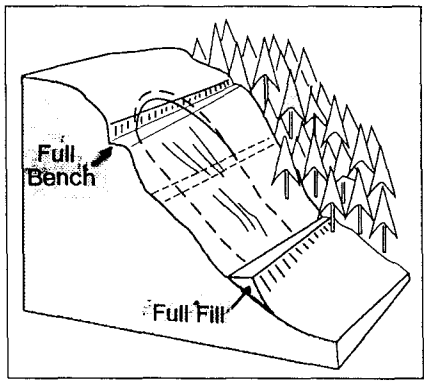


Figure 62. On certain rotational landslides, building a full fill across the toe (loading the toe), or cutting a full bench, endhauled road across the head (unloading the head} can be performed without decreasing slope stability. However, in most instances it is best to avoid unstable slopes altogether.

G. Constructing stream crossings

Common types of permanent stream crossings include bridges, culverted fills and fords as well as a variety of temporary stream crossings that are removed prior to the winter period. The use of "Humboldt" log crossings and unculverted fills are not suitable for permanent stream crossings, even through they were commonly used in past decades.

Constructing a stream crossing is a two part process consisting of: 1) constructing the road bench approaching and leaving **the** crossing site, and 2) constructing and installing the drainage structure and fill at the crossing.

1. Stream crossing approaches

Excavation of the approaching road is a critical part of constructing a stream crossing. If the channel side slopes are steep, any sidecasting on the approaches could easily deliver loose soil directly to the watercourse (Figure 63).

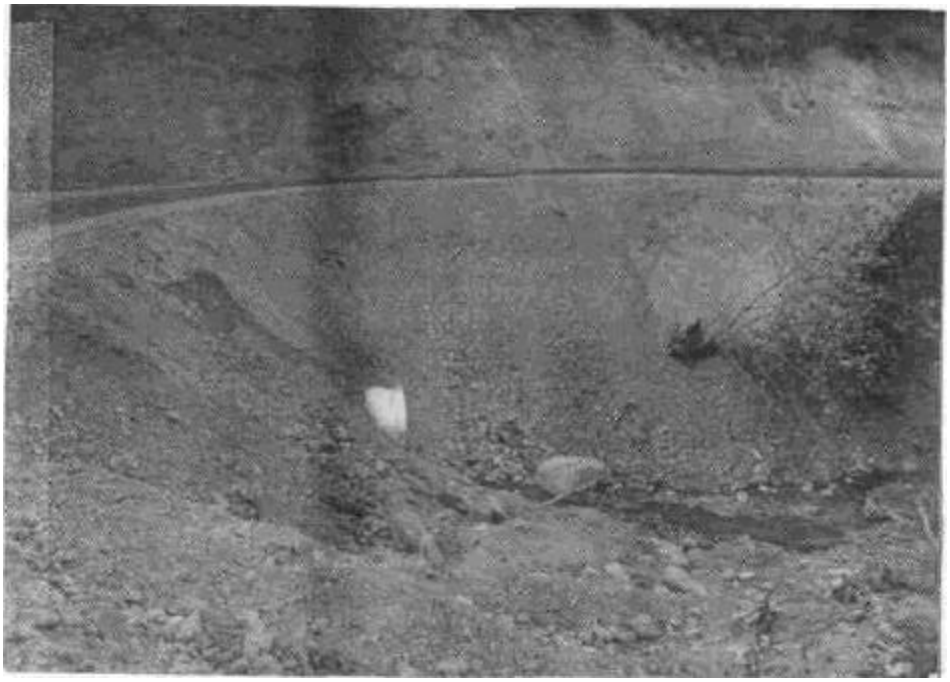


Figure 63. *Uncontrolled sidecasting on the approach to this stream crossing has delivered sediment directly to the stream channel. This type of road building is in violation of water quality standards and forest practice regulations.*

Where roads are to cross stream canyons or incised channels with steep sideslopes, the approaches to the channel should be built with full bench construction methods. Material may be endhauled with trucks or placed on the excavated road prism behind the excavator and pushed farther back from the crossing using bulldozers. ***Sidecasting should not be used!*** Excavators are ideal machines to perform full bench construction on difficult stream crossing approaches.

Roads which cross steep slopes in stream canyons also often pass through wet and/or unstable soil materials. Potentially unstable soils and slopes near a crossing site should be identified *before* the equipment cuts into *the* slope, so the approaches can be designed to avoid, or drain and stabilize, the unstable area. In wet areas, the road may need to be insloped and surfaced with rock to add stability and reduce erosion of the road bed.

Where roads are to cross channels with more moderate or gentle channel side slopes, full bench or cut-and-fill construction techniques can generally be used without damaging the stream. Roads can be pioneered using excavators to remove and place fill below and on the roadbed behind them without sediment reaching the stream channel. The excavated material can be stored temporarily for later use in the stream crossing fill, or a bulldozer can spread the material on the road bed

away from the approach. Fill can also be placed in compacted layers at the base of the newly build road prism and used to construct a stable fill. **Regardless of the construction method chosen, sidecasting on stream crossing approaches should be avoided.**

2. Bridge installation

Bridges are usually the best, least damaging choice for stream crossing installations and should be considered for all larger, deeply incised or Class I (fish-bearing) watercourses. There is less disturbance during installation of bridges and there is less chance they will fail during floods. In recent years, the materials and installation costs for small precast or portable bridges have also become much more competitive with the installation of large culverts.

The main components of most bridges used for forest and ranch roads include bank abutments, stringers or steel cross-channel members, decking, running-planks and wheel guards. Most **of** these parts can be pre-assembled off-site and quickly installed at the crossing location, or the bridge can be constructed entirely on-location.

As with culverted stream crossings, the greatest potential impact to stream channels occurs during bridge installation. Above all, installation should minimize or eliminate the use of equipment in the stream. A low impact equipment crossing (ford) may be needed in the immediate vicinity of the crossing to prepare both abutments and approaches for placement of the bridge. If approved by the Department of Fish and Game, this ford may later be used by tracked equipment crossing the stream to avoid damaging the bridge decking (Figure 64). If the stream is too large or deeply incised to be crossed with heavy equipment, access will need to be developed from the other side. In either case, construction activities should result in only minimal disturbance to, and no sidecasting into, the watercourse channel.

Figure 64. *Many bridges built on small forest and ranch roads cannot support or would be damaged by heavy tracked equipment passing over them. For this reason, an adjacent equipment ford is sometimes constructed. These steep fords can erode and deliver sediment to the stream channel if they are not waterbarred, mulched and seeded prior to winter rains.*

Successfully designing and installing a permanent or temporary bridge across a watercourse requires forethought and planning, and an experienced equipment operator and engineer may be required. First, the bridge abutments should be prepared and placed (or constructed) on each bank to accept the bridge. "Permanent" bridges may be secured to the banks by using piles driven at

least 10 feet into the natural ground, or by using a cast or precast concrete abutment that is pinned and grouted to the bedrock or is cabled to deadmen buried behind the abutment Temporary bridges may also need to be set on or secured to abutments such as logs or precast concrete slabs (Figure 65).

Figure 65. *Bridge abutments can be built of logs, piers, concrete pads and other supports. This abutment is a precast concrete support that was fabricated off-site and installed when road construction reached the crossing location. It is tied into the adjacent slope with cables secured to buried "deadmen."*

Each abutment should be leveled and secured far enough into the bank so that slumping or bank failure will not occur. Abutments and piers should be parallel to the stream channel and set back from the channel to prevent *any* narrowing of the streambed and banks. The bridge crossing should be at right angles to the channel, and, if possible, with at least 50 feet of straight approach before the bridge, but the bridge does not have to be level lengthwise across the stream (Figure 66).

Figure 66. *Railroad flatcar bridge correctly crosses stream channel at a 90° angle, but bare, unprotected soil abutments are subject to erosion during high flaws. Low, summer stream/low goes subsurface under the bridge because of extra sediment in the channel bottom at the crossing site.*

The grade of the bridge should be the same as the grade of the approaching road. To avoid draining road surfaces directly into the stream, bridges should not be located at the bottom of an abrupt dip in the road grade (Figure 67). If the road climbs away from the crossing in one or both directions, the approaches should be flattened for at least 50 feet, with road surface runoff directed into a ditch relief culvert or rolling dip which drains into a vegetated buffer strip before reaching the bridge site.

Figure 67a. *The segments of road which approach a bridge should not drain onto the bridge surface. Otherwise, soil eroded from the adjacent road surface can be carried onto the bridge and into the stream.*

Stringers and structural supports to be used for the bridge should not be dragged through the streambed. A crane, an excavator, or an excavator and a winch-tractor can be used to move a portable bridge into place, with one piece of equipment on each side. If decking is installed on the bridge surface, it should be laid and bolted solidly across the top to provide a good bearing surface and to spread the load of vehicles to all the spanning log stringers or structural steel members. On wood bridges, running planks can be attached to the decking. Bolts should be used to attach the decking because spikes tend to loosen and come out as the bridge flexes under heavy loads. Finally, for safety reasons, poles, sawn timbers or metal wheel guards should be installed along the outside edges of the bridge to alert drivers who wander off the running surface and too near the edge of the deck (Figure 68).

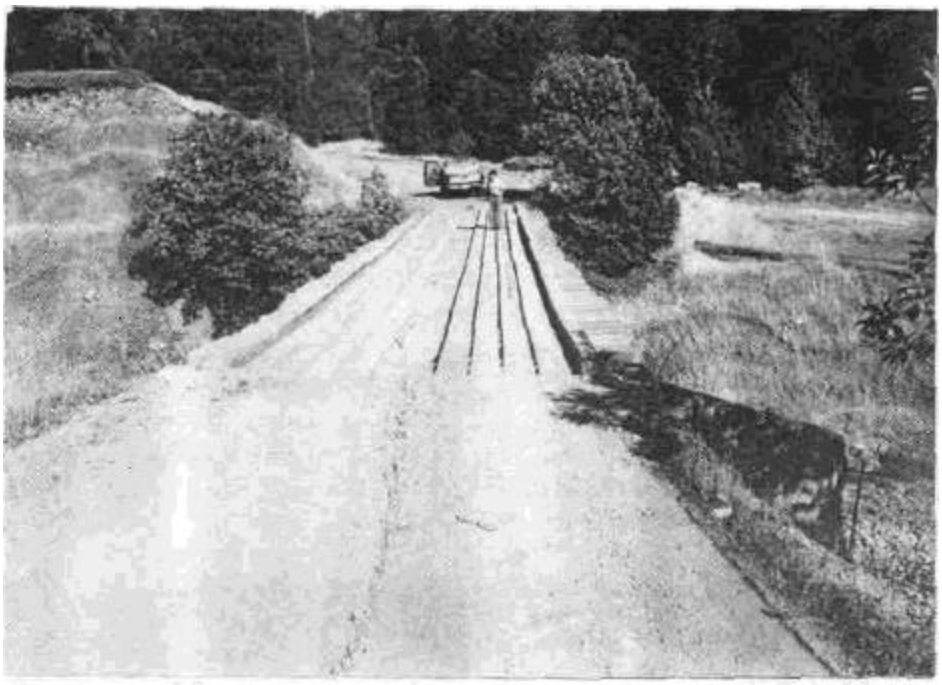


Figure 67b. *If the bridge is at a low point in the road grade, make sure the uphill road surface is well drained before the bridge and consider surfacing the approaches with rock or paving. Preferably, the bridge approaches should be flat or slightly elevated (see Figure 68).*

Figure 68. *Wheel guards on a railroad flatcar bridge signal the driver that he is too close to the edge of the bridge. Note how the approaching road slopes up to the bridge so that road runoff does not flow onto the. bridge deck*

3. Culvert installation

During road building, the construction of culverted stream crossings has the greatest potential of all activities to cause immediate sediment pollution. Culverts should be properly aligned, bedded, backfilled and covered, or they will be subject to eventual failure. In all cases, disturbance to the stream banks and streambed should be minimized during stream crossing construction.

If the stream is flowing at the culvert installation site, the crossing can be dewatered by constructing a small diversion dam just upstream and pumping or diverting flow around the

project area. The dewatered stream channel is then cleared for the culvert. Large rocks and woody debris should be removed. Both the culvert foundation and trench walls must be free of logs, stumps, limbs or rocks that could damage the pipe, or subsequently cause seepage of flow around the outside of the culvert.

The culvert should be aligned with the natural stream channel. Correct alignment is critical for the culvert to function properly. Misalignment can result in bank erosion and debris plugging problems. **Stream crossing culverts should also be placed at the base of the fill, and at the grade of the original streambed.** The culvert should be inset slightly into the natural streambed so that water drops several inches as it enters the pipe. Culvert inlets set too low can plug with debris and those set too high can allow water to undercut the culvert (Figure 69). Culverts placed midway up the outside of the fill are more likely to plug with sediment or organic debris, because their ability to pass materials is reduced, or to cause erosion of the fill below the culvert outlet

Figure 69a, b. *Proper culvert installation involves correct culvert orientation, setting the pipe slightly below the bed of the original stream, and backfllling and compacting the fill as it is placed over the culvert. Installing the inlet too low in the streambed (A) can lead to culvert plugging, yet if it set too high (B) flow can undercut the inlet (fromM.D.SL.,1991).*

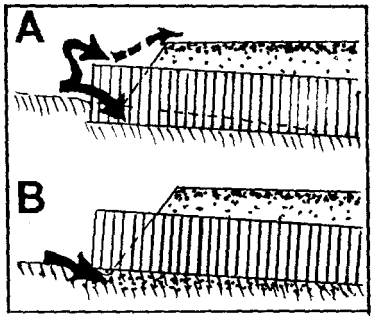
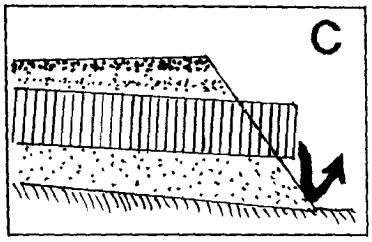


Figure 69c. *If the culvert outlet is placed too high in the fill (C), flow at the outfall will erode the fill.*



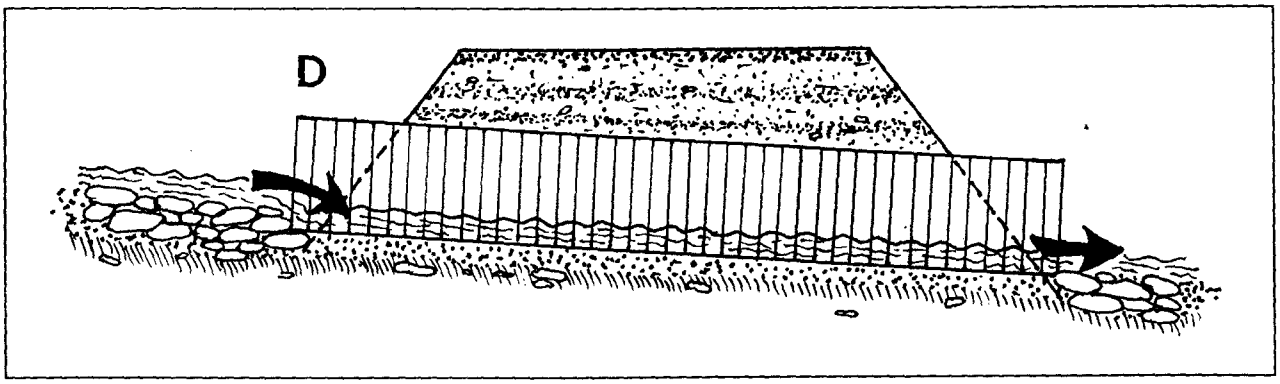


Figure 69d. *Placed correctly (D), the culvert is set slightly below the original stream, grade and protected with armor at the inlet and outlet.*

The culvert bed may be composed of either compacted rock-free soil, or gravel (Figure 69e). If gravel is used for the bed, filter fabric will be needed to separate the gravel from the soil to minimize the potential for soil piping. Bedding beneath the culvert should provide for even distribution of the load over the length of the pipe. Nearly every culvert will sag after it is buried. To allow for this, all culverts should be installed with a "camber" or slight hump in the bed centered under the middle of the pipe. The amount of camber should be between 1.5 to 3 inches per 10 feet of culvert pipe lengA. Natural settling and compaction which occurs after backfilling will then allow the pipe to settle into a straight profile.

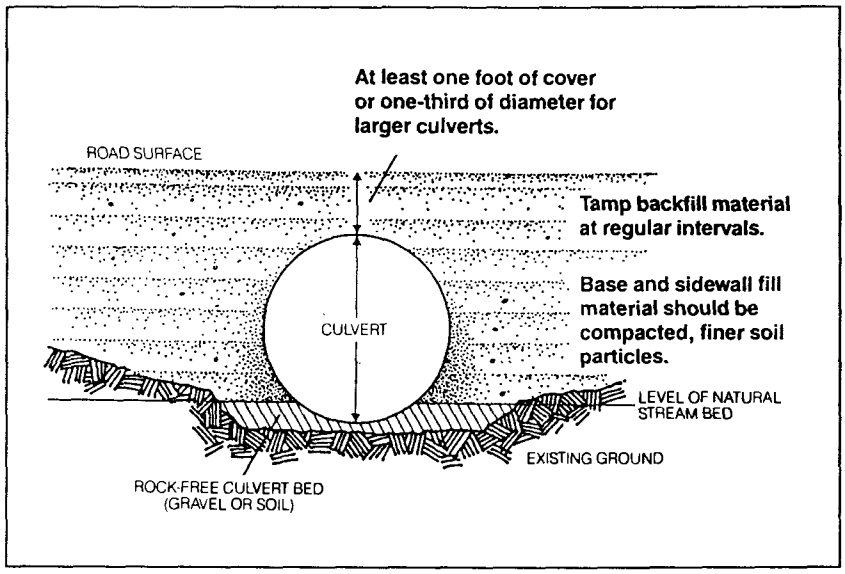


Figure 69e. *Rock-free fill is backfilled over the culvert in layers and compacted under the pipe and around the sidewall (E).*

Backfilling can begin once the culvert is in-place in its bed. Backfill material should be free of rocks, limbs or other debris that could dent the pipe or allow water to seep around the pipe. One end of the culvert should be covered, and then the other end. Once the ends are secured, the center is covered. Careful pouring or sifting of backfill material over the top of the pipe using a backhoe or excavator bucket will allow finer particles to flow around and under the culvert sides. Larger particles will roll to the outside. The fine soil particles will compact more easily and provide a good seal against leaks along the length of the pipe.

The backfill material should be tamped and compacted throughout the entire installation process. The base and sidewall material should be compacted before the pipe is placed in its bed. A minimum amount of fill material should be used for the bed of the culvert to reduce seepage into and along the fill. Backfill material should then be compacted at regular intervals (in approximately 0.5-1 foot lifts) until at least 1/3 of the diameter of the culvert has been covered (Figure 69). This will prevent leaking. A vibrating, gas-powered hand-compactor can be used.

Once backfilling has been completed, the inlet and outlet of the culvert should be armored. A metal, concrete, sandbag or rock head-wall can be constructed to prevent inlet erosion (Figure 70). A trash protector can be installed just upstream from the inlet where there is a hazard of floating limbs and wood chunks plugging the culvert inlet. This is especially important on logging roads where the upslope areas have recently been harvested or are slated for harvesting in the future.

If the stream is live, flow through the culvert should be observed to determine if and where additional rock armor is needed. As a precaution against sedimentation in the stream, a slash windrow can be constructed at the base of the road fill around and adjacent to the culvert outlet so that soil is not sidecast into the stream channel or onto the inlet during final grading of the road bed. Mulching and grass seeding can also be used on the bare fillslope to reduce erosion.

***Figure** 70. Culvert installation on a low gradient Class II (non-fish bearing) watercourse. Culvert is set slightly into the original streambed and inlet is armored to prevent erosion. Roadbed dips into and out of the stream crossing and trash rack (not visible) has been installed just upstream from the culvert inlet.*

Final filling of the stream crossing can now be performed. Layers of fill are pushed over the crossing until the final, design road grade is achieved. Fill should be placed over the top of the culvert to a depth of at least 1 foot, for 18" to 36" culverts, or a minimum of 1/3 to 1/2 the culvert diameter for larger pipes. If adequate cover cannot be achieved, then a pipe-arch or two smaller culverts should be installed (Figure 71).

***Figure 71. Pipe arch** culvert installed in a Class I fish bearing watercourse. Fill face has been **rock** armored to prevent erosion during high flows. Because of the shallow fill, a second pipe arch culvert was installed to upgrade the crossing to pass the 50-year flood flow.*

It is common practice to inslope the road bench at stream crossings, so that road surface runoff flows inward to the culvert inlet, rather than over the newly constructed, unprotected face along the outside of the fill. To minimize road runoff directly entering the crossing, the approaching road can be outsloped or a rolling dip can be placed just up-road from the crossing to drain the road surface. In addition, a dip should be placed in the road at the down-road edge of the fill to provide for a "fail-safe" drainage design (see Chapter V). If the culvert plugs, the stream will then flow over the road bench and back into the channel, not down the adjacent road bed.

Alternatively, you can construct the road with an outslope through the crossing. Road surface runoff can be controlled with an outside berm and then discharged onto native ground at the down-road edge of the fill, or carried to the base of the new fill in a berm-drain or open top culvert, or across an armored (rock surfaced) drain. Berms, however, are prone to failure and should only be used where regular, wet season maintenance is available. If the fill face is heavily vegetated with grass by the time of the first fall rains, the berm may not be necessary to prevent surface erosion.

Installation of ditch relief culverts follows the same basic principles as culverts for streams. They should be installed at a 30 degree angle to the ditch to lessen the chance for inlet erosion and plugging. Ditch relief culverts should be installed at a slope of 2-4 percent more than the ditch grade, or at least 5 inches every 10 feet (Figure 33). This will ensure sufficient water velocities to carry sediment through the pipe.

Ditch relief culverts should be seated on the natural slope. The bedding and fill material should be free of rocks and debris that could puncture the pipe. Backfill materials should be compacted from the bed to a depth of 1 foot or 1/3 the culvert diameter, whichever is greater, over the top of the culvert. The culvert outlet should extend beyond the base of the road fill (or a flume downspout is used) and empty onto an apron of rock, gravel, brush or logs (Figure 72).

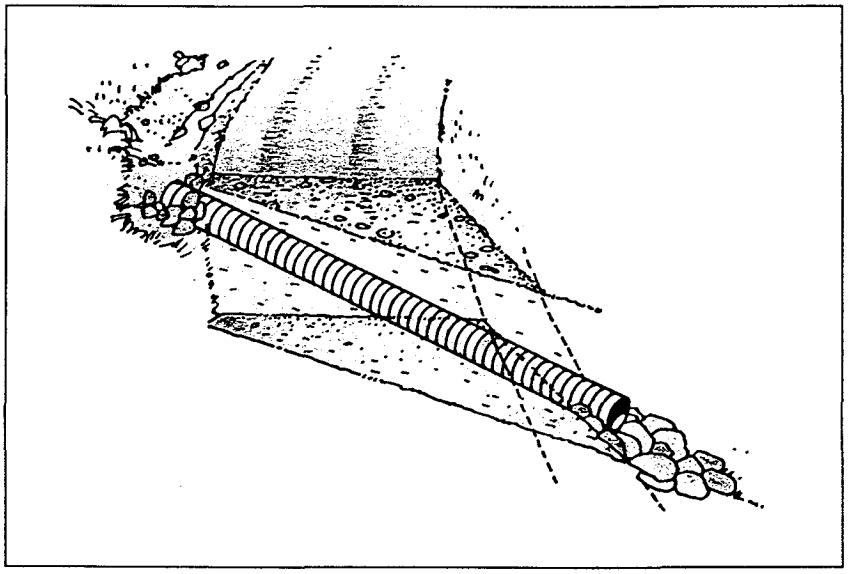


***Figure** 72. Like stream crossing culverts, ditch relief culverts should be installed at the base of the road fill, with armoring at the inlet and some type of energy dissipation at the outfall. If the culvert is placed higher in the fill, a downspout should be used to carry flaw from the outlet downslope past the base of the fill (M.DSL.,1991).*

4. Temporary stream crossings

By definition, temporary stream crossings are designed to be removed. As with bridges, installation of a temporary crossing should be done with the minimum possible amount of disturbance to the channel bed and banks, and using the least amount of fill material possible. The goal is to leave the site in a relatively undisturbed condition that is subject to minimal erosion following removal of the crossing.

As with the installation of all other stream crossings, there should be little or no sidecasting on the approaches to the channel. Colorful flagging, straw mulch or some other marker should be spread over the channel bottom so it is possible to identify the bottom of the natural channel when the temporary crossing is removed. The temporary crossing is then constructed on top of this marker.

For poorly incised, dry channels, rock-lined dry-fords can be installed as long as they are completely "pulled" or removed at the completion of use, or before the beginning of the winter period (whichever occurs first). Dry fords work well where the approaches to the channel are relatively flat. The road is built to dip across the channel using as little fill as is possible, and any fill along the outside edge of the road can be armored with fabric and appropriately sized rip-rap, or with an over-side drain. If the watercourse is incised and/or is flowing at the time of installation, temporary log, log-and-culvert, culverted fill or temporary bridge crossings can be installed'.

For log crossings, vegetation is first pruned from along the alignment and from the streambed and banks, as opposed to being stripped or bladed with a tractor. Next, straw is placed on the bed and against the banks, to help identify the original channel margins and to protect the channel from disturbance. In a flowing stream channel, a culvert capable of carrying flows expected during the period of operation should be placed at the base of the log fill. Logs are bundled into groups using choker cables and then lowered into the channel. Cabled logs make removal a simple, one-step operation using a bulldozer, loader or excavator. When the log "fill" has been built up to within about 18 inches of the temporary crossing grade, the remaining large spaces can be filled with smaller logs. A 6-inch layer of straw is then placed on top of the logs to prevent the overlying road surface soil from infiltrating through the logs to the streambed and being washed downstream[2] (Figure 73). Local soil is generally adequate for the running surface, and the straw layer enables easy removal of the capping soil fill.

1 The most common type of temporary bridge crossing used on forest and ranch roads is the railroad flatcar bridge. See the previous section on **bridge installation** for guidance on installing temporary bridge crossings.

2 Filter fabric can be used with or instead of straw on top of the logs, to keep sediment from filtering down into the stream, but it is difficult to clean out when the crossing is removed. Sediment is often spilled into the stream channel during crossing removal. Straw alone usually works better.

***Figure** 73. End view of a temporary stream crossing. First, a culvert was placed in the channel bottom. Then cabled logs were placed on top, followed by a thick layer of straw and then soil material for the temporary running surface. The materials comprising the temporary crossing are easily removed upon the completion of operations.*

H. Rolling dips

Rolling dips are simply breaks in the grade of a road. They are sloped either into the ditch or to the outside of the road edge to drain and disperse road surface runoff. Rolling dips are installed in the road bed as needed to drain the road surface and prevent rilling and surface erosion (Tables 3 and 17), and are most frequently used on outsloped roads. As a road becomes steeper, rolling dips should be made deeper and placed at a steeper angle to adequately capture and divert road runoff (Figure 74).

***Figure** 74. Several rolling dips in close succession on a rocked, outsloped road built across moderately steep terrain. As road grade increases, rolling dips need to be spaced more closely.*

It is easier to properly locate and construct rolling dips when they are designed into the original road plan. However, they may also be installed on existing roads to improve surface drainage where they can be built in about one hour, or less, using a medium size bulldozer (D-7 size). Unsurfaced roads are more easily reconstructed with rolling dips, but rocked road surfaces can also be reconfigured.

Excavation for a rolling dip typically begins 50 to 100 feet up-road from where the axis of the dip is planned (Table 18). Material is progressively excavated from the road bed, slightly steepening the grade, until the axis is reached. This is the deepest pan of the excavation, with the overall depth being determined by the slope of the road. The steeper the road, the deeper the dip will have to be in order to reverse grade (Table 18).

In order to safely and effectively direct runoff to the side of the road, the axis of a rolling dip should be angled about 30 degrees to the road alignment. On the down-road side of the rolling dip axis, the road bed slope should actually rise slightly to ensure that runoff cannot continue down the road surface. This is called a "grade change" (Figure 28). The rise in grade is carried for about 10 to 20 feet before the road surface begins to fall again at its original slope. This transition from axis bottom, through rising grade, to original falling grade is achieved in a road-distance of 15 to 30 feet. **Unlike a waterbar, the reverse grade portion of a rolling dip is not composed of fill. The entire drainage structure is excavated into the roadbed.**

Rolling dips require very little maintenance if they are constructed properly and at an adequate spacing. They should not collect enough runoff to develop significant erosion. The length and depth of the rolling dip should be adequate to divert road runoff but not so great as to interrupt or endanger traffic at normal speeds. Care should be taken to ensure that grader operators do not fill the depressions with soil or cut deeply into the lower part of the rising section, thereby eliminating the change-in-grade.

I. Subgrade and surfacing

The road surface can be a big source of stream sediment In some watersheds, it may be the primary source of accelerated (man-caused) erosion and sediment yield from the road system. Proper road construction and surfacing can significantly reduce this source of fine sediment.

Permanent roads that are to be used for winter and wet weather hauling, including ranch roads and roads used for commercial hauling of forest products, need to be surfaced to improve trafficability and reduce erosion. Roads which receive heavy use should be inspected regularly to discover early signs of damage. Serious damage to road surfaces usually begins with the build up of thick (1-4 inch) accumulations of dry dust during the summer, or excess water (and mud) during the winter. Standing water is a sign of poor road drainage and ruts indicate that road strength is deteriorating.

A stable and well drained subgrade is essential for a good road. The load bearing capacity of a road depends upon the subgrade's soil strength, drainage and compaction characteristics (Table 23). Native material is often suitable, and can be used for the road's subgrade. Weak or wet subgrades (soils unable to support a load by themselves) need to be strengthened by adding loose or crushed rock or gravel to provide ballast and distribute the stress placed on the soil.

Table 23. Soil characteristics for road subgrade materials[1]				
Material type	**Strength, compaction and foundation suitability**	**Drainage**	**Reaction to frost**	**Common symbols of soil types[2]**
Clean gravels and clean sand[3]	Good to excellent	Excellent	None to slight	GW, GP, SW, SP
Gravels and sands with non-plastic[4] fines	Good to excellent	Fair to poor	Slight to high	GMd, SMd
Gravels and sands with plastic[4] fines	Fair to good	Poor to impervious	Slight to high	GMu, GC, SMu, SC
Non-plastic and slightly plastic[4] silts and clays	Poor to fan-	Fair to impervious (mostly poor)	Medium to high	ML, CL, OL
Medium and highly plastic[4] silts and clays	Very poor to poor	Pair to impervious (mostly poor)	Medium to very high	MH,CH
Peat and other highly organic soils	Very unstable, poor compaction	Fair to poor	Slight	Pt

[1] *W.D.NJR. (1982)*

[2] *Unified Soil Classification System (USCS) symbol*

[3] *"Clean" means less than about 12% of the material is smaller than 1/64" (the smallest particle visible to the naked eye)*

[4] *Plasticity can be tested by simple field methods, including lightly wetting a hand sample, rolling the fines into a ball and then into a thread before it crumbles:*

> ***Non-plastic:*** *a thread cannot be formed, regardless of the moisture content.* ***Low plasticity:*** *after 2-3 times, the molded ball will crumble.*
>
> ***Medium plasticity:*** *After 3-5 times, the ball will easily crumble with moderate force (pressed between thumb and forefinger.*
>
> ***High plasticity:*** *ball will not crumble, even with moderate force, after five times.*

Wet, low strength soils may be stabilized by the use of synthetic fabrics (geotextiles) designed specifically for this application. The fabric is spread over the subgrade and then covered with a layer of rock. Water passes through the membrane, but the wet soil remains below and does not mix with the surface aggregate. As a result, the road dries faster and the fabric spreads the wheel loading pressures over a large surface area.

The running surface of the road should be smooth and hard-wearing, and it should not be subject to blowing or washing away. The most commonly used surfacing materials are angular (crushed) rock. In the past, river-run gravel was frequently used where crushed rock was not readily available. However, rounded material is not as well suited as long lasting surfacing material and may be difficult to keep in-place.

First, a "base course" of 2 to 3 inch diameter angular rock is usually dumped on the compacted native road surface using dump trucks, spread to a uniform depth using a grader or tractor and then compacted. The use of true compaction equipment (instead of tractors) will provide the best, longest lasting road surface. Geotextile engineering fabrics can be used beneath the base course material if soil conditions are wet. A finer "surface course" several inches in thickness is then spread over the compacted base coarse material to provide a dense, smooth running surface. The resulting layers of angular, interlocking rock will provide a low impact road surface that can be used during much of the winter (Figure 75).

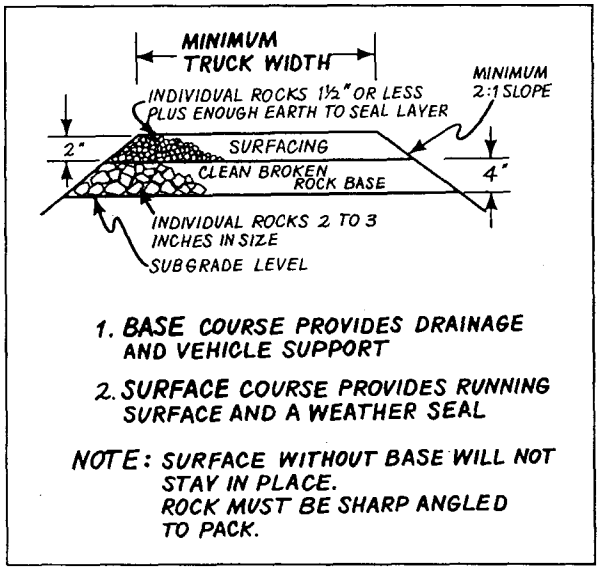


***Figure** 75. Cross section diagram showing typical base-course and surface-course application for forest and ranch roads (USDA-SCS, 1983).*

For all-weather use, angular rock should be placed to a total depth of 6-10 inches, or more, which will then compact to a finished depth of 4 to 6 inches under normal use. Table 24 lists the volume of aggregate needed to surface one mile of road, ranging from 10-20 feet wide, to a depth of 1-6 inches.

Table 24. Aggregate (yds^3) required to one mile of road[1]

Road width (ft)	Depth of uncompacted rock (inches)					
	2"	4"	6"	8"	10"	12"
10'	326	652	978	1,304	1,630	1,956
12'	391	782	1,174	1,564	1,956	2,348
14'	456	913	1,369	1,826	2,282	2,738
16'	522	1,043	1,565	2,086	2,608	3,130
18'	587	1,174	1,760	2,348	2,934	3,520
20'	652	1,304	1,956	2,608	3,260	3,912

[1] USDA (1978). Uncompacted, 16.3 yds^3 equals I inch deep by I foot wide by 1 mile long. When aggregate is compacted, increase volumes required by 15-30%, depending on type and gradation of material.

J. Erosion control during construction

Road construction, use and maintenance can cause soil erosion and stream sedimentation problems. In fact, roads have been identified as one of the greatest sources of man-caused erosion and sediment yield in forested watersheds of the Pacific Northwest. Some erosion is the result of poor road location and design, but some clearly comes from inadequate planning for erosion and sediment control on the construction site. Proper forest and ranch-land road construction and maintenance practices reduce long-term erosion and stream sedimentation from forest and ranch lands. However, even properly located, designed and constructed roads still need erosion control measures to minimize soil loss and sediment production.

1. Roads and landings

Both mechanical and vegetative measures are needed to minimize accelerated erosion from roads and landings under construction. Effective erosion prevention employs proper road location, pre-planning of cuts and fills, minimizing soil exposure, compacting fill or endhauling loose fill materials from steep slopes and stream-side areas, developing stable cut and fillslopes, mulching to control surface erosion for the first year, and seeding and planting to provide for longer-term erosion prevention.

Perhaps the best tool for preventing erosion is to keep soil disturbance to an absolute minimum during construction. Cuts and fills on gentle and moderate slopes should be balanced to minimize the amount of excavation and soil exposure. On steep slopes, or where soils are unstable, full bench construction techniques should utilize "bottom-up" compaction or endhauling to eliminate problems associated with loose, uncompacted fill materials and sidecasting. Soils that are wet and would become muddy should be allowed to dry before construction begins or continues.

Cut and fillslopes need to be constructed at stable angles to prevent mass failure. Slopes which develop instability, especially those which threaten to deliver sediment to stream channels, need to be stabilized immediately. Woody debris should not be incorporated in sidecast fill material during construction because it will decompose and can lead to future slope failure (landsliding). Woody debris and soil mixed together around the outside perimeter of landings built on steep slopes form a certain recipe for eventual landsliding.

Shallow failures or small slumps on the cutbank or fillslope can either be excavated (if they threaten to deliver sediment directly to the stream channel) or stabilized by placing large rocks at the slope base to buttress the unstable materials. Specific techniques for building rock buttresses, retaining walls, timber cribs, and reinforced slopes are beyond the scope of this manual and require advice and design by a qualified engineering geologist or geotechnical engineer.

Bare slopes created by construction operations also need to be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills can be minimized by mulching, seeding, planting, compacting, armoring and/or benching prior to the first fall rains. Installing filter windrows of slash at the base of the road fill can minimize the movement of eroded soil to downslope areas and stream channels. They are installed using heavy equipment as the road is being cleared and graded. During construction, it is also important to retain rooted trees and shrubs at the base of the fill as an "anchor" for the fill and filter windrows (Figure 76).

***Figure** 76. Newly constructed, outsloped forest road with accumulated line of slash, called a filter windrow, at the base of the fill to catch soil eroded from the fill slope. Slash should be placed at the base of the fill, and not Incorporated into the soil material. This fill has been straw mulched and is covered with a thick stand of grass. Filter windrows are most important to install where roads approach and cross stream channels. Note how the road conforms to the topography of the land and incorporates rolling dips at natural swales to shed surface runoff.*

Road construction activities should be performed during the "dry" season, and all surface drainage structures should be in-place and completed well before winter rains are expected (October 15 for forestry-related roads). Where construction or reconstruction activities are conducted near a live watercourse, silt fences and/or straw bale silt-dams may be needed both in the channel and on the adjacent slopes during the construction phase. Any use of roads during the winter period may require the application of road surfacing to prevent road deterioration, control erosion, and prevent sediment transport to nearby streams. Muddy runoff from unsurfaced roads can transport large volumes of sediment that flows through culverts and into streams.

2. Spoil disposal sites, borrow sites and rock pits

Erosion should also be controlled in areas where large expanses of bare soil have been created, such as spoil disposal sites, borrow sites and rock pits. Proper location, excavation and topographic development of spoil disposal sites and rock pits are key elements to assuring controlled drainage and minimizing erosion and sediment problems. When placed on slopes; spoil should be spread in lifts and compacted to develop strength in the materials. Spoil disposal Mes, borrow sites and rock pits should not be located near streams or where sidecast, tailings or sediment-laden runoff could reach a watercourse.

When a rock pit is under development, top soil and overburden should be stockpiled for later use as surface soil for reclamation. During development and use of borrow pits and disposal sites, it is also important to maintain internal and controlled external drainage. Outflows should be dispersed to prevent erosion and water should be directed through vegetated filter areas to trap sediment Runoff should not be directed straight to a watercourse.

Filled spoil areas and exhausted rock pits should be permanently reclaimed. Development and reclamation of rock pits on private lands may be subject to regulations under the California's Surface Mining and Reclamation Act (SMARA) if the proposed excavations are greater than 1 acre in size or 1000 yds3 in volume (Figure 77). Spoil sites should be mulched and seeded, **or** machine hydroseeded using a mulch and seed slurry, before winter rains. Compacted areas should

be ripped to promote revegetation. Areas of bare rock should be outsloped and covered with several feet of soil. Then, bare areas should be planted with brush and tree species that will be able to thrive in the altered environment.

***Figure** 77 a. Access road and rock pit before (A) and after (B) reclamation. Exposed areas have been reshaped and covered with soil to promote revegetation. The area was then mulched, seeded and planted. Reclamation work was performed using an excavator and large bulldozer.*

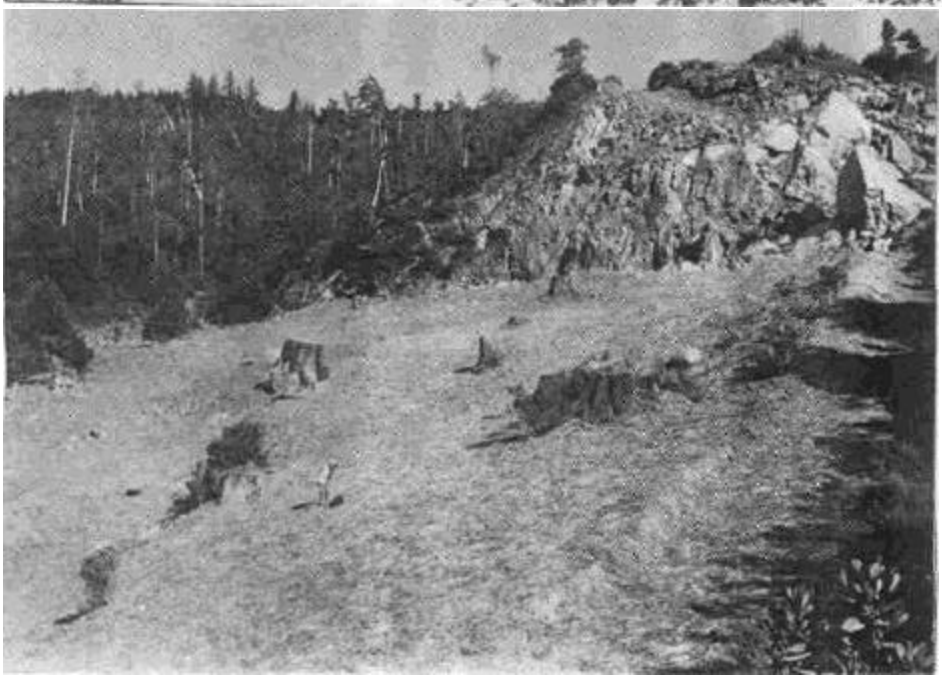


***Figure* 77b.**

3. Stream crossings

Stream crossings are where roads come into closest contact with flowing water. For this reason, it is critical that proper and sufficient erosion control measures be applied to ensure that erosion and sedimentation from culverted fill or bridge sites does not enter the watercourse.

Some stream crossing features are more sensitive to erosion than are others. Problems are most likely to develop at culvert inlets, culvert outlets, through-fill road surfaces, fillslopes, and inside ditches. Erosion prevention and erosion control measures for each of these areas, as discussed below, are commonly employed to limit post-construction erosion. **Regardless of the measures chosen, any successful erosion control technique must be *correctly installed and regularly maintained.***

At culvert inlets, rock armor or flared inlets can be used to protect the pipe entrance from undercutting and erosion (see Chapters IV and V). Trash racks (debris barriers) can be placed upstream from the culvert inlet to prevent culvert plugging and subsequent washout of the entire fill. Drop inlets can be used to prevent culvert plugging in channels with a lot of sediment movement.

Culvert outlets should extend past the end of the road fill and discharge into the natural channel, or a flume or downspout should be attached to the pipe end and extended past the fill before discharging into the channel. Rock armor or other energy dissipation should be used at the outlet of culverts and flumes to prevent erosion by the fast moving flow.

Soils eroded from the road surface can also be delivered to a stream when the road slopes towards the crossing. To prevent this, the road bed can be rock surfaced. If the road is unsurfaced, waterbars or rolling dips should be constructed above the crossing to disperse surface runoff. The road bed can also be insloped through the crossing, so water won't be delivered over the new fill, or the road can be outsloped with a berm to focus road surface water to a single point where it can then be carried down the fillslope in a metal berm-drain. Berms, however, are subject to failure and should only be used on roads that receive regular, wet weather maintenance. Regardless of the methods chosen, road surface runoff needs to be strictly controlled through the crossing.

In addition to controlling road surface runoff, a fail-safe drainage design should be incorporated into every stream crossing fill so that streamflow will not be diverted out of the natural channel and down the road if the culvert plugs with sediment or debris. This requires the road to physically dip down into and out of each stream crossing, even on roads which are climbing across a hillslope. **These changes in road grade at watercourse crossings are key to preventing serious stream crossing failures and gully erosion during large floods.**

Surface erosion on bare fillslopes and on the adjacent cutbanks, can also deliver sediment directly to the stream channel. Most of this erosion comes from raindrop impact and rilling or from shallow failures of saturated, loose or uncompacted soils during winter storms following construction.

Silt fences or straw bale barriers can be constructed on extremely large fills and on steep bare soil areas to retain soil that erodes from the surface. Silt fences do not prevent erosion, they merely trap the sediment and keep it from moving off the site and into a stream. Silt fence barriers and check dams can also be installed in swales and across small ephemeral streams to trap sediment

and control erosion. Installation of structures in channels requires careful design and construction, and long-term maintenance. They may have minimal effectiveness or actually cause unwanted erosion if they are improperly installed. Sediment retention dams are generally not an appropriate treatment for larger streams.

The use of silt fence barriers and straw bale check dams have become standard operating practice in many construction sites. To be successful, these measures should be ***correctly* applied and *maintained*** for as long as they are left in-place. Straw bale structures, for example, need to be replaced every one or two years if they are to remain effective. **However, incorrectly installed and maintained sediment retention structures can cause more erosion than might occur without such structures.** Erosion control specialists (SCS or a private consultant) can assist in the designing and installing special erosion control structures.

The best treatment for surface erosion on slopes less than about 50% is to mulch and vegetate the bare areas as quickly as possible. Surface erosion is immediately controlled on these slopes by applying a thick mulch, or a commercially-available mulching blanket, and by seeding the surface so a healthy stand of grass or legumes develops before major winter storms occur (Figure 78). On steeper slopes and in windy areas, a mulching blanket or a netting may be needed to keep the mulch in place and in contact with the ground surface. Very irregular ground surfaces may also need to be smoothed before applying mulch. Longer term erosion control requires planting or seeding fast growing woody species.

***Figure** 78. Mulching and seeding are effective methods for controlling surface erosion from bare fill slopes. Mulch protects the soil until the grass and vegetation is firmly established. However, because it decomposes rapidly, straw mulch is effective for only the first year. After that, well established vegetation should provide the needed protection.*

Successful revegetation of stream crossings and other bare soil areas may not always be as simple as throwing out a standard mixture of grass seed. Site conditions such as soil type, exposure, aspect, elevation, summer and winter temperatures, soil dryness or moisture and other site factors may require use of unique or native plant species, special planting techniques, special planting times, fertilizer or soil amendments. A trained wildland botanist, plant ecologist, your local farm advisor, or the SCS should be consulted to see what is recommended for your area.

Notes:

CHAPTER VII: RECONSTRUCTION

A. Introduction to reconstruction

Road reconstruction provides an opportunity to upgrade and improve a road that is substandard in one or more elements of its design. Culverts can be upgraded to current standards, additional drainage structures can be installed, the road bed can be reshaped for improved surface drainage and fills which exhibit instability can be removed and/or stabilized. In general, stream crossings and unstable fill and cutslopes present the greatest challenge to road reconstruction, and the greatest opportunities for future erosion prevention and rehabilitation.

B. Redesign considerations

Only after careful consideration, weighing the economic and environmental benefits against the potential impacts, is it justified to reopen roads that 1) cross unstable hillslopes, 2) were constructed up the axis of a stream channel or 3) would require considerable earth moving with the potential for unacceptable erosion and stream sedimentation. In many cases, temporarily reopening a poorly built road (for a single summer season) may provide substantial positive environmental benefits if subsequent rehabilitation could reduce continuing or future erosion and sedimentation from the old alignment

Decisions about reopening an abandoned road should be made on-site, after having inspected the entire route and reviewing the pros and cons of redisturbing the area. As **a general rule, it is often worth removing even abundant revegetation along the abandoned route if there are substantial erosion prevention projects that could be completed during or following reconstruction.** That is, it is often preferable to remove vegetation than to leave the vegetation intact and not treat potential and ongoing erosion "hot-spots" along the road alignment Removing vegetation and regrowth from the road prism, by itself, rarely causes serious erosion problems. When in doubt, ask for assistance from CDF, CDFG or a wildland erosion control specialist.

Some large, washed-out stream crossings or short sections of road on steep, unstable slopes that have been entirely lost by past erosion or landsliding may not be worth rebuilding. In these cases, it may be preferable to reroute the road around the problem areas with a section of newly constructed road using modem construction techniques and standards.

When reconstruction of an older, existing route has been selected as preferable to new construction, efforts should be made to make improvements in the existing road where ever possible. High maintenance insloped roads can be converted to low maintenance outsloped routes (Figure 79). If the road is to be permanent, all drainage structures should be checked to determine whether or not they are capable of passing the 50-year flood flow, as is currently required of all newly constructed roads used for commercial forestry operations. Any stream crossings that require reconstruction should be redesigned for the higher level of protection, and it is a good idea to replace or remove all intact drainage structures that are undersized for the design storm flow. Humboldt log crossings that were commonly constructed on forest roads from the 1940's through the 1970's should be excavated and permanently removed or replaced with bridges or culverts designed to accommodate 50-year flood flows (Figure 80).

Figure 79. *A former insloped road that was regraded and reconstructed to an outsloped configuration. Outsloping was performed to reduce erosion of the ditch and at the outlet of ditch relief culverts, and to lessen maintenance costs. The road bed was lowered about 8 inches along the outside edge of the fill and spoil was graded to cover the inboard ditch. The road was rock surfaced shortly after the photo as taken.*

Every stream crossing that currently has a high potential for stream diversion should be regraded so that the road dips into and out-of the crossing, thereby eliminating the diversion potential. Regrading the road, and adding rock surfacing, can be performed with a bulldozer in about one hour per site. Culverts should be retro-fitted with trash barriers above the inlets, and with downspouts and/or rock energy dissipation to prevent erosion at the outlet areas.

All reconstruction work should be conducted in a manner that minimizes soil disturbance. Only areas which truly require earth moving should be disturbed. Typically, most of the old road surface will still be intact and require only minor grading to become passable. Ditches and cutbanks should be left undisturbed unless there are specific areas needing repair work. New sidecasting should be avoided in areas of steep slopes, near stream channels or where fills are unstable or oversteepened. As a general rule, landings should not be enlarged by new sidecasting.

Figure 80. Under-designed or unmaintained stream crossings on older roads are prone to failure during large storms. During road reconstruction, stream crossings should be redesigned for the 50-year flood flow. Under-designed culverts and Humboldt log crossings should be removed and upgraded.

C. Reconstruction techniques

The most efficient equipment for road reconstruction include a hydraulic excavator, bulldozer and a grader for final road smoothing. These versatile pieces of equipment can complete reconstruction with a minimum of soil disturbance and loss of vegetation. A standard size backhoe is generally too small to perform the excavations required for stream crossing reconstruction and removal of unstable road and landing fills. Dump trucks may be needed to endhaul slide debris.

Many older roads were initially constructed with an insloped surface and an inside ditch. If conditions are appropriate, the rebuilt road can be converted to a low-impact outsloped surface with rolling dips to disperse road runoff. In ditched road segments, ditch relief culverts and other surface drainage improvements should be made to quickly direct water off the road surface. Many older seasonal and permanent roads have an outside berm which has been created and perpetuated by years of poor grading technique (Figure 81). Water flow off poorly drained roads can often be dramatically improved by outsloping, berm removal and/or other surface drainage improvements.

Washed-out stream crossings present one of the most common obstacles on older roads that are to be reconstructed. Usually, part or all the fill has been eroded and lost downstream because the drainage structure was either too small, not maintained, or not installed.

Washed-out stream crossings are reconstructed just like new ones, with all the same techniques and requirements. If the fill was only partially eroded from the crossing, the remaining material in the channel bottom will likely need to be excavated (down to the original channel bed) before a new culvert is installed. This may include removal of sediment and buried logs.

Figure 81. *Surface runoff problems cause by winter use of a bermed, unsurfaced road. Running surface is rutted and this acts to collect runoff and cause additional erosion. Lack of waterbars or rolling dips, together with the graded berm along the outside edge of the road, now acts to keep surface runoff on the road bed. Annual grading can produce an outside berm of soil and rock that should be pulled (graded) back onto the road surface before winter rains.*

If a temporary or permanent bridge is to be installed, all the fill should be removed from the old crossing, and the banks should be graded or excavated back to a stable angle. You can often tell that you have removed all the fill material from the former crossing when rounded boulders, old logs and branches, roots, in-place stumps and other features of the original bed and banks are exposed during excavation.

Failed road benches can also present a serious obstacle to reconstruction. In areas of steep inner gorge slopes, failures of the entire width of the road bed can extend all the way downslope to a fish-bearing stream. Sidecastmg into the void in hopes of developing a new road bench at the-same spot will usually result in direct sedimentation into the stream. The resulting fill would also be highly unstable. Road reconstruction where failures have removed most or all of the former road bench are likely to require an engineered solution, such a reinforced fill or a crib wall, and a qualified geotechnical engineer is should be consulted to design solutions for these difficult reconstruction sites.

In many cases, the outer 10-50 percent of the road prism has been lost as a result of fillslope failures or sliver failures, in which only sidecast materials have moved downslope. If there is sufficient road width remaining for vehicles to pass, the unstable area should not be disturbed. Where some additional road width is needed, consider cutting into the inside bank rather than trying to build the fill back out. If fill material has not moved off-site, but is showing signs of pending failure (e.g., scarps displacing or offsetting the road prism), and the failed soils will be delivered to a stream, then the unstable material should be excavated and hauled to a stable storage site for disposal.

Failed or unstable landing fills present similar problems on a larger scale, except that vehicle passage is usually not affected. Unstable landing fills usually result from mixing soils and woody debris together in the uncompacted sidecast around a landing perimeter. The fill face is often oversteepened by continued blading and sidecasting of landing wastes over the outside face of the landing. On steep slopes, these unstable fills and waste deposits can saturate with water and flow

great distances downslope and into stream channels. In other cases, failed landing fill material may not be delivered to a stream channel, and only the run-out area is impacted through damage to regeneration and reduced site productivity.

Each unstable landing fill should be evaluated to determine if it threatens downslope stream channels or other important resources. If it does, the unstable fill should be excavated and hauled to a stable storage site for disposal (Figure 82). Often, the inside of the landing is carved into bedrock and can serve as a suitable storage site for excavated fill materials.

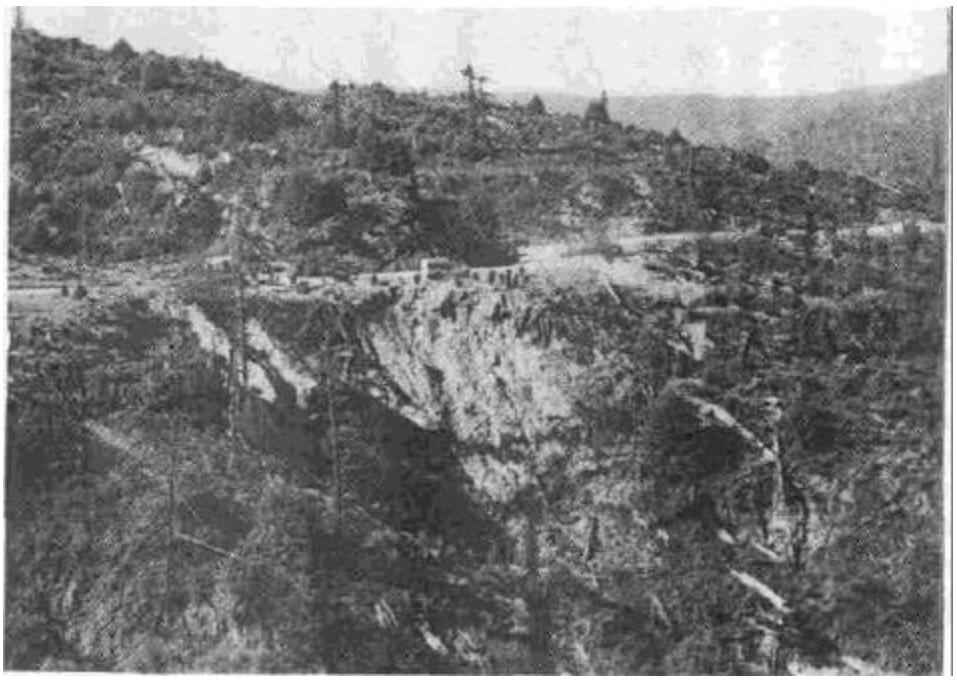


***Figure 82. Excess** sidecasting on forest roads and landings that are scheduled for reconstruction should be excavated before it fails and is delivered to a stream channel. Often, potentially unstable spoil can be recognized by cracks and/or scarps along the margins of the road or landing surface.*

Cutslope failures which block the road surface generally represent a less serious erosion problem than fillslope failures, since the road bed may store much of the failed cutbank material and prevent it from moving downslope (Figure 83). Failed materials can usually be excavated off the road bed and hauled to a suitable storage site. Unless slopes are gentle and the road is not close to a stream channel, debris should not be sidecast from the road surface and onto the slopes below. Sometimes the material can be spread over the road bed, thereby raising the road surface and avoiding the need for expensive endhauling.

D. Slash and spoil disposal

Reconstruction of abandoned roads often involves substantial vegetation removal from the road surface. Slash should not be mixed in and sidecast with soil materials. Instead, it can be piled and burned on landings, or windrowed along the outside edge of the cleared fill. Spoil materials generated from road reconstruction (largely from cutbank failures), should be safely disposed in a stable location where it will not erode or enter a watercourse. Spoil disposal techniques are the same as for new road construction (see sections on *construction* and *erosion control, and reconstruction techniques,* above).

***Figure** 83. Unstable embanks usually pose less of a threat to water quality than unstable fillslopes, but they may still be difficult to stabilize. Soil that is cleared from the road surface should be endhauled or pushed to a stable storage site and not sidecast over the outside edge of the road. In some instances, a slope buttress may need to be designed and installed to prevent further instability and road closures.*

E. Erosion control

Erosion prevention and erosion control can actually be improved by road reconstruction. Upgrading or removing stream crossings and removing unstable fills can significantly reduce the likelihood that sediment will be delivered to stream channels. **Even the temporary, single reuse of an abandoned road can serve as an opportunity to perform erosion control and erosion prevention when the road is permanently closed.**

Erosion control during reconstruction of permanent and seasonal roads is largely the same as for new construction. Surface erosion can be minimized by keeping excavation and soil exposure to a minimum, and by retaining as much roadside vegetation as possible. The largest potential source of erosion will be at reconstructed stream crossings. Use of temporary bridges, as well as protective measures at culvert inlets, culvert outlets, road surfaces, and fillslopes will help reduce the potential for accelerated erosion on reconstructed roads (see *construction: stream crossings,* above).

The timing of reconstruction, especially stream crossings, can also help prevent and control unnecessary erosion. Stream crossing reconstruction should be performed during low water conditions. Winter period road reconstruction should only be performed during dry periods and when erosion control measures (mulching, waterbars, etc) can be installed concurrently with road rebuilding. Large sections of road should not be "opened" without performing concurrent erosion control work.

CHAPTER VIII: MAINTENANCE

A. Introduction to road maintenance

Regular road maintenance is essential to protect the road and to prevent environmental damage. All roads used for vehicle travel should be regularly inspected and maintained. **If adequate personnel and financial resources are not available to provide for regular, long term maintenance, roads should be built (or rebuilt) as temporary, and then properly abandoned or closed at the end of the planned operations.** Temporary roads that have been properly abandoned do not need continued maintenance and pose little threat to downstream resources.

B. Inspection and maintenance schedules

Roads and drainage structures along all roads should be inspected annually, at a minimum, prior to the beginning of the rainy season. Inspections should cover culvert inlets and outlets on stream crossings, ditch relief culverts, and road surface drainage such as waterbars, outsloping, and ditches.

In addition to annual, pre-winter road and drainage structure inspections, crews are needed to inspect and perform emergency maintenance during and following peak winter storms. Shovel work at a culvert inlet that is beginning to plug can save the expenditure of thousands of dollars to rebuild an entire stream crossing after it has washed-out.

Some drainage structures are more prone to problems than others. For example, culverts on streams with heavy sediment loads or floating woody debris may be more likely to plug. Landowners or land managers frequently know which culverts in their road system have had the most problems, and which are most likely to plug during a winter storm. In contrast, many culverts, ditches and road surfaces almost never have erosion problems, no matter how severe the winter storm.

This background information can be used to develop a rating system and inspection plan for drainage structures in a watershed. Culverts can be coded by signs along the road. These signs note: 1) where the culvert is located (road name and milepost), 2) the diameter of the culvert, and 3) a number or color coding (e.g., red, yellow and green) that signifies how likely the culvert is to plug, and, therefore, its relative need for inspection during winter storms (Figure 84).

***Figure** 84. Culvert signing is an integral part of developing a culvert and drainage structure maintenance plan. Included at this crossing are the stream name (Puter Creek), the name of the road (5000 Road), the diameter of the culvert (84") and its location (0.6 miles from the beginning of the road). The signing can also be color coded (e.g., green, yellow, red) to indicate whether or not it is prone to plugging or other maintenance needs.*

The number or color coded rating system is based on past maintenance experience with that culvert, and is used in the field to alert inspection crews to which culverts should be inspected first during and following winter storms and floods. **Culvert coding schemes are especially useful for large landowners or companies with many miles of road who may rely on employees unfamiliar with the road system to perform inspections and field maintenance.** Culvert marking is also useful to grader operators, so they can avoid damaging culvert inlets when grading the road or ditch. Over time, each existing drainage structure within an ownership should be inventoried on a master file for quick reference.

C. Maintaining permanent roads

Road maintenance should address the road surface, cutbanks, and fillslopes, as well as drainage structures and erosion control measures. A poorly maintained road surface will channel water, reduce road life and increase erosion and sediment pollution to streams. It may also be difficult **or** hazardous to drive on and damage vehicles and equipment.

The first rule of maintaining a stable road surface is to minimize hauling and grading during wet weather conditions, especially if the road is unsurfaced. But even the best surface can be severely damaged by overuse during wet or thawing ground conditions. Be aware of early signs of road damage. Serious damage to road surfaces begins with loss of road drainage and excess water standing on the surface. Ruts indicate that road strength is deteriorating. Shutting down for several days can save thousands of dollars in road repairs and prevent unnecessary erosion and sedimentation.

Similarly, hauling on a dry road bed in the summer can chum and pulverize road surface material and create thick, loose layers of soil and rock powder (dust). Loose materials can then erode and flow into streams with the first fall runoff. Summer hauling should be accompanied by dust control and watering to maintain the road surface condition. Some dust abatement products can

be pollutants, so caution should be used in their application near streams and drainages or where ditch flow leads to a watercourse.

Road surfaces should be graded only when needed to maintain a stable, smooth running surface and to retain the original surface drainage. Over grading results in unnecessary erosion and increases road surface rock wear. Steep road sections will quickly loose their running surface with frequent grading, so *raise the blade wherever grading is not needed!* In addition, grading should only occur when the materials are slightly damp. Road surfaces graded when they are too dry will not compact and will result in subsequent erosion.

Grading should cut deeply into the road surface so loose material will mix, compact and bind with underlying materials. If deep potholes or ruts cannot be graded out, the surface should be ripped and then graded and recompacted to achieve proper binding. Otherwise, individual holes and ruts that are patched will quickly reform in the same locations. Oversized rock fragments that come to the surface during grading can be moved off the side of the road. However, unplanned berms that concentrate runoff during winter rains should not be left along the outside edge of the road.

Over years of hauling and grading, road surfacing materials gradually break down or are inadvertently moved off the side of the road. Steep sections of road and curves experience the highest rates of wear. Often, larger rock fragments are left jutting out of the road bed while the fine materials have been washed or blown away. This makes for a rough ride, and can significantly increase hauling times. When this occurs, it is time for the road to be resurfaced or restored. The road bed should be ripped and new loads of properly graded rock aggregate spread, mixed and compacted into the existing materials. If past grading has piled good surfacing materials along the outside edge of the road, it can be retrieved and worked back into the road bed.

Where inside ditches are used, ditch maintenance is important in order to clear blockages and maintain the flow capacity required to remove surface runoff. Inspecting ditches during periods of high runoff will tell you which ditches need grading to improve their capacity, and which ditches are carrying too much water. Often, nothing more than shovel work at problem spots is required to solved ditch drainage problems. Additional ditch relief culverts can be installed to drain ditches that show signs of erosion or downcutting. Where sections of ditch cannot be drained, such as in a throughout, rock armoring should be installed.

Frequent, routine mechanical grading of ditches is usually unnecessary and can cause erosion of the ditch, undermine cutbanks, and expose the toe of the cutslope to erosion. ***Ditches should be graded only when and where necessary.*** If cutbank slumps have blocked the ditch, clear out the material and move it to a stable storage site. Remove other sediment or restrictive brush and weeds from the ditch only if they create obvious drainage problems that affect the road surface. Do not remove more grass and weeds than is necessary to keep water moving. Vegetation prevents scour and filters out sediment **If the ditch is not a problem, don't "fix" it. Routine mechanical ditch grading should be avoided.**

When "pulling" a ditch (mechanically grading and removing fine sediments), avoid pulling fine silts and clays across or into the surface rock of the road. This unfortunately common practice creates muddy surface conditions and potential for sediment pollution in streams during the next heavy rains. Large amounts of ditch spoil can be windrowed at the inside road shoulder for later endhauling by loader, backhoe and/or truck.

D. Maintaining seasonal roads

Unsurfaced seasonal roads require almost the same maintenance effort as permanent roads, but are much more sensitive to wet weather use. These roads should not be used when wet, and hauling or other intensive vehicle activity should be limited to dry periods when soils retain their maximum natural strength. Road surface grading may be required after each period of intensive use, and prior to the rainy season, in order to maintain proper surface drainage. Dust control and watering during dry summer conditions is almost always necessary during intensive, dry season use to prevent excessive loss of surface materials (Figure 85).

***Figure** 85a. Excessive mud during the winter (a) and excessive road dust during the summer (b) are conditions which directly threaten water quality. Both conditions produce and deliver large quantities of fine sediment to nearby stream channels during periods of surface runoff. This fine material can be especially damaging to fish and fish habitat.*

Figure 85b.

Seasonal, unsurfaced roads can be badly damaged by even occasional use during wet periods when the road bed is soft. Damage to road surfaces can occur almost as easily by a pickup as by a log truck. Traffic control (temporary or seasonal road closures) can be an effective method to protect the road surface, minimize erosion problems and reduce road maintenance costs (Figure 86). However, **the use of gates or other barriers does not eliminate the need for annual and emergency winter maintenance inspection and repairs.**

Figure 86. *There are a variety of ways to close a road to off-season traffic, but it should always be remembered that barricading the road does not by itself prevent erosion along the alignment. Gating closes the road to unauthorized traffic but still allows for winter maintenance and inspections. If barricades or physical barriers are used, they must be removed with heavy equipment before maintenance activities can be performed. They should not be used on roads which have stream crossings since these need to be inspected and maintained during storms.*

In many cases, traffic control may require physically blocking the road. Gates are most often used for this because they provide temporary closure while still allowing access for emergency inspections and maintenance of drainage structures by authorized personnel. Gates should be strong and well anchored to prevent removal by vandals. More permanent alternatives to gates include large berms, ditches(tank traps), logs, stumps or boulders and physical outsloping (Figure 87). These barriers make it very difficult to access and inspect the rest of the road for maintenance needs, and their use should be limited to spur roads with no stream crossings, roads which do not cross or come close to stream channels and roads which have been "permanently" closed.

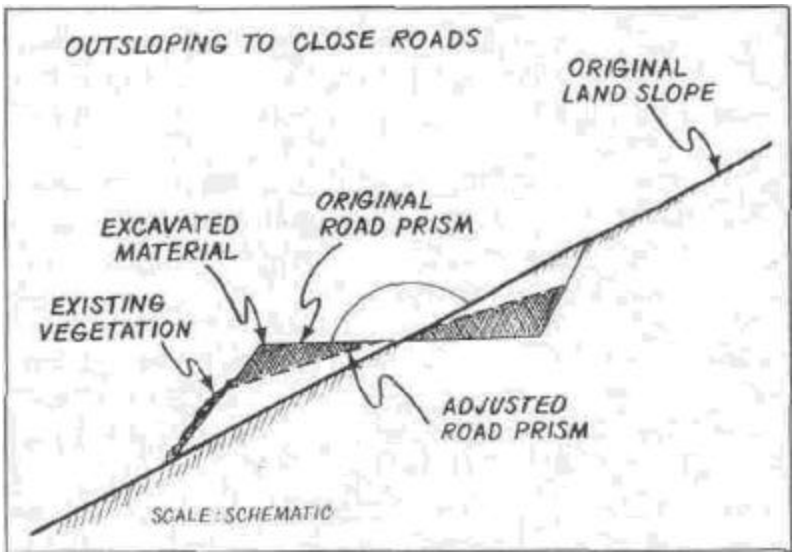


Figure 87a. A more permanent closure method is to outslope the first 100 feet of the road.

Figure 87b. Outsloping should only be used on temporary roads where all stream crossings have first been removed.

E. Stream crossing maintenance

Summer culvert inspections and maintenance is often performed at the same time as ditch maintenance. Culverts also need to be inspected and cleared during peak storms to prevent plugging. Problems found at such times should be corrected immediately, because delay can result in road damage requiring costly road repairs. **The critical component of successful culvert maintenance is to fix problems before complete failure occurs.**

Hand, shovel and chain saw work can take care of almost all culvert maintenance needs (Figure 88). Floatable debris should be removed from the catch basin and material wedged in the culvert inlet or hung up in the debris barrier should be removed and placed where it cannot get back into the watercourse. Sediment deposits that threaten to plug the culvert may need to be excavated. Culvert ends that have been bent or damaged during grading or by falling trees **or** branches should be straightened and re-opened. Outlets that are experiencing erosion should be armored or fitted with a downspout, and culverts that continue to experience overflow problems may need a larger pipe, or a second, overflow pipe installed at the crossing.

Bridges and fords may also require maintenance. Permanent fords that show erosion may need additional rock armor. However, except for emergency repairs, equipment should avoid operating in the flowing water of a ford, and re-armoring may have to wait until low flow conditions, or at least until peak flows subside.

In contrast, riprap and other bridge abutment protection should be repaired as soon as damage is noticed to prevent loss of bridge foundations and approaches. Floating trees and other debris that becomes lodged in the bridge structure should be cut free and removed or floated downstream. When cleaning bridge decks, soil and debris should be scraped to the adjacent road or hauled off. Material should not be dumped, scraped or washed into the stream. This is especially important during low flow conditions in the summer or fall.

Figure 88. *Most culvert maintenance involves cleaning the inlet of sediment or woody debris. This trash rack, built over the culvert inlet, was nearly plugged during a normal winter storm. Without storm maintenance inspections such minor culvert plugging often ends up causing severe gully erosion when the stream/low is diverted out of its channel, or it flows over and erodes the stream crossing/ill.*

All road grading should take material away from the bridge, and loose spoil should be kept away from the stream. If the approaches are persistently muddy during wet conditions, and cause trucks to bring dirt onto the bridge decking, then *the* approaches should be rock surfaced or paved.

F. Maintaining cuts and fills

The key to maintaining cut and fillslopes, including sidecast materials, is to observe and note when and how changes to these features occur. Corrective measures can then be implemented, depending on the problem.

Typical cutslope problems include excessive ravelling, rilling, and slumping which may block the ditch or require frequent ditch cleaning and maintenance. In the long term, it may be necessary to flatten the cutslope, revegetate bare soil areas, widen the ditch (so that it does not plug so easily), install ravel barriers on the slope and at the base, and/or build a retaining structure to contain or prevent slope movement. Often, simply loading the toe of a small cutbank slump with heavy riprap can provide sufficient weight to stabilize the feature. Stabilizing or controlling the movement of larger unstable areas may require analysis by an engineer or engineering geologist

Instability in fillslopes and sidecast materials often shows up on the surface or edge of the road as tension cracks and small scarps along the boundary of the unstable materials. The outside perimeter of landings build using sidecast methods commonly show such developing instabilities. Some settling of newly placed sidecast can be expected, but if movement persists and scarps continue to develop, the unstable materials should be excavated and removed, including organic debris, ***before*** they fail. If the potential instability is perched above a stream channel immediate treatment is usually required (Figure 89).

Figure 89a. *Unstable fill along the outside edge of active roads can often be excavated and removed without impeding normal traffic. In photo "a," 12 inch scarps bound unstable fill that threatens to fail on steep slopes above a perennial* ***stream.***

Figure *89b. In photo "V" an excavator was used to remove the unstable fill so it could be endhauled to a stable storage location. The road was still sufficiently wide for vehicle traffic after the erosion-proofing work was completed.*

Regular inspection and prevention (including excavation) is the key to maintaining stable fillslopes and sidecast areas. Local slides and slumps in the road bed often occur where material was placed or pushed over groundwater springs or seeps, where the road crosses steep swales, or where rotting roots, stumps or organic debris have been buried. These areas should be closely monitored and require fast action if cracks or scarps develop. Improved drainage (e.g., extra ditches), excavation of unsuitable soils or buried materials, or retaining walls may be needed. Left untreated, these unstable features can fail suddenly and develop into debris flows and landslides that deliver large amounts of sediment directly to downslope stream channels.

G. Winterizing roads

Before winter, all permanent, seasonal and temporary roads should be inspected and prepared for the coming rains. Winterizing consists of maintenance and erosion control work needed to drain the road surface, to ensure free flowing ditches and drains, and to open all culverts to their maximum capacity. On unsurfaced roads, waterbars may be required at spacings dictated by the road gradient and the credibility of the soil (Table 3). Trash barriers, culvert inlet basins and pipe inlets should all be cleaned of floatable debris and sediment accumulations. Ditches that are partially or entirely plugged with soil and debris should be cleaned and heavy concentrations of vegetation which impede ditch flow should be trimmed. This is also the best dme to excavate all unstable or potentially unstable fills and sidecast which could fail and be delivered to a watercourse during the coming winter. Once seasonal and temporary roads have been winterized, they should be gated and closed to "non-essential" traffic.

H. Spoil disposal

If excavations, grading and culvert basin cleaning and maintenance produces excess material, it should be stored locally or hauled away. Spoil may be feathered over the road, but on permanent roads, excess fine material may produce unwanted muddy conditions after the first rain. Spoil material should be hauled to a stable site safely distant from streams, contoured to disperse runoff and stabilized with mulch and vegetation. Excess spoil from maintenance activities should never be sidecast near streams. Berms of excess spoil along the road shoulder should be removed or frequently breached prior to the rainy season.

Notes:

CHAPTER IX: CLOSURE AND ABANDONMENT

A. Introduction to road closure and abandonment

There are many reasons for closing or proactively "abandoning" a forest or ranch road, most of which involve excessive maintenance costs, lack of continued need or continuing water quality problems (Table 25). Not all roads need to be part of the permanent or seasonal road system. For example, temporary roads are used once, and then "put-to-bed" until they are needed again. In addition to newly built temporary roads, there are many miles of existing roads that may no longer be needed, and older abandoned roads that are now overgrown. The same techniques can be used to "erosion-proof these older roads to prevent future erosion and sediment yield, and, as an added benefit or incentive, save the work and expense of continued maintenance.

Table 25. Conditions commonly leading to road closure
1. Roads constructed for temporary access (designated temporary roads)
2. Spur roads which are no longer needed for management for the next few years or for many years (e.g., all timber has been cut)
3. Roads with excessively high maintenance costs
4. Roads which have persistent erosion and water quality problems, often located in areas of extremely credible soils
5. Roads crossing extremely steep slopes or inner gorge locations where landsliding risk is high and sediment could enter stream channels
6. Roads crossing slopes with high or extreme landslide risk or on-going landslide activity caused by incompetent bedrock or unstable soils
7. Roads exhibiting potential for large fillslope or cutbank failures, often showing tension cracks and scarps in the roadbed
8. Roads built with excessive sidecast or fill in unstable locations or perched above stream channels
9. Old roads built in, along or immediately adjacent stream channels or up narrow stream channel valleys
10. Old, abandoned roads which have overgrown with vegetation and now have washed-out stream crossings and/or fill failures

Roads may be divided into four activity classes:

Active roads are part of the overall road network that *must* be actively inspected and maintained. These maintenance methods have already been described above.

Inactive roads are those needed only infrequently, for fire control, tree thinning or other intermittent forest or ranch activities. These roads remain largely unused for most of the year, or for several years in succession. There is a tendency to not maintain these routes because they are not often used, have low traffic volumes, and may only be used intermittently for administrative purposes. However, **all drainage structures on inactive roads must still be inspected and maintained because they are just as likely to plug and fail as those on more actively travelled routes.**

Temporary roads are constructed or reconstructed for a single entry access to an area, such as for harvesting an isolated stand of timber. These temporary roads are "put-to-bed" following their use, with stream crossings being removed using the techniques described in Chapter VI. Forest practice regulations for state and private lands currently require such preventive practices to stabilize temporary roads when they are closed.

Abandoned roads were previously a part of the active road network, but are no longer used. Many are now overgrown. There are thousands of miles of these abandoned roads on private forest and ranch lands in the state. They may have been abandoned because they were no longer needed, or because they cross unstable areas, require excessive maintenance or cause persistent environmental damage. Most have drainage structures which are in disrepair and are no longer being maintained. **These abandoned roads represent one of the greatest future threats of non-point source pollution from roaded, managed wildland watersheds. Landowners and resource managers should work aggressively to inventory and proactively treat these potential sources of erosion and sedimentation.**

Good land stewardship requires that all roads designated as part of a drivable road network be regularly inspected and maintained to protect water quality, regardless of how frequently they are used. Inactive and temporary roads that contain culverted stream crossings and other drainage structures *require* inspection and maintenance, and they should not be abandoned without first employing proper road closure techniques.

Any road that is not regularly inspected and maintained should be "put-to-bed" so they will not have the potential to impact streams and water quality. Roads should never be abandoned by simply blocking them off or letting vegetation take over without first "erosion-proofing" drainage structures and performing proactive erosion control work along the road alignment.

B. Techniques for road closure

It is no longer enough to close roads by simply closing a gate or blocking a road, because these actions will not prevent future road failure and future water quality problems (Figure 90). Specific techniques, described below, are available to successfully prevent road- and landing-related debris flows, to prevent or correct stream diversions (the leading cause of serious gullying in many areas), to prevent stream crossing washouts and fill failures, to dewater gullies and landslides fed

by road runoff, and to control surface erosion (rilling and ravelling) from abandoned road surfaces and fillslopes.

Figure 90. *Gating a road closes it to unauthorized traffic, but does nothing to protect the road from erosion. Scarps in the road fill behind this gate signal a slope failure that threatens to deliver sediment to an adjacent fish-bearing stream.*

Closing a road does not imply that every foot of the road needs intensive treatment to prevent future erosion. **Rather, the goal of proactive road closure is to aggressively treat only those segments of road which have a potential to generate erosion and to yield sediment to stream channels.** Segments of road which pose no risk of sediment delivery can be left intact and receive only minimal road drainage improvements. When the road is again needed to provide access to the area, it can be reconstructed with minimal effort.

Planned, systematic road closure can be an inexpensive and effective technique for minimizing long-term resource damage caused by roads built in steep areas and can prevent large scale damage to road alignments that require costly repairs if the road is to be reopened for future use. It also provides land managers with an opportunity to permanently prevent or control the majority of post-construction road-related erosion and its associated on-site and downstream impacts. In addition, implementing technically sound road closure practices also minimizes structural damage to widespread, expensive forest and ranch land road networks that cannot be economically maintained for the long time period between harvest rotations or other land uses.

There is little difference between treatments that are meant to permanently close a road and those designed for temporary closure. When a temporary road is built, or when a permanent or seasonal road is to be closed and taken off the active road network, erosion prevention work should be performed so that continued maintenance is not necessary. All closed roads should be "erosion-proofed" by excavating stream crossings and removing culverts, excavating unstable road and landing fills, treating the ditch and road surface to disperse runoff and prevent surface erosion, and planting bare soil areas.

The goal of road closure is to leave the road so that little or no maintenance is required for stability while the road is unused. Heavy equipment used for road closure typically includes a hydraulic excavator (a standard backhoe is too small and generally not versatile enough to

effectively perform road closure tasks), a bulldozer (D6 to D7 size, with hydraulic rippers for decompacting rocked roads) and dump trucks (when needed for endhauling spoil and debris to stable storage sites).

Typical road closure treatments are described below.

1. Stream crossing excavations

All stream crossings on temporary or abandoned seasonal and permanent roads need to be completely removed *before* the first winter period following their installation or closure (if not, they should be capable of passing the 50-year flood flow for that channel).

Removing a stream crossing involves excavating and removing all materials placed in the stream channel when the crossing was built. Fill material should be excavated to recreate the original channel grade (slope) and orientation, with a channel bed that is as wide or ***slightly wider*** than the original watercourse (Figure 91). If the channel sideslopes were disturbed, they should be graded ("pulled" or excavated) back to a stable angle (generally less than 50%) to prevent slumping and soil movement. The bare soils should then be mulched, seeded and/or armored to minimize erosion until vegetation can protect the surface, and the approaching road segments should be cross-road drained to prevent road runoff from discharging across the freshly excavated channel sideslopes.

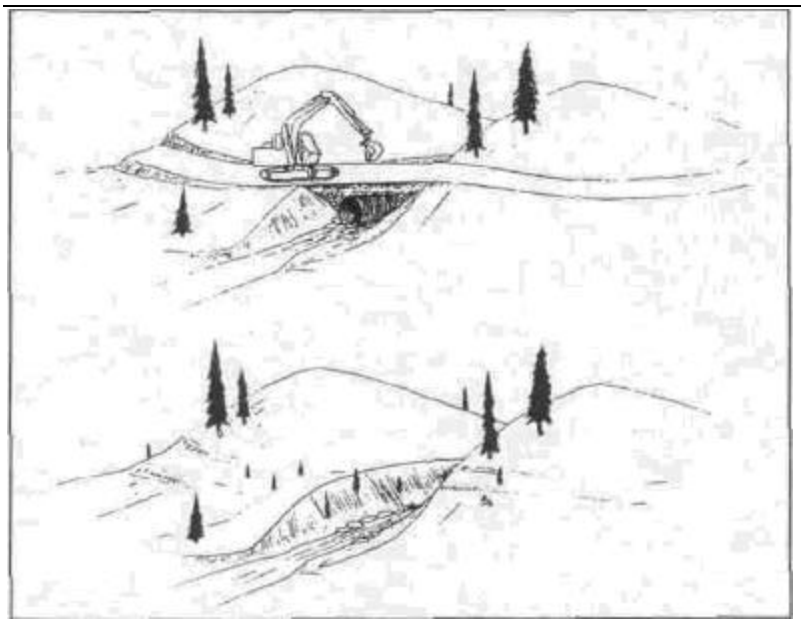


Figure 91. *On roads that are* ***to be*** *closed, all stream crossing culverts and fills should be removed. Stream crossing excavations are best performed using an excavator. Spoil can usually be stored on the road bench adjacent the crossing provided it is placed and stabilized where it will not erode and enter the channel (Furbniss, et.al.,1991).*

Procedures for removing crossings on abandoned, permanent or seasonal roads are similar to those used on temporary roads. Both culverted and unculverted stream crossings (e.g., culverts and Humboldt log crossings) should be completely excavated or removed so that no soil materials are left in or next to the channel following road closure. **It is not enough to simply excavate and remove the culvert; the entire fill must also be excavated.** As with temporary stream crossings, the excavation should extend down to the level of the original channel bed, with a channel as wide or wider than the original channel. Channel sideslopes should be sloped back to a stable angle and spoil material removed to a stable storage site. Erosion control measures, such as seeding, planting and mulching, should be applied to prevent subsequent surface erosion (Figure 92).

Figure 92a. *Stream crossing on a temporary road before (a) and after (b) it was excavated and the road was closed (person is standing over the axis of the stream channel}. Since the road bed is still intact everywhere but at the stream crossings, it can be reopened by simply reinstalling the culverts. In the meantime, no road maintenance is required.*

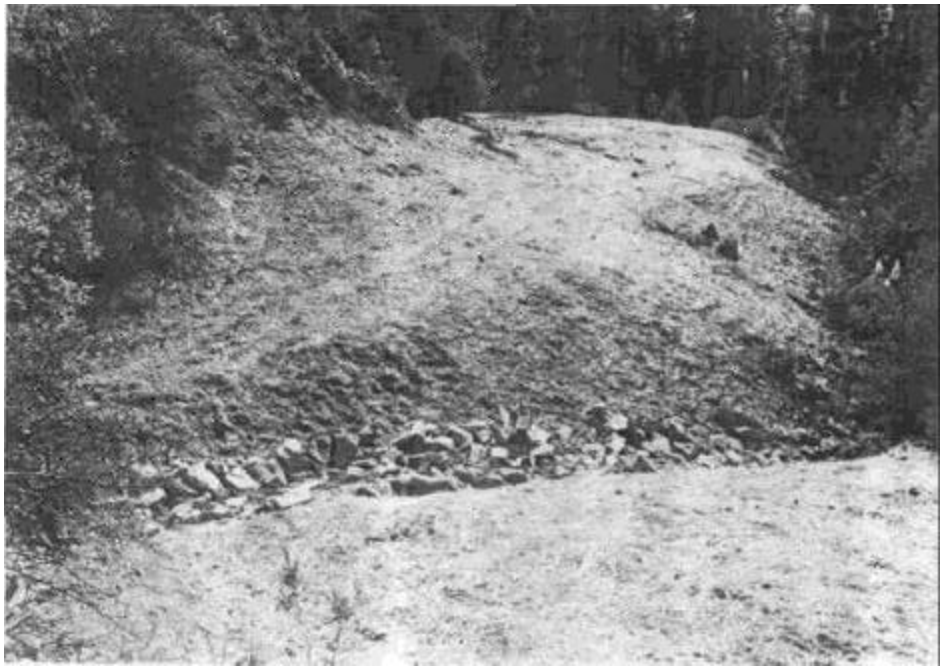


Figure 92b.

2. Treatment of unstable areas

Any unstable or potentially unstable road or landing fills (or sidecast) should be excavated and stabilized so material does not fail and enter a watercourse or destroy down-slope vegetation. Such areas include sidecast and fill materials which show recently developed scarps or cracks (Figure 93). These sites occur most often 1) around the perimeter of landings, 2) on sidecast constructed roads built on steep slopes, 3) where roads have been built on steep slopes over springs or seeps, or 4) where roads have been cut into steep headwater swales or "dips" in the hillside. Cribbed fills which were installed at unstable areas during road construction or reconstruction should also be removed and outsloped if they could fail into a downslope stream channel.

Figure 93a. *Excavation of unstable landing fill on a road scheduled for permanent closure: (a) before excavation.*

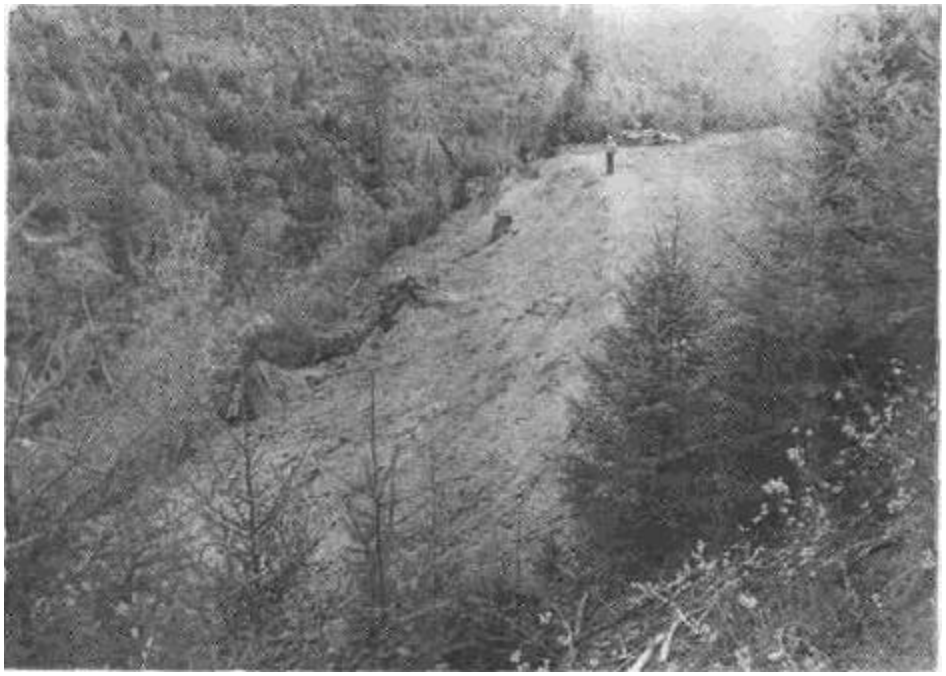


Figure 93b. *(b) after excavation.*

Potentially unstable road material that is likely to enter a Class I, II, or III watercourse or damage reproduction or other sensitive resources should be excavated and treated during road closure operations. All spoil material should be placed in a stable location and revegetated. Spoil disposal sites include the cut portion of closed roads and the inside portion of landings and turnouts.

Cutbank failure materials are often completely caught and stored on the adjacent road prism. For this reason, cutbank instabilities often do not need the same amount of "erosion-proofing" and stabilizing as is needed on fillslopes and stream crossings. Some buttressing, revegetation and upslope drainage control may be required to prevent larger failures and erosion that could affect

water quality. No active ditches or diversions should be left at the base of an unstable or ravelling cutbank on a closed road. In fact, ditches should not be left open and functioning when a road is closed because all ditches are likely to eventually become plugged with sediment or vegetation and cause water to be diverted onto the road surface.

3. Road surface runoff and other drainage structures

Roads that are to be closed and unmaintained should have adequate, self-maintaining surface drainage so that the road surface is stable and will not erode and deliver sediment to a stream.

Most temporary roads should have been built as outsloped roads, and any ditched segments of roads to be closed should be outsloped or drained with cross road ditches during closure operations. Outside road berms should be removed to encourage continuous drainage off the road surface.

Inside road ditches should be eliminated when closing temporary and abandoned roads so that water is not diverted and gullies do not form. Drains should be made deeper than standard waterbars and extend all the way from the cutbank to the outside edge of the road in order to intercept all ditch flow. On steep sections of road (>10%) cross drains should be skewed at 45% to the road alignment (instead of the usual 30%) to reduce the threat of erosion at the inlet (Figure 94). Since inside ditches will be breached and no longer carry runoff, ditch relief culverts are no longer needed on closed roads and can be either removed and salvaged or left in-place.

Cross-road drains should be placed frequently enough such that flow through individual drains will not require the use of rock armor energy dissipators to prevent erosion at the outlet. However, cross drains that carry spring flow or flow from small upslope gullies may require armoring at their outlet and should be discharged into vegetation to filter water and sediment before runoff reaches a stream.

Figure 94. *Insloped and ditched roads, especially those with springs and seeps on the cutbanks, should have cross road drains constructed to provide drainage across the alignment. Drains can be installed at wet areas along the cutbank, or at intervals frequent enough to prevent gullying of the roadbed between drains.*

Ripping and planting abandoned roads can reduce runoff and erosion, and greatly increase the amount of forest and ranch land in production. Ideally, the abandoned road surface should be scarified (ripped to a depth of 15-24 inches), outsloped at least 4% more than the road grade, waterbarred, seeded and planted to control surface runoff and erosion (Figure 95). Wet, spring-fed cutbanks along outsloped roads should not be covered with spoil, and roads that are not outsloped should have frequent cross-road drains installed. Tree growth on compacted or rocked road surfaces is generally much slower that on adjacent, uncompacted sites unless the roadbed is mechanically ripped. Ripping is most effective in breaking compaction and promoting tree growth when it is conducted with a winged subsoiler that lifts and shatters the soil. Ripping can also be performed using hydraulically operated chisel teeth mounted on the back of a large tractor, although several passes may be required to disaggregate the entire roadbed.

Figure 95a. *On forest roads which are to be formally closed, rather than just "abandoned," the roadbed can be returned to forest production by ripping and disaggregating the surface and then planting with trees. Photos "a" and "b" show a road/landing before and after decompaction. This simple, inexpensive process also helps reduce runoff from compacted areas.*

Figure 95b. *"After.'*

4. Erosion control

Most erosion control work along closed roads is accomplished by 1) the physical excavation of stream crossings, unstable fills and landing sidecast, 2) installation of cross-road drains, 3) road ripping, and 4) local road outsloping. These techniques are usually performed by heavy equipment. Other hand-labor erosion control and revegetation practices that may be of use include mulching, installation of energy dissipation (e.g., rock armoring and woody debris), seeding and planting.

The banks of all excavated stream crossings, as well as all bare soil areas immediately adjacent a watercourse, should be mulched with straw (3,000 to 5,000 Ibs/acre) or another mulching product. On slopes over about 45%, or where high winds are common, mulches will need to be tacked, punched or secured to the ground surface to hold them in-place and against the ground. Straw can be punched into loose soil using shovels, crimpers or a spiked roller, or held onto the surface using a netting or a "tacking" spray. Mulches can also be purchased in rolls, in which the mulch is bound between fine plastic netting, which can then be rolled out and secured or "stapled" to the ground.

If rock armor materials are plentiful, the channel-bottom of excavated stream crossings can be armored with well graded rock to minimize subsequent channel downcutting or widening. However, rock armor should not be necessary for erosion control *if* all fill material is removed from the crossing and the original channel profile and sideslope configuration are reconstructed by excavation. If the natural channel armor was not removed during initial culvert installation, it should be sufficient to protect the channel from downcutting.

Rock and/or woody debris can be placed at the outlets to cross-road drains that are expected to carry substantial spring-flow. Rock armor is generally preferable because it is more permanent and adjusts its position when there is minor channel downcutting.

5. Revegetation

Vegetation is the ultimate, long-term erosion control agent. However, because it takes time to grow a thick, effective cover, some physical erosion control measures (such as straw mulch or "silt fences") are often needed for the first year or two following road construction or closure. Seeding with grass and legumes reduces surface erosion and can improve soil physical condition. Planting trees and shrubs adds longer lasting vegetative cover and provides stronger root systems which enhances slope stability. Within their appropriate range, conifers, hardwoods and other tree species provide for long term land stability and erosion control.

Seeding with grass and other fast growing species can be used to protect slopes from raindrop and rill erosion, if it is planted and grows to provide a thick cover before the first fall rains. Planting is best conducted immediately after the surface is disturbed. The rough surface provides miniature traps for seeds, fertilizer and rain water, creating a favorable environment for seed germination and growth. Mulches increase seedling establishment by improving germinating conditions and controlling erosion until the plants become established.

The two basic methods for spreading seed are dry seeding and hydraulic seeding. Each method is suited for specific ground conditions (Table 26). Dry seeding and fertilizing along small roads is often done with cyclone-type rotary seeders. This method is usually done by hand for road-related applications, but may also be performed by truck and aerial application for larger jobs. Hand

seeders are typically restricted to moderate or gentle slopes and can shoot seed and fertilizer from 15 to 20 feet. Drilling seed into the planting bed ensures an even distribution, but may not be possible due to the steepness of many road cuts and fills. In hydraulic seeding (hydro-seeding), seed, mulch (or binder) and fertilizer is applied in a water-based slurry from a pump truck or portable trailer. Hydroseeding may be necessary for planting 1:1 or steeper slopes, where the seed must be "tacked" to the slope because of high ravel or erosion rates.

Table 26. Guidelines for seeding method selection[1]

Site conditions	Sample situations	Seeding method
Steep (>50%) or windy slopes, high to extreme erosion hazard	steep cutbanks and fillslopes	hydraulic seeding with a sprayed or tacked mulch
Moderate (30-50%) and steep slopes, medium to high erosion hazard	moderate and steep cutbanks and fillslopes; stream crossing fills and bridge sites	hydraulic seeding or dry seeding with a mulch
Gentle and moderate slopes, medium to high erosion hazard	cutbanks, fillslopes and spoil disposal sites not near a watercourse	hydraulic seeding or dry seeding; mulch where needed
Gentle and moderate slopes, low to moderate erosion hazard	cutbanks, fillslopes and spoil disposal sites not near a watercourse	dry seeding; mulch if needed to improve revegetation

[1] *Modified from B.C.M.F., 1991*

Regardless of the method selected, seed must be evenly distributed to result in a continuous plant cover. Seeding onto a roughened soil surface or thinly covering the seed with soil ensures good germination. In dry climates or in soils with poor water holding capacities, broadcast seeding may yield poor results unless the seeds are covered.

Severely disturbed sub-soils and cutbank exposures are usually infertile, and fertilizer applications containing nitrogen (N), phosphorous (P), potassium (K), and occasionally sulphur (S) may be needed for successful grass-legume establishment and growth. Fertilization rates vary according to the level of nutrients needed for establishment Soils can be tested for nutrient content before fertilizer mixes are prepared. More often, commercial mixes are used which provide all the necessary nutrients for plant growth.

Parent materials and subsoils are always deficient in nitrogen. A common recommendation is to broadcast ammonium phosphate sulfate fertilizer (16-20-0) at the rate of 500 Ibs/acre at planting time. This provides sufficient nutrients for the first growing season. Critical sites (e.g., stream crossings) may need to be refertilized after 3 to 5 years to maintain plant vigor and an adequate ground cover. Planting legumes in infertile soils is often suggested because they are able to grow without nitrogen fertilizer. Before seeding, legume seeds require inoculation with a nitrogen fixing bacteria which then grows on its roots.

Typically, a combination of 2 to 5 species, including sod forming grasses, bunch grasses and legumes, is used for erosion control. Legumes are included for their deeper roots and nitrogen

fixing capability. Seed mixes suitable for an area depend on the soil and climatic conditions of the site. Seeding rate depends on the desired species mix, seed weight and viability of the seed stock.

The *California interagency seeding guide for erosion control plantings (1986)* is a short publication which describes general seed mixes which have been found to be useful for erosion control within the mediterranean climate of California (Table 27). It describes seeding rates and environmental requirements for a number of proven perennial and annual grasses, annual clovers and vetch, one shrub and several flower species, and outlines the steps to successful plantings.

The most important considerations in seeding are timing of application, even distribution of seed and covering the seed with soil. Planting at the wrong time is the most common reason for seeding failure. Seeding must be done early enough in the growing season so that an adequate ground cover can become established before the critical winter period. Seed application should begin immediately following heavy equipment operations and soil disturbance, and a minimum of 6 weeks before periods of drought or damaging frost. Fall seeding is best in areas with summer drought.

Planting and seeding for erosion control requires the development of a rapid, persistent and continuous plant cover. Annual grasses often produce the quickest protection, but are only a temporary solution and can sometimes actually impede the growth of other plants. Perennial grasses are slower to establish but provide better root systems than annuals. Perennials may also have difficulty competing and surviving when seeded with annual grasses in the same mix. Annual legumes provide nitrogen to the soil as they grow, but they too are relatively slow to grow and may not compete well with heavily seeded annual grasses. Shrubs and trees are slow to provide a ground cover, and may not compete well when seeded with other species, but they often provide the best long term stability to a disturbed road site. Native shrubs and trees will seed naturally to many disturbed sites in forested areas. Planting or transplanting can be used to speed their return.

Utilizing a mix of seeds increases the likelihood that one of the plant species will find local conditions favorable and produce a good plant cover. If a commercial seed mix is used, it is important that plants known to be effective in erosion control be found in the mix, that the species are adapted to grow in the local environment, and that the species are compatible in mixtures (i.e., that one doesn't out-compete the other). In general, seed mixes should be kept simple. The grass-legume ratio, by live pure seed, should be about 70:30 in humid regions and 80:20 in dry regions. It is a good idea to consult your local Soil Conservation Service office or Resource Conservation District for seeding recommendations for your specific area and need.

Following seeding, all bare soils on newly constructed, reconstructed and closed roads should be planted with trees and/or other woody vegetation. In addition, the slopes and channel banks adjacent to excavated stream crossings can be planted with willow, alder or other riparian tree species (Table 28) and shrub species (Table 29) compatible with the local site conditions. These woody species take longer to become established, but they provide the long-term ground cover and soil binding needed for effective erosion prevention, soil development and slope stability on these heavily disturbed sites.

Table 27. Species, growth characteristics and minimum seeding rates of plants know to be effective in controlling erosion on California forest and ranch lands[1]

Species	Characteristics	Planting	LBS/Acre pure live seed[2]		Minimum annual rainfall (in)	Growth rate/ longevity
			Good seedbed[3]	Poor seedbed[4]		
Annual Grasses (usually fast growing, adaptable and competitive)						
Annual or Wimmera-62 ryegrass	fast, winter growing, short-lived grass, requires fertilization to persist, very competitive (to the detriment of other seeded plants)	never plant with perennial grasses, legumes or flowers; should be less than 50% of any annual grass mix	22	50	12	fast, short-lived
Barley	winter grain, grows fast and tall,	may be seeded at 100 Ibs/acre without being overly competitive	150	200	12	fast, temporary
Blando brome	winter growing, self seeding grass, very adaptable to various climates	use in any proportion with annual grasses, keep to less than 70% when planted with legumes; should not be planted with flowers or perennial grasses	15	50	12	fast, reseeds
Panoche red brome	winter active, self-seeding grass, common in low rainfall areas; very drought tolerant	best if planted alone in droughty areas; in wetter areas may be used as 25% mix with legumes, flowers or shrubs	10	20	7	fast, reseeds
Zorro annual fescue	winter growing, early maturing, self seeding grass; very drought tolerant; good in low-fertility, acid soils	is compatible with perennial native grasses and shrubs, can comprise 70% of mix with annual legumes and 25% of mix with flowers, legumes and shrubs	10	20	10	fast, reseeds

Table 27. (continued)						
Species	**Characteristics**	**Planting**	**LBS/Acre pure live seed[2]**		**Minimum annual rainfall (in)**	**Growth rate/ longevity**
			Good seedbed[3]	**Poor seedbed[4]**		
Perennial Grasses (usually restricted to sites requiring deep rooting and/or minimum maintenance; are slow growing in the first year and do not compete well with most annual grasses; flowers or annual grasses may constitute up to 50% of a mix with perennial grasses)						
Berber orchardgrass	long lived, drought tolerant bunch grass; good for dryland areas	Palestine orchardgrass may be substituted as second choice, but no others will survive without irrigation	10	20	16	medium
Luna pubescent wheatgrass	long lived, fast maturing, sod forming, winter active grass	often used on deeper soils such as fillslopes, including serpentine soils	20	40	16	slow
Mission veldtgrass	long lived, densely tufed bunchgrass	outstanding in coastal sandy soils	30	40	14	slow
Smilo	long lived, drought tolerant bunchgrass	best on well drained soils that once grew chamise in brushlands; best stands obtained after fire	10	20	16	slow
Annual clovers and vetch Annual clovers are used because of their ability to provide their own nitrogen. This make them suitable for low fertility areas that would otherwise need fertilizer. The seed should be inoculated with nitrogen fixing bacteria prior to planting. May be seeded alone or in mixes.						
Rose clover	self seeding legume	used of slightly acid soils	20	30	10	medium, reseeds
Lana wollypod vetch	widely adapted, self seeding legume	useful for providing wildlife food and habitat, alternates should be used in fire hazard areas	45	60	14	medium, reseeds

Table 27. (Continued)						
Species	**Characteristics**	**Planting**	**LBS/Acre pure live seed[2]**		**Minimum annual rainfall (in)**	**Growth rate/ longevity**
			Good seedbed[3]	**Poor seedbed[4]**		
Shrubs Most shrubs must be transplanted from cans or liners; these may be directly seeded.						
Australian saltbush	low growing, semi-prostrate perennial; plant is drought and alkali tolerant	—	15	20	10	slow
Duro California buckwheat	widely adapted and drought tolerant	used extensively in road side seeding, is adapted to much of the state	10	20	10	slow
Flowers Flowers are useful for short duration cover on sites with low erosion potential; seldom persist for more than 1-2 years; do not plant with annual grasses and do not fertilize with nitrogen. Poppies and lupine have the record for persisting the longest of most flowers.						
California poppies	can be planted on most weed-free soils; will not compete with grasses or weeds	—	5	20	10	slow
Lupine	adapted to a variety of soils; lupine should be inoculated with bacteria before seeding	several varieties *of Lupinus* may be planted	5	20	10	slow

[1] *from California Interagency Seeding Guide for Erosion Control Plantings. Plants are known to control erosion in the mediterranean climate of California. Specific soils and rainfall may limit the use of each species. Suggested seeding rates are minimum; consider increasing rates as difficulty of site and climate increase.*

[2] "pure-live seed" = % germination x % purity divided by 100.

[3] "Good seedbed" = seed covered with soil, slopes 3:1 or flatter, straw secured to slope surface at 1.5 to 2 tons/acre.

[4] "Poor seedbed" = poor soil, steep slopes, no seed coverage (no mulch). May be hydroseeded.

Table 28. Recommended tree species for revegetating riparian zones[1]			
Riparian species (common name)	**Coastal**	**Interior valley**	**Interior foothill**
California buckeye		X	X
Bigleaf maple	X	X	
California box elder		X	
White alder	X		X
Red alder	X		
California black walnut		X	X
Western sycamore	X	X	X
Fremont cottonwood	X	X	X
Coastal live oak	X	X	
California black oak			X
Valley oak		X	
Interior live oak		X	X
Red willow	X	X	X
Black willow	X	X	X
Sandbar willow	X	X	X
Oregon ash	X	X	X
California bay	X		
Dogwood	X	X	X
Wax myrtle	X		

[1] *From C.D. F.G.. (1992) When selecting species/or a revegetatlon project, those species found in similar environmental conditions near to the project site should be preferred.*

Table 29. Recommended shrub species revegetation for riparian zones [1]			
Riparian species (common name)	**Coastal**	**Interior Valley**	**Interior Foothill**
Elderberry	X	X	X
Brewers saltbush	X	X	
Coyote brush	X	X	X
Mule fat	X	X	
Ceanothus spp.	X	X	X
Western redbud	X		X
Mountain mahogany			X
Button bush	X	X	
California buckwheat	X	X	X
Toyon		X	X
California coffeeberry		X	X
Red flowering current			X
California wild rose		X	X
California blackberry		X	X
Black sage			X
Squaw bush		X	X
Prunusspp.	X	X	X
Rims spp.	X	X	X

From C.D.F.G. (1992) When selecting species for a revegetation project, those species found in similar environmental conditions near to the project site should be preferred.

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GLOSSARY

Terms

Abandoned road - a road which is no longer maintained. An abandoned road may or may not still be driveable and may or may not be overgrown with vegetation (see also *road abandonment)*.

Abney level - a hand-held instrument used to measure slopes and vertical angles in the field.

Abutment (bridge) - a solid foundation on each stream bank on which the ends of a bridge are secured. Naturally occurring rock outcrops may serve as abutments, but most commonly abutments are made of cement sills, logs or piers installed by man.

Accelerated erosion - erosion which has been caused directly or indirectly by human activities or land management. Accelerated erosion is typically thought of as erosion which is not "natural" or that which is excess of that which would have naturally occurred.

Active road - a road that is pan of the overall road network that needs to be actively inspected and maintained.

Altimeter - a hand-held instrument which can be used to determine elevation or altitude in the field.

Anadromous fish - fish that are born and rear in freshwater, move to the ocean to grow and mature, and return to freshwater to reproduce. Salmon, steelhead and shad are examples.

Angle of repose - the steepest slope angle at which a material will freely stand without failing or sliding downslope. The angle of repose of material without cohesion, like loose sand, is about 33 degrees. For material with some cohesion, the comparable term is called the angle of internal friction. Slopes which are steeper than the angle of repose or angle of internal friction are likely to be unstable.

Archaeological site - a geographic locale that contains the material remains of prehistoric and/or historic human activity.

Aspect - The direction a slope faces with respect to the cardinal compass points.

Backcasting - a road construction technique which utilizes a hydraulic excavator to cut a wide bench in front of the machine and below the centerline of the new road, while placing the excavated soil on the bench behind as the new subgrade.

Balanced benching - a road building method used on gentle or moderate sloping land in which material excavated during road construction is used to build the roadbed and fill the low spots along the alignment. In balanced benching, the cut volumes equal the fill volumes and the road is often referred to as a "half-bench" road.

Bearing surface - the driving surface of the road. Road rocking is a common method of increasing the load bearing capacity of the road surface if the subgrade soils are relatively weak.

Bench - a naturally occurring bench refers to a relatively flat or low gradient portion of a hillside. A constructed bench is a step or flat area cut into a deep soil or bedrock in an attempt to create a more stable road bed.

Beneficial use-In water use law, reasonable use of water for a purpose consistent with the laws and best interest of the people of the state. Such uses include, but are not limited to, the following: instream, out of stream, and ground water uses, domestic, municipal, industrial water supply, mining, irrigation, livestock watering, fish and aquatic life, wildlife, fishing, water contact recreation, aesthetics and scenic attraction, hydropower and commercial navigation.

Berm - A curb or dike constructed to control water and prevent roadway runoff waters from discharging onto roadside slopes and/or to provide material for subsequent road maintenance.

Bottom-up road construction - road construction techniques which involve excavating a bench on the hillside and then filling and compacting fill on the bench to build up a stable roadbed at the desired elevation (as opposed to sidecasting or top-down construction).

Borrow site - locations on the landscape where sand, gravel and/or rock is excavated for use in road construction activities elsewhere in the watershed. Borrow pits and rock quarries on California wildlands may be subject to the new Surface Mining and Reclamation Act (SMARA) which requires landowners to develop site reclamation plans for many such sites (see also *rock pit)*.

Box culvert (open top) • a open-top trough-like drainage structure, usually constructed of lumber, built into and obliquely across the road surface. It acts to collect and discharge road surface runoff and, less often, ditch flow across the road. Open-top box culverts are more commonly used on ranch roads than on forest roads used for logging operations.

Buffer strip - an area or strip of land adjacent a stream containing relatively undisturbed vegetation that acts as a filter or buffer for erosion and runoff from upslope roads or other land management activities.

Center stake method - a method of curve layout, especially for switchbacks, in which a stake is used to mark the center of the curve and radial measurements are taken out from the stake to mark the curve on the ground.

Check dam (straw bale) - a temporary structure used to contain eroded soil from leaving a construction site. Straw bale check dams are often used in swales and small channels below a new road alignment to collect and store sediment eroded from the work site. Straw bale check dams quickly decompose and will usually not provide sediment storage or protection for more than a single season.

Class I watercourse - for forestry purposes, those watercourses serving as domestic water supplies, including springs, onsite and/or within 100 feet downstream of the operations area, and/or those watercourses where fish are always or seasonally present onsite, including habitat to sustain fish migration and spawning.

Class II watercourse - for forestry purposes, those watercourses where fish are always or seasonally present offsite within 1000 feet downstream, and/or watercourses which contain aquatic habitat for non-fish aquatic species. Class III watercourses that are tributary to Class I watercourses (hence within 1000 feet of a fish-bearing watercourse) are specifically excluded.

Class III watercourse - for forestry purposes, watercourses that have no aquatic life present, but still show evidence of being capable of sediment transport downstream to Class I or Class II watercourses under normal high water flow conditions after completion of timber operations.

Class IV watercourse - for forestry purposes, man-made watercourses, usually supplying downstream established domestic, agricultural, hydro-electric or other beneficial uses (see also *man-made watercourse)*.

Clearing - the act of removing the standing vegetation along a proposed road alignment. Clearing is one of the tasks of road construction, and is followed by grubbing and grading (earthmoving).

Clinometer - A pocket field instrument which measures slope steepness in degrees and percent.

Compaction - An increase in bulk density (weight per unit volume) and a decrease in soil porosity resulting from applied loads, vibration or pressure.

Control points - locations along a proposed road alignment that control the position of the road. Examples of control points include rock outcrops, the end of another road you must tie in to, a saddle on a ridge that you need the road to pass through, a favorable stream crossing location, a landslide that must be avoided, etc.

CMP - corrugated metal pipe, often used synonymously with culvert. Metal culverts are typically made from galvanized steel or aluminum.

Cross road drain - a deeply cut ditch, excavated across a road surface, which drains the road bed and inboard ditch. Cross-road drains are more substantial and deeper than conventional waterbars used to drain forest and ranch roads, and are steeper and more abrupt than rolling dips. Well constructed cross-road drains will often be deep enough to prevent vehicular access to an area and are typically installed on roads which are being closed permanently or for several years. Cross-road drains are typically constructed (excavated) using a tractor, an hydraulic excavator, or a backhoe.

Crowned - A crowned road surface is one which slopes gently away from the centerline of the road and drains to both sides of the crown. Crowning a road surface is one method of providing for surface drainage. The inside half of the road drains inward to the cutbank and ditch, while the outside half drains out across the fillslope.

Crushed rock - rock which has been run through a mechanical crusher to produce a more uniform range of particle sizes. Crushed rock is useful as a road surfacing material.

Culvert - a transverse drain, usually a metal pipe, set beneath the road surface which drains water from the inside of the road to the outside of the road. Culverts are used to drain ditches, springs and streams across the road alignment.

Curve layout - the technique or method of laying out a road curve on the ground before a road is constructed. Curves may be broad enough such that little or no layout is necessary. Switchbacks and sharp curves often require the use of surveying techniques to ensure the best, most functional design (see *center stake method).*

Cut-and-fill - a method of road construction in which a road is built by cutting into the hillside (usually using a bulldozer) and spreading the spoil materials in low spots and as sidecast along the route. "Cut-and-fill" is often a synonym for "cut-and-sidecast" (see also *balanced benching* and *top-down road construction).*

Cutslope (cutbank) - the artificial face or slope cut into soils or rock along the inside of a road.

Debris flow - A rapidly moving mass of rock fragments, soil and mud, with more than half of the particles being larger than sand size. In contrast to debris slides, debris flows are usually saturated with water.

Debris slide - A slow to rapid slide, involving downslope translation of relatively dry and predominantly unconsolidated materials, with more than half of the particles being larger than sand size.

Debris torrent - Rapid movement of a large quantity of materials (wood and sediment) down a stream channel during storms or floods. This generally occurs in smaller, steep stream channels and results in scouring of streambed.

Decking - the traveling surface (usually wood planks) of small flatcar and log stringer bridges used on forest and ranch roads. Decking is usually bolted in place and can be replaced when it is worn out.

Decommission - to remove those elements of a road that unnaturally reroute hillslope drainage or present slope stability hazards (see also *road abandonment* and *road closure).*

Decompaction - see *ripping.*

Ditch relief culvert - A drainage structure or facility which will move water from an inside road ditch to an outside area, beyond the outer edge of the road fill.

Diversion potential (DP) - a stream crossing has a diversion potential if, when the culvert plugs, the stream would back up and flow down the road rather than directly over the fill crossing and back into the natural drainage channel.

Downspout - a flume or trough attached (bolted) to a culvert outlet and used to convey water from the culvert outlet down over and beyond the road fill so as to prevent erosion. Culverts that are placed at the base of the road fill discharge directly into the natural channel or hillslope and usually do not require a downspout.

Drainage basin - see *watershed.*

Drainage blanket - a layer of permeable fill (usually gravel or coarse aggregate) several feet thick installed beneath road fill to provide subsurface drainage. Drainage blankets are typically used to drain wet soils and seeps beneath cut-and-fill and backcast constructed roads. A well drained subgrade can support up to 50% more weight than poorly drained, well graded soils.

Drainage structure - A structure installed to control, divert or to cross over water, including but not limited to culverts, bridges, ditch drains, fords, waterbreaks, outsloping and rolling dips.

Drop inlet - a vertical riser on a culvert inlet, usually of the same diameter as the culvert, and often slotted to allow water to flow into the culvert as streamflow rises around the outside. Drop inlets are often used on stream or ditch relief culverts where sediment or debris would otherwise threaten to plug a traditional horizontal inlet.

Dry seeding - a method of spreading seed on the ground surface. Dry seeding can be accomplished by drilling (actually placing seed in the ground and covering it) or by broadcasting (where seed is aerially spread over the surface of the ground).

Earthflow - A mass-movement landform and slow-to-rapid mass movement process characterized by downslope translation of soil and weathered rock over a discrete shear zone at the base, with most of the particles being smaller than sand.

Easement (right-of-way agreement) - an agreement which defines the conditions under which one party may use a road or roads owned by someone else. An easement is usually longer lived than an agreement, which may apply to a limited period of use.

Emergency road maintenance - see *storm maintenance.*

Endhauling - the removal and transportation of excavated material to prevent sidecast, and the storage of the material in a stable location where it cannot enter stream channels. Endhauling is usually accomplished using dump trucks, but on larger jobs may be performed by mobile scrapers.

Energy dissipator - A device or material used to reduce the energy of flowing water. Energy dissipators are typically used at and below culvert outlets and other drainage structures to prevent erosion.

Environmental impact - The positive or negative effect of any action upon a given area or resource.

Ephemeral streams - Streams that contain running water only sporadically, such as during and following storm events.

Equipment limitation, equipment exclusion - The terms used when the use of heavy equipment is to be limited or prohibited, respectively, for the protection of water quality, the beneficial uses of water, and/or other wildland or forest resources.

Erodible soils - soils which are relatively prone to erosion by rain drop impact and surface runoff. Granular, noncohesive soils (such as soils derived sand dunes or from decomposed granite) are known to be especially erodible.

Erosion - the dislodgement of soil particles caused by wind, raindrop impact or by water flowing across the land surface. Erosion usually refers to processes of surface erosion (rain drop erosion, rilling, gullying and ravel) and not to mass soil movement (landsliding).

Erosion control - the act of controlling on-going erosion caused by rain drop impact, rilling, gullying, ravelling and other surface processes.

Erosion hazard rating (EHR) - a calculated measure of the susceptibility of soils to erosion by raindrop impact and surface runoff. According to the California Forest Practice Rules, EHR is calculated using a defined field methodology, and the resulting rating (low, moderate, high, extreme) influence subsequent land management practices which can be employed.

Erosion prevention - preventing erosion before it has occurred. Erosion prevention is typically less expensive and more effective than erosion control.

Erosion-proof - the act of performing erosion control and erosion prevention activities which will protect a road, including its drainage structures and fills, from serious erosion during a large storm and flood.

Excess material - see *spoil*.

Fail safe - a term used to describe a stream crossing that has no diversion potential.

Fail soft - a fail safe stream crossing where the dip or change in road grade occurs over the hinge line between the fill and the natural ground surface. With the road dip or low point in this location, overflow from a plugged culvert will likely result in the least possible amount of erosion. Roads which dip deeply as they cross a stream channel have smaller fills which can be eroded when culvert plugging occurs.

Favorable ground - terrain which is favorable for road construction, usually consisting of gentle and stable slopes
and ridges.

Fifty-year flood - the magnitude of peak flow which one would expect to be equaled or exceeded, on the average, once every 50 years. This flow should be estimated by empirical relationships between precipitation, watershed characteristics and runoff, and then may be modified by direct channel cross section measurements and other evidence.

Fillslope - that part of a road fill between the outside edge of the road and the base of the fill, where it meets the natural ground surface.

Fill - the material that is placed in low areas, compacted and built up to form the roadbed or landing surface.

Filter fabric (geotextile) - a synthetic fabric manufactured and designed for use in, among others, subsurface and surface drainage applications. Filter fabric is especially useful in maintaining a separation between coarse aggregate and finer native soil particles. It comes in a number of different types (with different specifications and uses) and is used in a number of different road building settings. Manufacturer's specifications should always be consulted before using a fabric for drainage or other engineering applications.

Filter strip - see *buffer*.

Filter windrow - a row of slash and woody debris laid and pressed down along the base of a road fill or sidecast slope to contain soil eroded from the fillslope. Filter windrows are often used to contain erosion from fillslopes and sidecast areas where a road approaches and crosses a stream channel.

Fish-bearing - a stream which supports fish during some part of the year.

Flared inlet - a culvert inlet which is flared or widened to increase its capacity and reduce the chance of inlet plugging and damage. Mitred inlets, usually made by cutting a normal culvert at an angle, are also used on ditch relief culverts to decrease inlet erosion and improve culvert efficiency. Flared inlets are attached to the normal culvert inlet using a band or bolts.

Flatcar bridge - a portable bridge constructed from a railroad flatcar. Single flatcar bridges can span channels up to about 80 feet wide.

Ford (wet) - a rock, concrete or other hardened structure built on the bed of a live stream which allows vehicle passage during low flow periods.

Ford (dry) - a rock, concrete or other hardened structure built on the bed of a swale, gully or usually dry stream which allows vehicle passage during periods or low or no flow.

French drain - a buried trench, filled with coarse aggregate, which acts to drain subsurface water from a wet area and discharge it in a safe and stable location. French drains are often lined with filter fabric to keep soil from plugging the drain.

Full bench road - road construction technique in which the bench cut width is the same as the road width, and no fill is used in construction. Endhauling is needed to remove the excavated spoil material.

Full fill road - road construction technique in which no bench cut is made into the hillslope and the road prism is made entirely from imported fill. The ground surface must still be prepared (grubbed and bared) for the fill to bind to the underlying substrate.

Geomorphic - pertaining to the form or shape of the earth's surface, and to those processes that affect and shape the land's surface. Geomorphic processes include all forms of soil erosion and mass soil movement, as well as other processes.

Geotextile - *see, filter fabric.*

Grade-break - the location of a reversal in the slope (grade) of the road from climbing to falling, or from falling to climbing.

Grading - the act of excavating and moving soil along the road alignment to an established grade-line during road construction or reconstruction. Grading is one of the tasks of road construction, and is preceded by grubbing and followed by surfacing. Grading also refers to the mechanical smoothing of the road bed to maintain a free-draining, smooth traveling surface.

Groundwater - The standing body of water beneath the surface of the ground, consisting largely of surface water that has seeped down into the earth.

Grubbing - the act of scarifying the surface of the ground along a proposed road alignment prior to placing fill or sidecast on top. Grubbing is one of the tasks of road construction, and is preceded by clearing and followed by
grading.

Gully (gullied) - an erosion channel formed by concentrated surface runoff which is generally larger than 1 ft^2 in cross sectional area (1' deep by 1' wide). Gullies often form where road surface or ditch runoff is directed onto unprotected slopes.

Habitat - the place where a plant or animal (including aquatic life and fish) naturally or normally lives and grows.

Headwater swale - the swale or dip in the natural topography that is upslope from a stream, at its headwaters. There may or may not be any evidence of overland or surface flow of water in the headwater swale.

Horizontal curve - The horizontal arc of a circle whose radius is that of the curve of the road.

Hydro-seeding (hydraulic seeding) - a technique for applying a slurry of seed, fertilizer and mulch by hydraulically spraying the mixture on the ground surface. Hydro-seeding is typically performed on slopes that are too steep for dry seeding.

Humboldt log crossing - see *log crossing.*

Inactive road - a road needed only infrequently, for fire control, tree thinning or other intermittent forest or ranch activities. These roads remain largely unused for most of the year, or for several years in succession, but have drainage structures intact and require regular inspection and maintenance.

Inboard ditch - the ditch on the inside of the road, usually at the foot of the cutback.

Infiltration - the movement of water through the soil surface into the soil.

Inner gorge - A stream reach bounded by steep valley walls that terminate upslope into a more gentle topography. Common in areas of rapid stream downcutting or uplift.

Insloped road - road surface that is sloped in toward the cutbank. Insloped roads usually have an inboard ditch that collects runoff from the road surface and cutbank.

Intermittent stream - Any nonpermanent flowing drainage feature having a definable channel and evidence of scour or deposition. Intermittent streams flow in response to rainfall, and then for some period after the cessation of rainfall (being fed by groundwater discharge).

Intervisible - the ability to see from one feature to the next. Turnouts which are intervisible can be seen from one another.

Landslide - The downslope movement of a mass of earth caused by gravity. Includes but is not limited to debris slides, torrents, rock falls, debris avalanches, and creep. It does not, however, include dry ravel or surface erosion by running water. It may be caused by natural erosional processes, by natural disturbances (e.g., earthquakes or fire events) or human disturbances (e.g., mining or road construction).

Landing - Any place on or adjacent to a logging site (usually on a road) where logs are collected and assembled for further transport.

Landing excavation - excavation and removal of unstable or potentially unstable soil and organic debris from the outer edge or perimeter of a log landing. Landing excavations are performed as a preventive measure to guard against landsliding of unstable material into downslope stream channels.

Log crossing - a drainage structure made out of logs laid in and parallel to a stream channel and then covered with soil. Before the mid-1980's log crossings were frequently used as "permanent stream crossings" instead of culverts or bridges. Log crossings are highly susceptible to plugging and washout during storm flows. Log crossings are used today only for temporary stream crossings that are to be removed prior to the winter period.

Logging road - a road other than a public road used by trucks going to and from landings to transport logs and other forest products.

Maintained road - A road which is regularly inspected and whose cutslopes, road surface, drainage structures and fillslopes are maintained to prevent erosion and deterioration.

Man-made watercourse - a watercourse which is constructed and maintained to facilitate man's use of water. They include but are not limited to ditches and canals used for domestic, hydropower, irrigation and other beneficial uses. According to forestry regulations, man-made watercourses technically do not include road-side drainage ditches.

Mass soil movement - downslope movement of a soil mass under the force of gravity. Often used synonymously with "landslide," common types of mass soil movement include rock falls, soil creep, slumps, earthflows, debris avalanches, debris slides and debris torrents (see also *landslide).*

Mulch - material placed or spread on the surface of the ground to protect it from raindrop, rill and gully erosion. Mulches include wood chips, rock, straw, wood fiber and a variety of other natural and synthetic materials.

Multi-benching - a road building method used on moderate or steeply sloping land in which two or more benches are excavated into the native hillslope and fill is then compacted on the benches to provide a stable road bench.

Obstacle - locations along a proposed road alignment that need to be avoided. Obstacles include rock outcrops, landslides, extremely steep slopes, unsuitable stream crossing locations, wet areas, lakes, etc.

Outsloped road - road surface that is sloped out away from the cutbank toward the road's fillslope. Outsloped roads may or may not have an inboard ditch.

Outsloping - the act of converting an insloped road to an outsloped road. Outsloping can also refer to the act of excavating the fill along the outside of the road and placing and grading it against the cutbank, thereby creating an outsloped surface where the roadbed once existed.

Partial bench - a partial bench road is one in which the road bed is part bench and part fill, somewhere between a full bench and a full fill road.

Permeable fill - see *drainage blanket*.

Peak flow (flood flow) - the highest amount of stream or river flow occurring in a year or from a single storm event.

Perennial stream - A stream that typically has running water on a year-round basis.

Permanent road - A road which is planned and constructed to be part of a permanent all-season transportation system. These roads have a surface which is suitable for hauling of forest and ranch products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Permanent roads receive regular and storm-period inspection and maintenance.

Permanent watercourse crossing - A watercourse crossing that will be constructed to accommodate the estimated fifty-year flood flow and will remain in place when timber [or ranching] operations have been completed.

Permeable fill - see *drainage blanket*.

Put-to-bed - The process of actively abandoning a road by eliminating all conceivable risks of sediment production until the road is again needed in future years. "Putting-to-bed" or road closure involves completely removing stream crossing fills and associated drainage structures and eliminating the risk of sediment production from roads and landings (see also *decommission* and *road closure)*.

Ranch road - a road other than a public road used by ranch and farm vehicles in the conduct of ranching operations. Ranch roads are sometimes used for hauling forest products and thereby are also classified as, and subject to, the same regulations as logging roads.

Range finder - a hand-held field instrument used to measures distances less than about 1000 feet.

Ratio (slope) - a way of expressing slope gradient as a ratio of horizontal distance to vertical rise, such as 3:1 (3 feet horizontal for every 1 foot vertical rise of fall).

Rational formula (method) • an empirical method for estimating peak flows from a small watershed. The rational formula is often used to estimate flows and to select appropriate culvert sizes for small, ungaged stream channels crossed by a road.

Ravel (dry ravel) - soil particles dislodging and rolling down a slope under the influence of gravity. Ravel occurs most rapidly when a cohesionless soil on a steep slope dries out Ravelling is dramatically increased when frost acts on the exposed soil. Ravel on some steep, bare cutbanks can quickly fill ditches and supply sediment that is then eroded and moved to nearby ditch relief culverts or streams by concentrated ditch flow.

Reconstruction (road) - the upgrading or rebuilding of a road that is abandoned or substandard in one or more elements of its design.

Rill - an erosion channel, varying in size from a rivulet up to about 1 ft? in cross section, that typically forms where rainfall and surface runoff is concentrated on fillslopes, cutbanks and ditches. If the channel is larger than 1 ft2 in size, it is called a gully.

Rip-rap - The rock or other suitable material placed on the ground to prevent or reduce erosion.

Riparian - The banks and other adjacent terrestrial environs of lakes, watercourses, estuaries and wet areas, where transported surface and subsurface freshwater provides soil moisture to support mesic vegetation.

Ripping (road) - The process of breaking up or loosening compacted soil (e.g., skid trails, spur roads or landings) to better assure penetration of roots of young tree seedlings and to increase infiltration (see also *scarified).*

River run rock - aggregate (gravel) that is excavated from a river bed. River run rock is usually well rounded and, unless it is screened, also contains sand.

Road abandonment - in the past, road abandonment was synonymous with blocking the road and letting it grow over with vegetation. Today, proper road abandonment involves a series of proactive steps and activities which essentially erosion-proof a road alignment so that further maintenance will not be needed and significant erosion will not occur (see also *road closure, decommission).*

Road closure - or "proactive road abandonment" is a method of closing a road so that regular maintenance is no longer needed and future erosion is largely prevented. The goal of road closure is to leave the road so that little or no maintenance is required for stability while the road is unused. Road closure usually involves erosion-proofing techniques including removing stream crossing fills, removing unstable road and landing fills, installing cross road drains for permanent road surface drainage and other erosion prevention and erosion control measurers as needed. Proper road closure is not accomplished by blocking a road and walking away from it to let "nature reclaim the road" (see also *decommission, road abandonment).*

Road failure - damage to the roadbed (usually caused by a road bed slump, fill failure, stream crossing washout or major gully) which prevents vehicular passage, but does not usually mean minor cutbank or fill sloughing incidental to road settling.

Road fill excavation - excavation and removal of unstable or potentially unstable fill and/or sidecast spoil from the outer edge a road prism. Road fill excavations are performed as a preventive measure to guard against landsliding of unstable material into downslope stream channels.

Road grade - the slope of a road along its alignment.

Road maintenance - the actions taken to prevent erosion and/or the deterioration of a road, including the cutbank, the road surface, the fillslope and all drainage structures. Road maintenance activities include such tasks as grading, ditch cleaning, brushing and culvert cleaning.

Road network - the pattern of all the roads in an ownership, watershed, hillside or other defined area. The road network typically includes main trunk roads, secondary roads and spur roads.

Road reconstruction - repair or upgrading of those pre-existing roads that are to be restored or improved to make them useable for hauling forest products or for ranching operations. Reconstruction typically refers to road rebuilding required when one or more road failures have occurred (see *road failure).*

Road runoff - surface runoff that collects on and is drained from the road surface, usually as a direct response to rainfall.

Rock armor - course rock that is placed to protect a soil surface, usually from erosion caused by flowing or falling water. Rock armor is one type of material used for energy dissipation at culvert outfalls.

Rock pit - a large outcrop of bedrock that has been developed for aggregate uses, such as road surfacing material and/or larger rock armor. A borrow pit is an excavation from which material is removed for use in another location (see also *borrow site).*

Rolling dip - shallow, rounded dip in the road where road grade reverses for a short distance and surface runoff is directed in the dip or trough to the outside or inside of the road. Rolling dips are drainage facilities constructed to remain effective while allowing passage of motor vehicles at reduced road speed.

Rotational slide - a landslide that has an accurate, concave-up failure plain, and whose movement is rotational rather than translational.

Runoff • rainfall or snowmelt which flows overland across the surface of hillslopes and along roads and trails.

Scarified (scarification) - a soil surface whose organic material is removed and whose surface is mechanically broken up or decompacted (see also *ripping).*

Seasonal road - a road which is planned and constructed as part of a permanent transportation system where most hauling and heavy use may be discontinued during the winter period and whose use is restricted to periods when the surface is dry. Most seasonal roads are not surfaced for winter use, but have a surface adequate for hauling of forest and ranch products in the non-winter periods, and in the extended dry periods or hard frozen conditions occurring during the winter period. Seasonal roads have drainage structures at watercourse crossings which will accommodate the fifty-year flood flow.

Sediment delivery - material (usually referring to sediment) which is delivered to a stream channel. Sediment delivery often refers to the percent of material eroded from a site which actually gets delivered to a stream channel (as opposed to that which is stored on the hillslope).

Sediment yield - the quantity of soil, rock particles, organic matter, or other dissolved or suspended debris that is transported through a cross-section of stream in a given period. Technically, yield consists of dissolved load, suspended load, and bed load.

Sidecast - the excess earthen material pushed or dumped over the side of roads or landings.

Silt fence - a constructed barrier used to contain soil eroded from a construction site. The barrier is made from filter fabric stretched between fence posts placed on contour along a slope.

Sliver fill - a thin fill lying parallel to the underlying hillslope, rather than as a wedge used in normal cut and fill construction. Sliverfills cannot be compacted on slopes exceeding about 35%. As they thicken, sliver fills become more susceptible to failure. Sliver fills are only appropriate where it is impossible to dispose of the material elsewhere and where the fill is composed entirely of coarse rock. Sliverfills are "placed" and are never constructed by uncontrolled sidecasting.

Slope ratio - see *ratio.*

Slope stability - the resistance of a natural or artificial slope or other inclined surface to failure by landsliding (mass movement).

Slump - an episodic, fast to very slow mass movement process involving rotation of a block of hillslope or road along a broadly concave slip surface, often referred to as a rotational slide (see *rotational slide).*

Soil series - a group of soils developed from a particular type of parent material having naturally developed horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement of the profile.

Soil erosion - see *erosion.*

Soil texture - The relative proportion of sand, silt and clay in a soil; grouped into standard classes and subclasses in the Soil Survey Manual of the U.S. Department of Agriculture.

Soil water - water in the soil, including groundwater and water in the soil above the groundwater table.

Spoil disposal site - the location where spoil material (woody debris and excavated soils) can be placed without the threat of accelerated erosion or of initiating slope instability. Stable spoil disposal sites include the cut portion of closed roads, the inside portion of landings and turnouts, and flat or low gradient natural benches.

Spoil (spoil materials) - Material (soil and organic debris) that is not used or needed as a functional part of the road or a landing. Spoil material is generated during road construction, reconstruction and maintenance activities.

Spur road - a side road off a main trunk road or a secondary road. Most spur roads are dead-end.

Storm maintenance (emergency road maintenance) - road inspection and maintenance that is performed during periods of high rainfall and runoff when drainage structures are most likely to plug, malfunction or fail.

Stream crossing - the location where a road crosses a stream channel. Drainage structures used in stream crossings include bridges, fords, culverts and a variety of temporary crossings.

Stream crossing excavation - the excavation of the fill material that was used to build (fill) a stream crossing, specifically a culverted crossing, a log crossing or a temporary crossing. A stable stream crossing excavation must be dug down to the level of the original stream bed, with side slopes graded (excavated) back to a stable angle (usually 50% or less, depending on soil characteristics).

Subdrainage (subsurface drainage) - the flow of water beneath the surface of the ground. Along roads, specific construction techniques can be used to make sure subsurface drainage is not impeded by the road bed or road fill.

Subgrade - a thoroughly compacted portion of natural embankment material directly beneath the base or road foundation.

Surface erosion - the detachment and transport of soil particles by wind, water or gravity. Surface erosion can occur as the loss of soil in a uniform layer (sheet erosion), in many rills, gullies, or by dry ravel.

Surfacing (surface course) - the top layer of the road surface, also called the wear course. Rock aggregate and paving are two types of surfacing used to weather-proof the road for winter use.

Swale - a channel-like linear depression or low spot on a hillslope which rarely carries runoff except during extreme rainfall events. Some swales may no longer carry surface runoff under the present climatic conditions.

Switchback - the location along a road where the route turns and reverses direction, usually over a short distance.

Temporary road - a road that is to be used only during short-lived ranch or timber operations. These roads have a surface adequate for seasonal hauling use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use. These drainage structures must be removed prior to the beginning of the winter period (see *temporary stream crossing).*

Temporary stream crossing - a stream crossing that is to be excavated and removed, usually on a temporary road. If a temporary stream crossing is to remain in place over one winter, it should be designed to the same standards as a permanent watercourse crossing.

Through-cut - a road cut through a hillslope or, more commonly, a ridge, in which there is a cutbank on both sides of the road. Through-cuts that are more than about 2 feet deep are very difficult to drain and are prone to gullying.

Through-fill - a road which is entirely composed of fill material and which has a berm along both sides of the road, thereby intentionally containing road surface runoff on the road and directing it to a single discharge point, usually a fabricated metal berm-drain. Through-fills are typically found at sensitive stream crossings where the fill is bermed on both sides of the road.

Top-down road construction - road construction techniques which involve excavating a road bench on the hillside and sidecasting the spoil material on the slopes below. Top-down road construction techniques should only be employed on gently or moderately sloping hillslopes where sidecast material cannot fail or be eroded and transported to local stream channels.

Trash rack - a barrier built just over or just upstream from a culvert inlet to trap floating organic debris before it can plug the culvert.

Trunk road - a main, through-going road which typically forms the core of a road network that also contains secondary and spur roads.

Turnout - a planned wide spot along a single lane road that is used to allow vehicles to safely pass.

Unstable areas - areas characterized by mass movement features or unstable soils, or by some or all of the following: hummocky topography consisting of rolling bumpy ground, frequent benches, and depressions; short irregular surface drainages which begin and end on the slope; visible tension cracks and head wall scarps; irregular slopes which may be slightly concave in upper half and convex in lower half as a result of previous slope failure; evidence of impaired ground water movement resulting in local zones of saturation including sag ponds with standing water, springs, or patches of wet ground; hydrophytic (wet site) vegetation; leaning, jackstrawed or split trees; pistol-butted trees with excessive sweep in areas of hummocky topography.

Unstable soils - are indicated by the following characteristics: (1) unconsolidated, non-cohesive soils (coarser textured than loam) and colluvial debris including sands and gravels, rock fragments, or weathered granules. Such soils are usually associated with a risk of shallow-seated landslides on slopes of 65% or more, having non-cohesive soils less than 5 feet deep in an area where precipitation exceeds 4 inches in 24 hours in a 5-year recurrence interval. (2) Soils that increase and decrease in volume as moisture content changes. During dry weather, these materials become hard and rock-like exhibiting a network of polygonal shrinkage cracks and a blocky structure resulting from desiccation. Some cracks may be greater than 5 feet in depth. When wet, these materials are very sticky, dingy, shiny, and easily molded.

Vertical curve - The vertical arc of a circle whose radius is that of the road as it rises and falls (over a hill), or falls and rises (across a swale or dip) through a change in grade.

Washed out stream **crossing -** a stream crossing fill that has been partially or completely eroded and "washed" downstream. Washouts usually occur when a culvert plugs and streamflow backs up and flows over the roadbed during flood events.

Waterbar (waterbreak) - shallow ditch excavated at an angle across a road or trail to drain surface runoff. Waterbars are usually built on seasonal or temporary roads which are to receive little or no traffic during the winter period.

Watercourse - any well defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand or gravel. Watercourse also includes man-made watercourses (see also *Class I, II, HI and IV watercourse).*

Watercourse and lake protection zone (WLPZ) - a strip of land, along both sides of a watercourse or around the circumference of a lake or spring, where additional practices (or restrictions) may be required

for protection of the quality and beneficial uses of water, fish and riparian wildlife habitat, other wildland resources, and for controlling erosion.

Water quality - the chemical and biological characteristics of stream and lake water.

Watershed - the area or drainage basin contributing water, organic matter, dissolved nutrients and sediments to a stream or lake. An area bounded mostly by ridges and drained, at its outlet, by a single trunk stream.

Wetlands - areas that are inundated by surface water or ground water with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that require saturated or seasonally saturated soil conditions for growth and reproduction (Executive Order 11990). Wetlands generally include, but are not limited to, swamps, marshes, bogs and similar areas.

Wheel guards - slightly elevated rails along both sides of the running surface of a flatcar bridge, designed to warn drivers and to help keep vehicles on the bridge.

Winter operations - generally refers to logging and associated forest road operations conducted during the winter operating period, from October 15 to April 15. A winter operating plan is required by the California Department of Forestry and Fire Protection for winter operations.

Winter operating period - The period between November 15 to April 1, except for purposes of installing waterbreaks and rolling dips, in which case the period is October 15 to April 1 (for forestry operations).

Winter operating plan - a functional plan developed to describe how land use operations will be conducted during the winter period. Winter operating plans usually contain detailed information on erosion control and erosion prevention actions that are to be followed to protect the site from rainfall and storm runoff.

Winterize - to perform erosion prevention and erosion control work on a road in preparation for winter rains and flood flows. Winterizing activities include waterbarring, ditch cleaning, culvert cleaning, removal of berms, resurfacing, etc.

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APPENDIX A: CULVERT SIZING PROCEDURE FOR THE 50-YEAR STORM

Introduction

Several methods have been developed for estimating the peak flood discharge that can be expected from small ungaged, wildland watersheds. These procedures are useful for determining the size (diameter) of culvert needed to install in a stream crossing that is to be constructed or reconstructed.

Determining the proper size (diameter) culvert requires: 1) estimating the volume of runoff which would occur at each stream crossing during the 50-year flood, and then 2) calculating the size of culvert which would handle that flow.

A summary of some methods, with example calculations for flood estimating is available from the California Department of Forestry and Fire Protection in an "in-house" document called *Suggested culvert sizing procedures/or the 50-year storm.* This document covers such techniques as the Rational Method, the California Nomograph Method, the Magnitude and Frequency Method, the SCS Curve Number Method and the Slope Number Method. Other techniques are also available and may have been developed for your area and climatic region. Each method has its strengths and weaknesses, and relies on field or map measurements, published climatic data and subjective evaluations of watershed conditions.

Several of the methods require precipitation intensity data which are available in several reports published by the State of California. These are available from the state and can be found in good public and college libraries. Your local CDF office may also have copies of the most recent data. Ask the Forest Practice Inspector with jurisdiction for your area.

1. Department of Water Resources, 1981 (and more recently). Rainfall depth-duration-frequency for California.

2. NOAA, 1973, Atlas 2, Precipitation frequency atlas of the western U.S., vol XI, California.

3. Department of Water Resources, 1976, Rainfall atlas for drainage design, vol. I and vol III, (out of print).

The most commonly used technique for estimating 50-year flood discharges from small watersheds in north coastal California forest land is the Rational Method. The methodology and an example is described in this appendix. However, it is recommended that two or three different methods be used in an area to compare and verify the results.Field experience can also be used as

a check. Just remember, most of us have not been around for a 50-year flood and we naturally tend to underestimate the amount of water that is carried by streams during these extreme events.

Step 1: The Rational Method of Estimating Flood Discharge from Small Watersheds

This method is based on the equation:

$$Q=CIA$$

Where: Q = peak runoff at crossing (in cfs)

C = runoff coefficient (percent runoff)

I = uniform rate of rainfall intensity (inches/hour)

A = drainage area (in acres)

Advantages:

1. Frequently used and flexible enough to take into account local conditions.
2. Easy to use if local rainfall data is available.

Disadvantages:

1. Rexibility may lead to misuse, or misinterpretation of local conditions.
2. Precipitation factor "I" may be difficult to obtain in remote areas.

Information needed:

A = area of watershed (acres)

H = elevation difference between highest point in watershed and the crossing point (ft.).

L = length of channel in miles from the head of the watershed to the crossing point

I = uniform rate of rainfall intensity. Obtained from precipitation frequency-duration data for local rain gages as in example on page A5.
C = runoff coefficient from table on page Y.

Procedures:

1. Selecting "C" values:

Several different publications give a range of "C" values for the rational formula, however, the values given in the following table by Rantz (1971) appear to be the most appropriate.

Table of "C" Values		
Rural Areas		**C Value**
Sandy and gravelly soils:	cultivated	0.20
	pasture	0.15
	woodland	0.10
Loams and similar soils without impeded horizons	cultivated	0.40
	pasture	0.35
	woodland	0.30
Heavy clay soil or those with a shallow impeding horizon: shallow over bedrock:	cultivated	0.50
	pasture	0.45
	woodland	0.40

2. Selecting an "I" value:

In selecting an "I" value, two factors are considered: a) the travel time or time of concentration, T_C, for the runoff to reach the crossing, and b) the precipitation conditions for the particular watershed in question.

a. Time of concentration, T_C can be calculated using the formula:

$$T_C = \left[\frac{11.9\ L^3}{H}\right]^{0.385}$$

Where: T_C = time of concentration (in hours)

L = length of channel in miles from the head of the watershed to the crossing point

H = elevation difference between highest point in watershed and the crossing point (in feet)

b. Uniform rate of rainfall intensity.

Once the time of concentration has been determined, then that value is used to determine which rainfall duration to use (i.e., if T_C = 1 hour, then use 50-year, 1 hour precipitation duration; if T_C=4 hours, then use 50-year, 4-hour duration). Precipitation frequently, duration tables are available for precipitation stations throughout the state similar to figure 1 (DWR, 1981).

Figure 1. Short-Duration Precipitation-Depth-Duration-Frequency Data

Sample Microfiche Frame

MAXIMUM ANNUAL PRECIPITATION (IN)

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	BSN	LATITUDE	LONGITUDE	COUNTY CODE
810 3649 0	GRIZZLEY FLAT	3855	15	09N	13E	6	M	38.637	120.524	09

DURATION

M=MINUTES,H=HOURS,D=DAYS,C YR=CALENDAR YEAR,W YR=WATER YEAR,F YR=FISCAL YEAR

YEAR	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
1940	.13	.16	.19	.28	.40	.71	.99	1.28	2.16	3.07	0
1941	.21	.40	.49	.60	.70	.89	.94	1.50	2.36	3.33	50.41
1942	.20	.25	.30	.45	.57	.88	1.16	1.81	3.11	5.16	51.23
1943	.14	.23	.28	.34	.40	.89	1.02	1.82	2.95	5.32	41.21
1944	.17	.24	.29	.37	.52	.89	1.36	1.98	3.24	5.03	45.82
1945	.30	.43	.49	.79	1.08	1.17	1.27	1.94	2.78	4.39	58.10
1946	.12	.19	.21	.24	.35	.66	.91	1.43	2.35	3.72	26.32
1947	.09	.15	.22	.33	.52	.74	.85	1.28	1.78	2.22	27.00
1948	.08	.10	.11	.20	.30	.49	.71	1.25	1.97	3.21	46.52
1949	.19	.30	.31	.40	.47	.60	.80	1.31	2.61	3.30	30.57
1950	.14	.29	.36	.56	.68	.98	1.25	2.21	3.14	6.21	69.76
1951	.09	.15	.20	.32	.53	1.06	1.50	2.46	5.86	4.68	53.38
1952	.06	.10	.12	.16	.28	.52	.75	1.22	1.65	2.54	46.66
1953	.10	.20	.29	.34	.45	.77	1.01	1.61	1.75	2.41	32.42
1954	.10	.14	.19	.29	.49	.59	.61	1.02	1.49	2.67	46.55
1955	.12	.18	.24	.34	.50	.76	1.01	2.00	3.35	6.24	49.86
1956	.08	.14	.17	.25	.38	.74	.78	1.31	1.80	2.87	34.90
1957	.09	.15	.20	.39	.47	.87	1.14	1.61	2.33	2.91	43.73
1958	.11	.14	.17	.25	.40	.60	.78	1.44	2.08	2.65	49.45
1959	.10	.18	.25	.30	.37	.59	.75	1.37	1.94	2.65	28.06
1960	.22	.30	.42	.46	.53	.69	1.07	1.78	2.80	4.90	42.86
1961	.12	.15	.15	.25	.30	.49	.66	.86	1.17	1.52	24.40
1962	.09	.15	.24	.36	.65	1.15	1.56	2.61	3.81	5.63	49.89
1963	.14	.15	.26	.36	.51	.97	1.29	2.02	2.39	3.50	50.28
1964	.07	.11	.18	.30	.46	.71	.92	1.65	1.89	2.22	0

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	BSN	LATITUDE	LONGITUDE	COUNTY CODE
810 3649 0	GRIZZLEY FLAT	3855	15	09N	13E	6	M	38.637	120.524	09

MAXIMUM PRECIPITATION FOR INDICATED DURATION D=DAYS H=HOURS

RETURN PERIOD IN YEARS	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	C-YR
2	.12	.19	.24	.34	.47	.73	.94	1.33	2.28	3.47	42.16
5	.16	.25	.32	.45	.63	.97	1.26	2.05	3.05	4.63	53.37
10	.19	.29	.37	.52	.73	1.13	1.46	2.38	3.54	5.38	59.84
20	.22	.33	.42	.59	.82	1.29	1.65	2.68	4.00	6.08	65.51
25	.22	.34	.43	.61	.85	1.32	1.71	2.78	4.14	6.30	67.22
40	.23	.35	.44	.62	.87	1.35	1.74	2.83	4.21	6.40	70.68
50	.25	.37	.48	.67	.94	1.46	1.89	3.07	4.57	6.95	72.26
100	.27	.41	.52	.73	1.03	1.59	2.06	3.33	4.99	7.58	76.97
200	.29	.44	.56	.79	1.11	1.72	2.23	3.62	5.39	8.20	81.44
1000	.34	.52	.66	.93	1.30	2.01	2.60	4.23	6.30	9.58	91.12
10000	.41	.62	.79	1.11	1.56	2.41	3.12	5.07	7.55	11.48	103.82
PMP	.80	1.22	1.55	2.18	3.06	4.75	6.13	9.97	14.85	22.59	231.79
MEAN	.131	.199	.253	.357	.500	.776	1.003	1.631	2.429	3.694	43.206
CLOCK HR. COR.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	1.316	1.422	1.049	1.391	1.767	.415	.349	.700	.586	.507	.076
REGIONAL SKEW	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	.500
SKEW USED	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	.500
KURTOSIS	4.978	4.327	4.057	6.375	8.439	2.749	2.840	3.520	2.712	2.421	3.231
N	25	25	25	25	25	25	25	25	25	25	25
RECORD YEAR	1945	1945	1941	1945	1945	1945	1942	1951	1951	1953	1950
RECORD MAXIMUM	.300	.430	.490	.790	1.080	1.170	1.560	2.660	3.840	6.240	69.760
NORMALIZED MAX	2.946	2.648	2.342	3.191	3.503	2.035	2.150	2.285	1.975	1.890	2.355
CALC. COEF. VAR	.434	.458	.399	.380	.331	.250	.258	.276	.294	.345	.269
REGN. COEF. VAR	.341	.341	.341	.341	.341	.341	.341	.341	.341	.341	.291
USED COEF. VAR	.341	.341	.341	.341	.341	.341	.341	.341	.341	.341	.291
MEAN/A	.0030	.0046	.0059	.0083	.0116	.0180	.0232	.0377	.0562	.0855	1.0000
RP10/A	.0044	.0067	.0085	.0120	.0169	.0262	.0338	.0550	.0819	.1246	1.38[illegible]
RP25/A	.0052	.0079	.0100	.0141	.0197	.0306	.0396	.0643	.0956	.1457	1.5559
RP50/A	.0057	.0087	.0110	.0156	.0218	.0338	.0437	.0710	.1058	.1609	1.6725
RP100/A	.0062	.0095	.0120	.0170	.0238	.0369	.0476	.0775	.1154	.1755	1.7815
RP1000/A	.0079	.0120	.0152	.0214	.0300	.0466	.0602	.0979	.1458	.2218	2.1090
RP10000/A	.0094	.0143	.0182	.0257	.0360	.0559	.0722	.1174	.1748	.2658	2.4030
PMP/A	.0186	.0282	.0358	.0504	.0708	.1099	.1419	.2308	.3438	.5226	5.3650

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL RESULTS ARE NOT DEPENDABLE

The values in Figure 1 must be converted to inches per hour as shown in the following examples:

Example 1:

T_C = 3 hours

from Figure 1, 50-year, 3-hour ppt = 1.89
1.89/3 = 0.63 inches per hour I =0.63

Example 2:

T_C = 15 minutes

from Figure 1, 50-year, 15-minuteppt =0.48

0.48x4 = 1.92 inches per hour I = 1.92

3. Once the "C" and "I" values are determined, apply values along with area of watershed "A" to rational equation.

Q = CIA

Example:

Digger Creek (Near Fort Bragg, California)

C = 0.30 (loam woodland soil, from Table 1, page A3)

$$\mathbf{T_C} = \left[\frac{11.9(1.8\text{ mi.})^3}{200}\right]^{0.385}$$ where: L = 1.8 mi., A =200 ft.

= 0.67 or 40 min. from the Intensity Duration Frequency table (see example above and Figure 1, page A4)

I = 1.4in./hr.

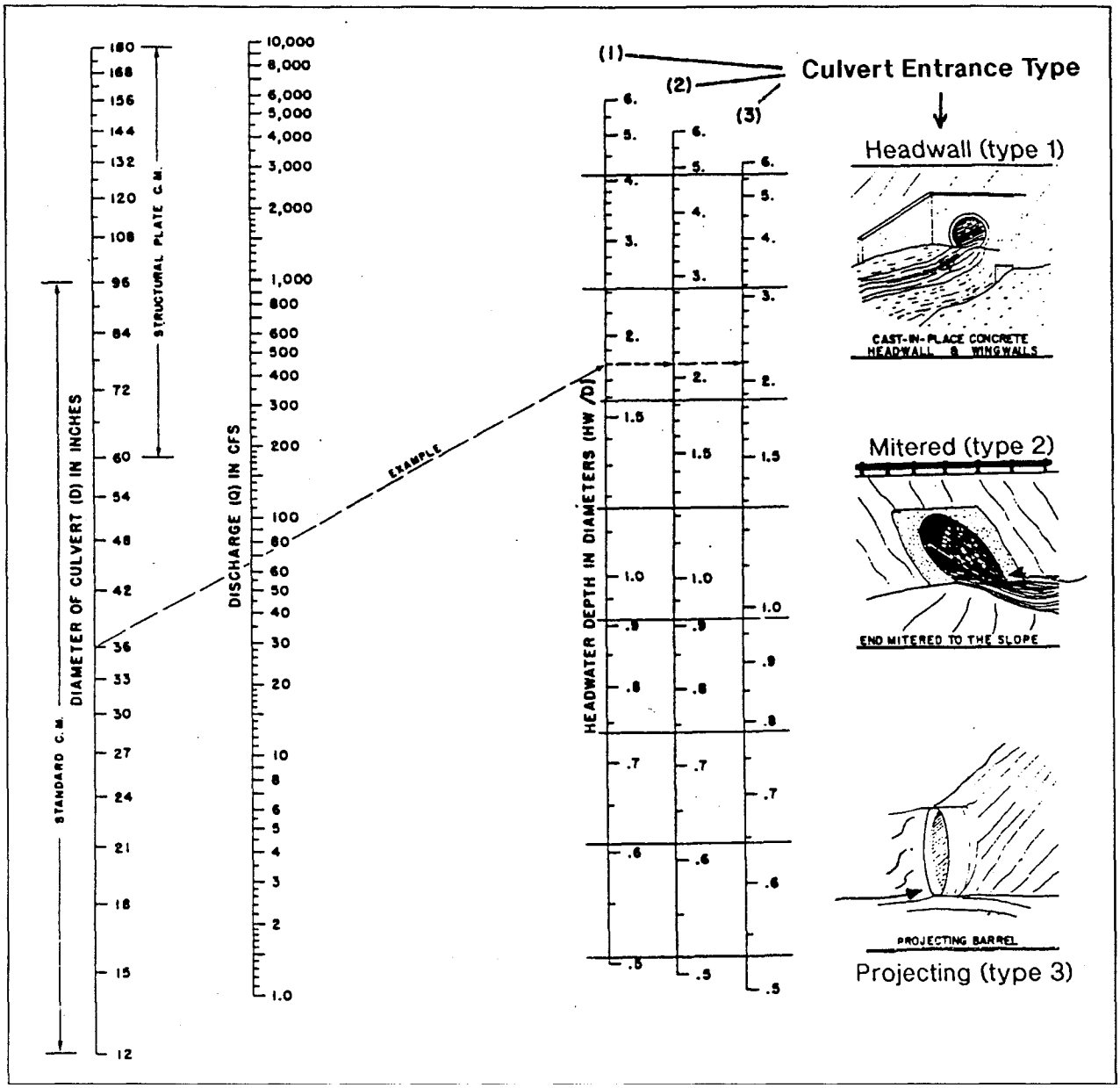
A = 536 acres

Q = CIA

Q = 0.30 x 1.4 x 536

= 225 cfs

Step 2: Using the Culvert Capacity Nomograph to determine needed culvert size



1. Determine the "entrance type" from the sketches above.
2. Calculate the expected "Headwater Depth" in **diameters** from field measurements (e.g., a 36 inch culvert whose bottom will be 8 feet below the lowest point on the road grade over the crossing has a headwater depth of 8 feet, or 2.7 culvert-diameters (8ft./3 ft. = 2.7).
3. Place a straight edge connecting the Headwater Diameter scale (right side of nomograph) through the calculated 50-year flood discharge (from the Rational Method, in this example).
4. Read off the needed culvert diameter on the left scale of the nomograph.
5. In the example, the Headwater Depth for a Type 1 entrance (1.8), Type 2 entrance (2.1) or a Type 3 entrance (2.2) culvert to be installed on a small stream with a calculated 50-year flood discharge of 66 cubic feet per second would require a 36-inch diameter culvert.

APPENDIX B: STREAMBED ALTERATION AGREEMENT

Notification No. _____ THP No. _____

AGREEMENT REGARDING PROPOSED STREAM OR LAKE ALTERATION

THIS AGREEMENT, entered into between the State of California, Department of Fish and Game, hereinafter called the Department, and _____ of _____, State of _____, hereinafter called the operator, is as follows:

WHEREAS, pursuant to Division 2, Chapter 6 of California Fish and Game Code, the operator, on the _____ day of _____ 19_____, notified the Department that he intends to substantially divert or obstruct the natural flow of, or substantially change the bed channel, or bank of, or use material from the streambed of, the following water: _____, in the County of _____, State of California, S_____ T_____ R_____.

WHEREAS, the Department (represented by _____ has made an inspection of subject area on the _____ day of _____, 19 ____, and) has determined that such operations may substantially adversely affect existing fish and wildlife resources including: _____

THEREFORE, the Department hereby proposes measures to protect fish and wildlife during the operator's work. The operator hereby agrees to accept the following recommendations as part of his work: Numbers _____ from the list of recommendations on the back of this page and the following special recommendations:

1. All work in or near the stream or lake shall be confined to the period _____

The operator, as designated by the signature on this agreement, shall be responsible for the execution of all elements of this agreement. A copy of this agreement must be provided to contractors and subcontractors and must be in their possession at the work site.

If the operator's work changes from that stated in the notification specified above, this agreement is no longer valid and a new notification shall be submitted to the Department of Fish and Game. Failure to comply with the provisions of this agreement and with other pertinent Code Sections, including but not limited to Fish and Game Code Sections 5650, 5652 and 5948, may result in prosecution.

Nothing in this agreement authorizes the operator to trespass on any land or property, nor does it relieve the operator of responsibility for compliance with applicable federal, state, or local laws or ordinances.

THIS AGREEMENT IS NOT INTENDED AS AN APPROVAL OF A PROJECT OR OF SPECIFIC PROJECT FEATURES BY THE DEPARTMENT OF FISH AND GAME. INDEPENDENT REVIEW AND RECOMMENDATIONS WILL BE PROVIDED BY THE DEPARTMENT AS APPROPRIATE ON THOSE PROJECTS WHERE LOCAL, STATE, OR FEDERAL PERMITS OR OTHER ENVIRONMENTAL REPORTS ARE REQUIRED.

This agreement becomes effective on _____

Operator _____	_____ Department Representative
Title _____	Title _____
Organization _____	Department of Fish and Game, State of California
Date _____	Date _____

The department has 30 days from date of receipt of a completed application in which to make its recommendations. This time period does not begin until the department receives the appropriate fee (see attached fee schedule).

T.H.P. No. _____

Notification No. _____ Received _____

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

NOTIFICATION OF REMOVAL OF MATERIALS AND/OR ALTERATION OF LAKE, RIVER, OR STREAMBED BOTTOM, OR MARGIN

A. APPLICANT Pursuant to Sections 1601–1607 of the California Fish and Game Code

I. _____ of _____ ,
Name of Applicant — Mailing Address

Representing _____
Name and address of Individual, Agency, Company, etc. owning property or doing work.

Hereby notify the California Department of Fish and Game of operations to be carried out by or for me

from _____ to _____ on or affecting
Starting Date — Ending Date

_____ of _____ County, tributary to _____
Name of Stream, River, or Lake — Major Water Body

Located _____
Distance and Direction to Landmarks

Section _____ Township _____ Range _____

USGS Map _____ Co. Assessor's Parcel No. _____

Property owners name and address (if different from applicant) _____

_____

_____ is responsible for operations at the site.
Name of Person to Be Contacted at Site During Operations

He/she can be reached at _____
Mailing Address — Telephone

B. Description of operation 1. The nature of said operations will be as follows:
Check all squares which apply.

- ☐ Soil, sand, gravel, and/or boulder removal or displacement
- ☐ Water diversion or impoundment
- ☐ Mining—other than aggregate removal
- ☐ Road or bridge construction
- ☐ Levee or channel construction
- ☐ Timber harvesting or any related activity required for harvesting timber
- ☐ Temporary, recreational or irrigation dam
- ☐ Fill or spoil in bed, bank, or channel
- ☐ Other—Describe below

2. Type of material removed, displaced or added ☐ Soil ☐ Sand ☐ Gravel ☐ Boulders
Volume _____

3. Equipment to be used in the described site _____

4. Use of water (i.e., domestic, irrigation, gravel, washing, etc.) _____ Quantity _____

5. Describe type and density of vegetation to be affected, and estimate area involved.

_____

6. What actions are proposed to protect fish and wildlife resources and/or mitigate for project impacts? _____

_____

7a. Does project have a local or state lead agency or require other permits? ☐ Yes ☐ No

7b. If 7a answer is yes, please attach or identify any available environmental document.

7c. For state-designated wild and scenic rivers, a determination of the project's consistency with the California Wild and Scenic Rivers Act must be made by the Secretary for Resources. Until the Secretary determines the project is consistent with the Act, the Department cannot issue a valid agreement. A tentative agreement will be issued, conditioned upon a finding of consistency by the Resources Secretary.

7d. THIS AGREEMENT IS NOT INTENDED AS AN APPROVAL OF A PROJECT OR OF SPECIFIC PROJECT FEATURES BY THE DEPARTMENT OF FISH AND GAME. INDEPENDENT REVIEW AND RECOMMENDATIONS WILL BE PROVIDED BY THE DEPARTMENT AS APPROPRIATE ON THOSE PROJECTS WHERE LOCAL, STATE, OR FEDERAL PERMITS OR OTHER ENVIRONMENTAL REPORTS ARE REQUIRED.

8. Briefly describe proposed construction methods. Attach diagram or sketch of the location of your operation to clearly indicate the stream or other water and access and distance from named public road. Indicate locked gates with an "X". Show existing features with a solid line (————) and proposed features with a broken line (– – – – – –). Show compass direction. Attach larger scale map if necessary.

NO CARBON NEEDED
FG2023 (Rev. 11-87)

_____
Signature of Applicant — Date

37 83409

DEPARTMENT OF FISH AND GAME
Notification of Proposed Removal of Materials and/or
Alteration of Lake, River, or Streambed Bottom or Bank
(Pursuant to Sections 1603-1606, Fish and Game Code)

The following information that accompanies the Timber Harvesting Plan is not a part of the Timber Harvesting Plan to be enforced by the Department of Forestry. Such information is given only for convenience in providing notice to the Department of Fish and Game as required by Sections 1603 and 1606 of the Fish and Game Code of proposed timber operations that will substantially divert, obstruct, or change the flow or bed of any river, stream, or lake. If the proposed timber operations in the Timber Harvesting Plan area do not involve any such disturbance to rivers, streams, or lakes, this attachment should be left blank. If at a later date it is decided that operations will involve disturbances to rivers, streams, or lakes, a separate notification should be submitted to the Department of Fish and Game at that time.

Attach a sketch of the location of the proposed operation which clearly indicates the stream or other water, and access from a named public road. Locked gates and the compass direction shall be indicated. Please indicate the location of all proposed stream crossings, fills, dikes, excavations, log landings (near streams), streambed vegetation removal, channel changes, impoundments, diversions or other significant alterations to rivers, streams, or lakes. (This may require a larger scale map.)

Date_____ THP Number_____
(leave blank)

Please Fill In Applicable Blanks

(1) Streambed Excavations:

(a) Approximate volume of material to be removed from streambed: _____cu. yds.*

(b) Type of material removed (rock, gravel, sand, soil, etc.):_____

_____

(c) Equipment to be used (bulldozer, backhoe, dragline, bucket dredge, etc.):

_____

(d) Type, density and area of vegetation to be removed:_____

_____

(2) Stream Crossings, Channel Changes, Landings or Other Fills Near Streams:

(a) Purpose of activity (culvert, bridge, skid crossing, ford, landing, dike, etc.). Please indicate which crossings are permanent:

_____

(b) Approximate volume and type of material to be deposited in streambed:

_____

(c) Type of equipment to be used:_____

* Excavations are generally not permitted within the flowline of a stream unless the water is diked off from the excavation.

Attachment to Form FM-63 (12/76)

(d) How long will equipment be used in flowing water to install crossings or isolate work area from flowing water? (Prolonged work in flowing water is usually not permitted): _____

_____

(e) Type, density and area of vegetation to be removed: _____

_____

(3) Impoundments and Diversions:

(a) Volume and type of material to be deposited in streambed: _____

_____

(b) Quantity of water to be used: _____

(c) Intended water use (i.e., fire and dust control, etc.): _____

_____

(d) Describe the period of time in which operations will be carried out: _____

_____

(4) Name and/or Legal Description of Area (include names of USGS Quadrangle Map).

_____

_____

(5) Work in or near the stream or lake is to be performed during the period _____

_____ to _____

(6) If an onsite inspection, in your opinion, is not possible because of weather or other circumstances within the next 30 days, you may enter into a mutual agreement to extend the period for inspection an additional 30 days. If you agree to an additional 30 days, indicate a new notification date which will start the 30 day period.

_____ _____
Notification Date Signature

If the proposed activity is amended to change any of the above, or if it is not completed within the agreed upon time period, the Department shall be notified.

Please fill in the following:

_____ _____
Name (Print or Type) Signature

_____ _____ _____ _____
Address City State Zip Code

( ) - _____
Telephone No.

APPENDIX C: FORESTRY RULES FOR ROAD CONSTRUCTION AND MAINTENANCE

Article 12. Logging Roads and Landings

§§ 923, 943, 963. Logging Roads and Landings. [All Districts]

All logging roads and landings in the logging area shall be planned, located, constructed, reconstructed, used, and maintained in a manner which: is consistent with long-term enhancement and maintenance of the forest resource; best accommodates appropriate yarding systems, and economic feasibility; minimizes damage to soil resources and fish and wildlife habitat; and prevents degradation of the quality and beneficial uses of water. The provisions of this article shall be applied in a manner which complies with this standard.

Factors that shall be considered when selecting feasible alternatives (see 14 CCR 897 and 898) shall include, but are not limited to, the following:

(a) Use of existing roads whenever feasible.

(b) Use of systematic road layout patterns **to** minimize total mileage.

(c) Planned to fit topography to minimize disturbance to the natural features of the site.

(d) Avoidance of routes near the bottoms of steep and narrow canyons, through marshes and wet meadows, on unstable areas, and near watercourses or near existing nesting sites of threatened or endangered bird species.

(e) Minimization of the number of watercourse crossings.

(f) Location of roads on natural benches, flatter slopes and areas of stable soils to minimize effects on watercourses.

(g) Use of logging systems which will reduce excavation or placement of fills on unstable areas.

§§923.1,943.1,963.1. Planning for Roads and Landings. [All Districts]

The following standards for logging roads and landings shall be adhered to:

(a) All logging roads shall be located and classified on the THP map as permanent, seasonal, or temporary. Road failures on existing roads which will be reconstructed shall also be located on the THP map. In addition to the requirements of 14 CCR 1034(v), the probable location of those landings which require substantial excavation or which exceed one quarter acre in size, shall be shown on the THP map.

(b) New logging roads shall be planned in accordance with their classification and maintenance requirements.

(c) Logging roads and landings shall be planned and located, when feasible, to avoid unstable areas. The Director shall approve an exception if those areas are unavoidable, and site-specific measures to minimize slope instability due to construction are described and justified in the THP.

(d) Where roads and landings will be located across 100 feet or more of lineal distance on any slopes over 65% or on slopes over 50% which are within 100 feet of the boundary of a WLPZ, measures to minimize movement of soil and the discharge of concentrated surface runoff shall be incorporated in the THP. The Director may waive inclusion of such measures where the RPF can show that slope depressions, drainage ways, and other natural retention and detention features are sufficient to control overland transport of eroded material. The Director may require end-hauling of material from areas within 100 feet of the boundary of a WLPZ to a stable location if end hauling is feasible and is necessary to protect water quality. The Director shall require maintenance provisions in the THP for drainage structures and facilities provided that such maintenance is feasible and necessary to keep roadbeds and fills stable.

(e) New logging roads shall not exceed a grade of 15% except that pitches of up to 20% shall be allowed not to exceed 500 continuous feet (152.4m). These percentages and distances may be exceeded only where it can be explained and justified in the THP that there is no other feasible access for harvesting of timber or where in the Northern or Southern Districts use of a gradient in excess of 20% will serve to reduce soil disturbance.

(f) Roads and landings shall be planned so that an adequate number of drainage facilities and structures are installed to minimize erosions on roadbeds, landing surfaces, sidecast and fills.

(g) Unless exceptions are explained and justified in the THP, general planning requirements for roads shall include:

> (1) Logging roads shall be planned to a single-lane width compatible with the largest type of equipment used in the harvesting operation with turnouts at reasonable intervals.
>
> (2) Roads shall be planned to achieve as close a balance between cut volume and fill volume as is feasible.
>
> (3) When roads must be planned so that they are insloped and ditched on the uphill side, drainage shall be provided by use of an adequate number of ditch drains.

(h) Road construction shall be planned to stay out of Watercourse and Lake Protection Zones. When it is a better alternative for protection of water quality or other forest resources, or when such roads are the only feasible access to timber, exceptions may be explained and justified in the THP and shall be agreed to by the Director if they meet the requirements of this subsection.

(i) [Coast] The location of all logging roads to be constructed shall be flagged or otherwise identified on the ground before submission of a TUP or major amendment. Exceptions may be explained and justified in the THP and agreed to by the Director if flagging is unnecessary as a substantial aid to examining (1) compatibility between road location and yarding and silvicultural systems, or (2) possible significant adverse effects of road location on water quality, soil productivity, wildlife habitat, or other special features of the area.

(i) **[Northern, Southern]** All logging roads shall be flagged or otherwise identified on the ground before submission of a THP or major amendment, except for temporary roads less than 600 feet in length that would meet the requirements for a minor deviation (see 14 CCR 1036,1039,1040) if they were submitted as such. Exceptions may be explained and justified in the THP and agreed to by the Director if flagging or other identification is unnecessary as a substantial aid to examining (1) compatibility between road location and yarding and silvicultural systems or (2) possible significant adverse effects of road location on water quality, soil productivity, wildlife habitat, or other special features of the area.

§§ 923.2, 943.2, 963.2. Road Construction. [All Districts]

Logging roads shall be constructed or reconstructed in accordance with the following requirements or as proposed by the RPF, justified in the THP, and found by the Director to be in conformance with the requirements of this Article.

(a) Logging roads shall be constructed in accordance with the approved THP. If a change in designation of road classification is subsequently made, the change shall be reported in accordance with 14 CCR 1039 or 1040, as appropriate.

(b) Where a road section which is greater than 100 feet in length crosses slopes greater than 65 percent, placement of fill is prohibited and placement of sidecast shall be minimized to the degree feasible. The director may approve an exception where site specific measures to minimize slope instability, soil erosion, and discharge of concentrated surface runoff are described and justified in the THP.

(c) On slopes greater than 50 percent, where the length of road section is greater than 100 feet, and the road is more than 15 feet wide (as measured from the base of the cut slope to the outside of the berm or shoulder of the road) and the fill is more than 4 feet in vertical height at the road shoulder for the entire 100 feet the road shall be constructed on a bench that is excavated at the proposed toe of the compacted fill and the fill shall be compacted. The Director may approve exception to this requirement where on a site-specific basis a Registered Professional Forester has described and justified an alternative practice that will provide equal protection to water quality and prevention of soil erosion.

(d) [Coast] Fills, including through fills across watercourses shall be constructed in a manner to minimize erosion of fill slopes using techniques such as insloping through-fill approaches, waterbars, berms, rock armoring of fill slopes, or other suitable methods.

(d) **[Northern, Southern]** Roads shall be constructed so no break in grade, other than that needed to drain the fill, shall occur on through fill; breaks in grade shall be above or

below the through fill, as appropriate. Where conditions do not allow the grade to break as required, through fills must be adequately protected by additional drainage structures or facilities.

(e) Through fills shall be constructed in approximately one foot lifts.

(f) On slopes greater than 35 percent, the organic layer of the soil shall be substantially disturbed or removed prior to fill placement. The RPF may propose an exception in the THP and the Director may approve the exception where it is justified that the fill will be stabilized.

(g) Excess material from road construction and reconstruction shall be deposited and stabilized in a manner or in areas where downstream beneficial uses of water will not be adversely affected.

(h) Drainage structures and facilities shall be of sufficient size, number and location to carry runoff water off of roadbeds, landings and fill slopes. Drainage structures or facilities shall be installed so as to minimize erosion, to ensure proper functioning, and to maintain or restore the natural drainage pattern. Permanent watercourse crossings and associated fills and approaches shall be constructed where feasible to prevent diversion of stream overflow down the road and to minimize fill erosion should the drainage structure become plugged.

(i) Where there is evidence that soil and other debris is likely to significantly reduce culvert capacity below design flow, oversize culverts, trash racks, or similar devices shall be installed in a manner that minimizes culvert blockage.

(j) Waste organic material, such as uprooted stumps, cull logs, accumulations of limbs and branches, and unmerchantable trees, shall not be buried in road fills. Wood debris or cull logs and chunks may be placed and stabilized at the toe of fills to restrain excavated soil from moving downslope.

(k) Logging roads shall be constructed without overhanging banks.

(1) Any tree over 12 inches (30.5 cm) d.b.h. with more than 25 percent of the root surface exposed by road construction, shall be felled concurrently with the timber operations.

(m) Sidecast or fill material extending more than 20 feet (6.1 m) in slope distance from the outside edge of the roadbed which has access to a watercourse or lake which is protected by a WLPZ shall be seeded, planted, mulched, removed, or treated as specified in the THP, to adequately reduce soil erosion.

(n) All culverts at watercourse crossings in which water is flowing at the time of installation shall be installed with their necessary protective structures concurrently with the fill, construction and reconstruction of logging roads. Other permanent drainage structures shall be installed no later than October 15. For construction and reconstruction of roads after October 15, drainage structures shall be installed concurrently with the activity.

(o) Drainage structures and drainage facilities on logging roads shall not discharge on credible fill or other credible material unless suitable energy dissipators are used. Energy

dissipators suitable for use with waterbreaks are described in 14 CCR 914.6(f) [934.6(f), 954.6(f)].

(p) Where roads do not have permanent and adequate drainage, the specifications of Section 914.6 [934.6, 954.6] shall be followed.

(q) Drainage facilities shall be in place and functional by October 15. An exception is that waterbreaks do not need to be constructed on roads in use after October 15 provided that all such waterbreaks are installed prior to the start of rain that generates overland flow.

(r) No road construction shall occur under saturated soil conditions, except that construction may occur on isolated wet spots arising from localized ground water such as springs, provided measures are taken to prevent material from significantly damaging water quality.

(s) Road construction not completed before October 15 shall be drained by outsloping, waterbreaks and/or cross-draining before the beginning of the winter period. If road construction does take place after October 15, roads shall be adequately drained concurrent with construction operations.

(t) Roads to be used for log hauling during the winter period shall be, where necessary, surfaced with rock in depth and quantity sufficient to maintain a stable road surface throughout the period of use. Exceptions may be proposed by the RPF, justified in the THP, and found by the Director to be in conformance with the requirements of this subsection.

(u) Slash and other debris from road construction shall not be bunched against residual trees which are required for silvicultural or wildlife purposes, nor shall it be placed in locations where it could be discharged into Class I or n watercourses.

(v) Road construction activities in the WLPZ, except for stream crossings or as specified in the TUP, shall be prohibited.

§§ 923.3, 943.3, 963.3. Watercourse Crossings. [All Districts]

Watercourse crossing drainage structures on logging roads shall be planned, constructed, and maintained or removed, according to the following standards. Exceptions may be provided through application of Fish and Game Code Sections 1601 and 1603 and shall be included in the THP.

(a) The location of all new permanent watercourse crossing drainage structures and temporary crossings located within the WLPZ shall be shown on the THP map. If the structure is a culvert intended for permanent use, the minimum diameter of the culvert shall be specified in the plan. Extra culverts beyond those shown in the THP map may be installed as necessary.

(b) The number of crossings shall be kept to a feasible minimum.

(c) Drainage structures on watercourses that support fish shall allow for unrestricted passage of fish.

(d) When watercourse crossings, other drainage structures, and associated fills are removed the following standards shall apply:

(1) Fills shall be excavated to form a channel which is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel.

(2) The excavated material and any resulting cut bank shall be sloped back from the channel and stabilized to prevent slumping and to minimize soil erosion. Where needed, this material shall be stabilized by seeding, mulching, rock armoring, or other suitable treatment.

(e) Permanent watercourse crossings and associated fills and approaches shall be constructed or maintained to prevent diversion of stream overflow down the road and to minimize fill erosion should the drainage structure become obstructed. The RPF may propose an exception where explained in the THP and shown on the THP map and justified how the protection provided by the proposed practice is at least equal to the protection provided by the standard rule.

§§ 923.4, 943.4, 963.4. Road Maintenance. [All Districts]

Logging roads, landings, and associated drainage structures used in a timber operation shall be maintained in a manner which minimizes concentration of runoff, soil erosion, and slope instability and which prevents degradation of the quality and beneficial uses of water during timber operations and throughout the prescribed maintenance period. In addition those roads which are used in connection with stocking activities shall be maintained throughout their use even if this is beyond the prescribed maintenance period.

(a) The prescribed maintenance period for erosion controls on permanent and seasonal roads and associated landings and drainage structures which are not abandoned in accordance with 14 CCR 923.8 [943.8,963.8] shall be at least one year. The Director may prescribe a maintenance period extending up to three years in accordance with 14 CCR 1050.

(b) Upon completion of timber operations, temporary roads and associated landings shall be abandoned in accordance with 14 CCR 923.8 [943.8,963.8].

(c) Waterbreaks shall be maintained as specified in 14 **CCR** 914.6 [934.6,954.6].

(d) Unless partially blocked to create a temporary water source, watercourse crossing facilities and drainage structures, where feasible, shall be kept open to the unrestricted passage of water. Where needed, trash racks or similar devices shall be installed at culvert inlets m a manner which minimizes culvert blockage. Temporary blockages shall be removed by November 15.

(e) Before the beginning of the winter period, all roadside berms shall be removed from logging roads or breached, except where needed to facilitate erosion control.

(f) Drainage structures, if not adequate to carry water from the fifty-year flood level, shall be removed in accordance with 14 CCR 923.3(d) [943.3(d), 963.3(d)] by the first day of the winter period, before the flow of water exceeds their capacity if operations are conducted during the winter period, or by the end of timber operations whichever occurs

first. Properly functioning drainage structures on roads that existed before timber operations need not be removed. The RPF may utilize an alternative practice, such as breaching of fill, if the practice is approved by the Director as providing greater or equal protection to water quality as removal of the drainage structure.

(g) Temporary roads shall be blocked or otherwise closed to normal vehicular traffic before the winter period.

(h) During timber operations, road running surfaces in the logging area shall be treated for stabilization (rocked, watered, chemically treated, asphalted or oiled) where necessary to prevent excessive loss or road surface materials.

(i) Soil stabilization treatments on road or landing cuts, fills, or sidecast shall be installed or renewed, when such treatment could minimize surface erosion which threatens the beneficial uses of water.

(j) Drainage ditches shall be maintained to allow free flow of water and minimize soil erosion.

(k) Action shall be taken to prevent failures of cut, fill, or sidecast slopes from discharging materials into watercourses or lakes in quantities deleterious to the quality or beneficial uses of water.

(1) Each drainage structure and any appurtenant trash rack shall be maintained and repaired as needed to prevent blockage and to provide adequate carrying capacity. Where not present, new trash racks shall be installed if there is evidence that woody debris is likely to significantly reduce flow through a drainage structure.

(m) Inlet and outlet structures, additional drainage structures (including ditch drains), and other features to provide adequate capacity and to minimize erosion of road and landing fill and sidecast to minimize soil erosion and to minimize slope instability shall be repaired, replaced, or installed wherever such maintenance is needed to protect the quality and beneficial uses of water.

(n) Permanent watercourse crossings and associated approaches shall be maintained to prevent diversion of stream overflow down the road should the drainage structure become plugged. Corrective action shall be taken before the completion of timber operations or the drainage structure shall be removed in accordance with 14 CCR Section 923.3 (d) [943.3(d), 963.3(d)].

(o) Except for emergencies and maintenance needed to protect water quality, use of heavy equipment for maintenance is prohibited during wet weather where roads or landings are within a WLPZ.

(p) The Director may approve an exception to a requirement set forth in subsections (b) through (o) above when such exceptions are explained and justified in the THP and the exception would provide for the protection of the beneficial uses of water or control erosion to a standard at least equal to that which would result from the application of the standard rule.

§§ 923.5, 943.5, 963.5. Landing Construction. [All Districts]

Landings shall be constructed according to the following standards:

(a) On slopes greater than 65 percent, no fill shall be placed and sidecast shall be minimized to the degree feasible. The director may approve an exception if, site specific measures to minimize slope instability, soil erosion, and discharge of concentrated surface runoff are described and justified in the THP.

(b) On slopes greater than 50 percent, fills greater than 4 feet in vertical height at the outside shoulder of the landing shall be: 1) constructed on a bench that is excavated at the proposed toe of the fill and is wide enough to compact the first lift, and 2) compacted in approximately 1 foot lift from the toe to the finished grade. The RPF shall flag the location of this bench or shall provide a description of the bench location (narrative or drawing) in the THP for fills meeting the above criteria, where the length of landing section is greater than 100 feet. The RPF may propose an exception in the THP and the Director may approve the exception where it is justified that the landing will be stabilized.

(c) Waste organic material, such as uprooted stumps cull logs, accumulations of limbs and branches, or unmerchantable trees, shall not be buried in landing fills. Wood debris or cull logs and chunks may be placed and stabilized at the toe of landing fills to restrain excavated soil from moving downslope.

(d) Constructed landings shall be the minimum in width, size, and number consistent with the yarding and loading system to be used. Landings shall be no larger than one-half acre (0.202 ha) unless explained and justified in the THP.

(e) No landing construction shall occur under saturated soil condition.

(f) The following specifications shall be met upon completion of timber operations for the year or prior to October 15, whichever occurs first:

(1) Overhanging or unstable concentrations of slash, woody debris and soil along the downslope edge or face of the landings shall be removed or stabilized when they are located on slopes over 65 percent or on slopes over 50 percent within 100 feet of a WLPZ.

(2) Any obstructed ditches and culverts shall be cleaned.

(3) Landings shall be sloped or ditched to prevent water from accumulating on the landings. Discharge points shall be located and designed to reduce erosion.

(4) Sidecast or fill material extending more than 20 feet in slope distance from the outside edge of the landing and which has access to a watercourse or lake shall be seeded, planted, mulched, removed or treated as specified in the THP to adequately reduce soil erosion.

(5) Sidecast or fill material extending across a watercourse shall be removed in accordance with standards for watercourse crossing removal set forth in 14 CCR 923.3 (d).

(g) On slopes greater than 35 percent, the organic layer of the soil shall substantially removed prior to fill placement

(h) When landings are constructed after October 15 they shall be adequately drained concurrent with construction operations and shall meet the requirements of (f)(l) through (f)(4) of this subsection upon completion of operations at that landing.

(j) The RPF may propose and the Director may approve waiver of requirements in (f)(l) through (f)(4) of this subsection if the Director finds they are not necessary to minimize erosion or prevent damage to downstream beneficial uses. The Director may also approve an exception to the October 15th date for treatment of slash and debris, including the practice of burning.

§§ 923.6, 943.6, 963.6. Conduct of Operations on Roads and Landings [All Districts]

Routine use and maintenance of roads and landings shall not take place when, due to general wet conditions, equipment cannot operate under its own power. Operations may take place when roads and landings are generally firm and easily passable or during hard frozen conditions. Isolated wet spots on these roads or landings shall be rocked or otherwise treated to permit passage. However, operations and maintenance shall not occur when sediment discharged from landings or roads will reach watercourses or lakes in amounts deleterious to the quality and beneficial uses of water.

This section shall not be construed to prohibit activities undertaken to protect the road or to reduce erosion.

APPENDIX D: STICK METHOD OF CURVE LAYOUT

Horizontal Curve Layout

Two simple procedures are described. The first, the center stake method, has been described in the text of the Handbook. The second, a stick procedure, is described below. The center stake method is limited to gentle terrain and good visibility while the latter is more suitable to difficult sites.

Stick Method

Simple curves may be staked on the ground with a stick and a tape. Using a 25 or 50 foot staking distance, consult Table D-l for the proper stick length to set the radius shown. Figure D-l shows the process.

Adjustments needed for Topography and Grade

The curve layout description assumes that the area is flat. Seldom is this the case. Measurements of length then need adjustment to compensate for slopes.

When the distance being measured is short, the tape can be held level. For longer lengths, measure the distance by segments-each held level. Where the distance is longer than convenient for the leveling method, adjust the measured slope's length by using Table 11 (see Chapter ffl).

Grade may be carried around the curve by running a line with the desired slope for the distance of the curve. This will often be away from the center line of the road due to the topography. If this occurs, run a level line to the point of tangency (PT), where the curve ends (see Figure D-2).

Table D-l. Stick length for curve radius by stake distance (ft)		
Curve Radius Feet	Stake Distance	
	25 feet	50 feet
50	6.7[1]	
60	5.5	26.8
80	4.1	17.6
100	3.2	13.4
150	2.1	8.6
200	1.6	6.4
250	1.3	5.1
300	1.1	4.2
350	0.9	3.6
400	0.8	3.1
600	0.5	2.1
800	0.4	1.6
1000	0.3	1.3

[1] *Convert tenths offeet to inches by multiplying 12 x decimal shown in table. For example: 6.7 ft.; 0.7 x 12 = 8.4 or 8; 6ft. 8 inches.*

Switchbacks

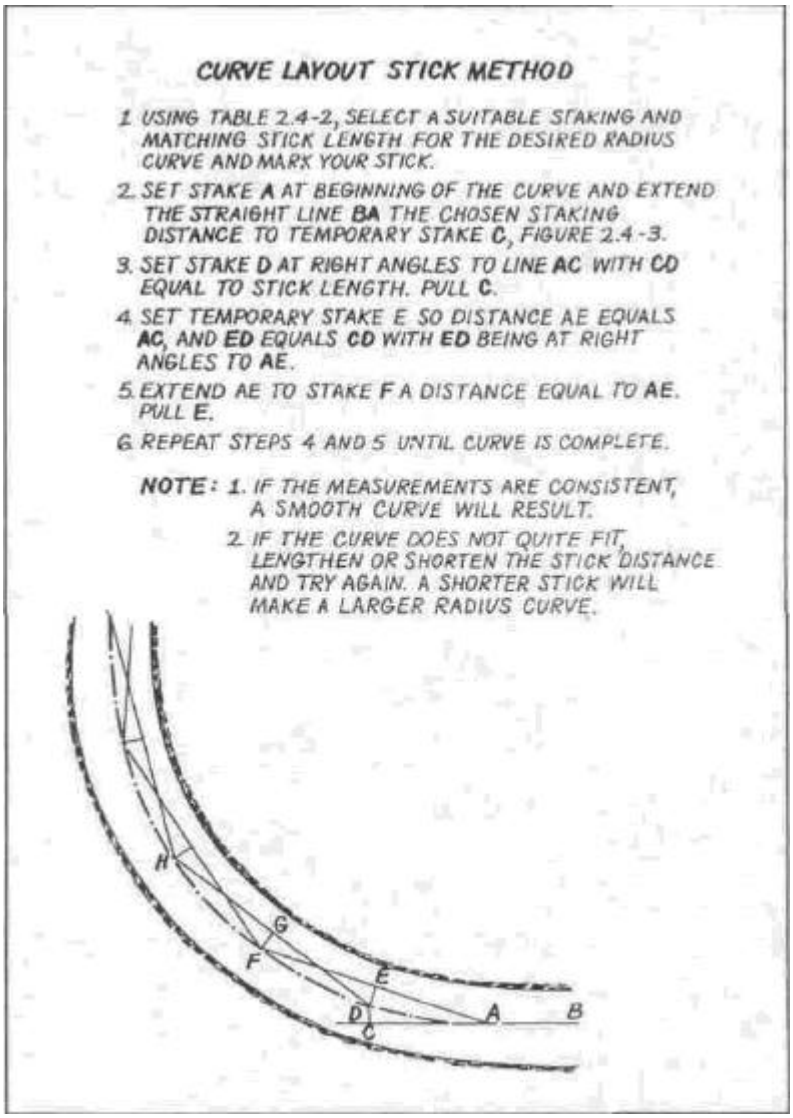
Where two control points cannot be reached by running maximum grade in a single direction, switchbacks are required. They are placed at the point where a grade reverses direction on a slope. Find the location for a switchback by running the greatest allowable grade downhill from the higher control to a location suitable for the turn.

Good switchback sites are areas with little side slope where the loop may be constructed with the least excavation. Look on low gradient benches or along broad, flat ridges for suitable sites.

Once the switchback has been located, you reverse the course of the tagline and continue downhill to see if additional turns are needed. Maximum grade is maintained until all switchbacks are located. Some adjusment can take place after one is assured of reaching the two control points.

Switchbacks usually require much earth movement. For this reason a comparison should be made between crossing controls and the added work to install a switchback.

Figure D-1



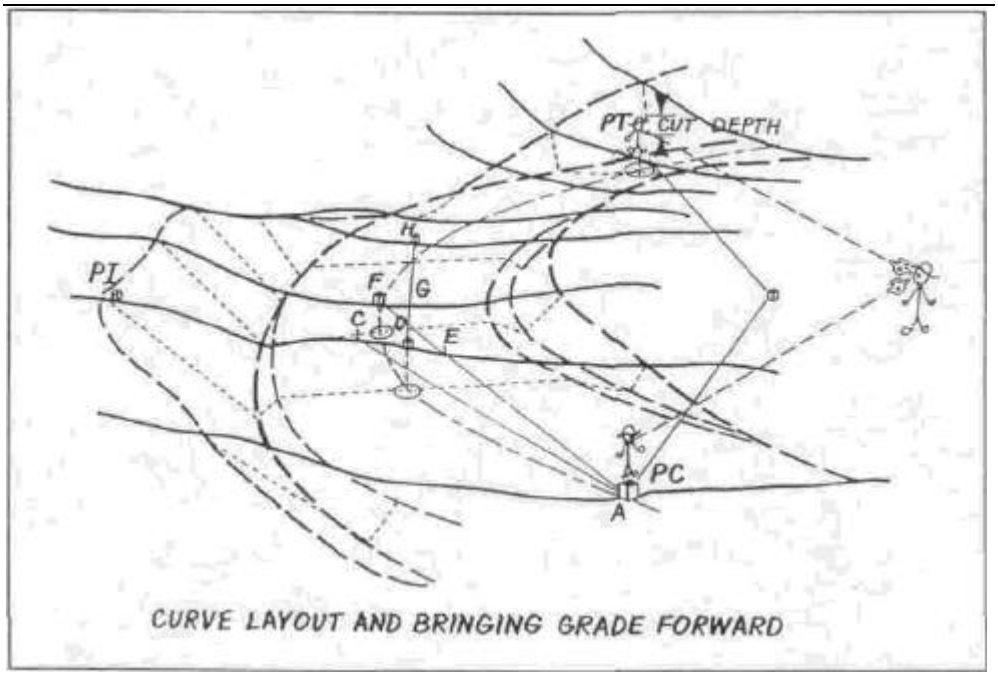


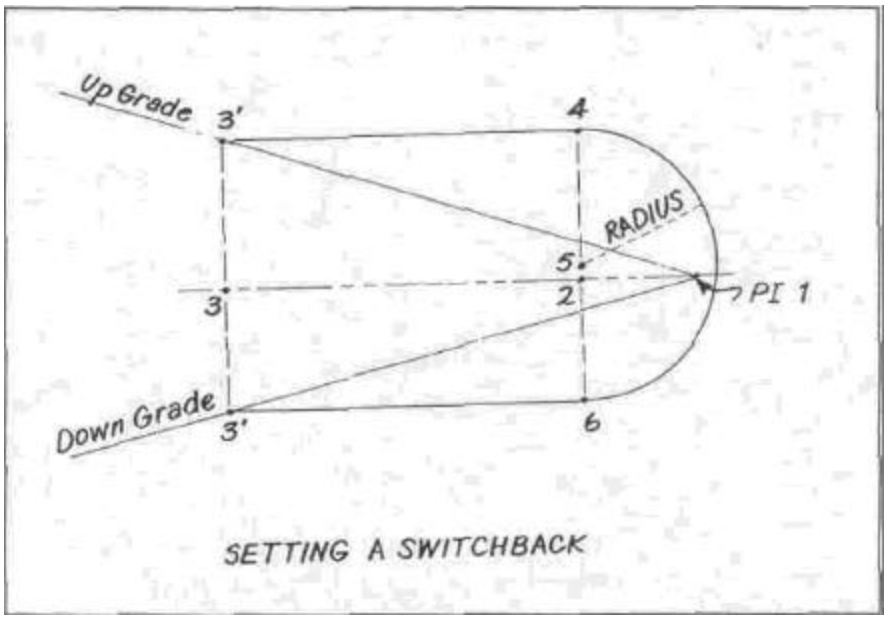
*Figure **D-2.***

Reduce the grade of the straight stretches into and out of the switchback. This will help maintain the grade through the curve. The curve itself is set at not more than 8 percent grade, and preferably much less.

There should be no more excavation of the hillslope than that needed to form fill along the lower side of the switchback. This is accomplished by offsetting the center of the curve until about half the curve is excavated.

To construct a switchback, do the following:

Figure D-3.



1. Stake intersection of the two grade lines, stake 1, Figure D-3.

2. Bisect the intersection angle, and set stake 2 on the line a curve radius distance from the point of intersection (PI).

3. Along the line bisecting the angle, place a stake 3 on its path where a right angle line equal to the curve diameter just touches the two grade lines. Set stakes 3'.

4. From the upper tagline,
run a new grade line back to the curve from stake 3 feet at approximately 2 percent less than the tagline grade. Where this new line reaches the extension of a right angle line from stake 2, set a new stake 4.

5. Measure the radius distance along the right angle line from stake 4 and place a new stake 5 for the center of the curve.

6. Mark out a curve using the center stake 5 until the extended right angle line from stake 2 is again reached. Set a stake 6.

7. From stake 7 run a grade line that will reach stake 3 feet along the lower side of the curve.

8. Note: Distances measured are horizontal (correct for slope. Table 11 (Chapter III). Constructing a right angle. Figure D-4. Bisecting an angle, Figure D-5.

Figure D-4.

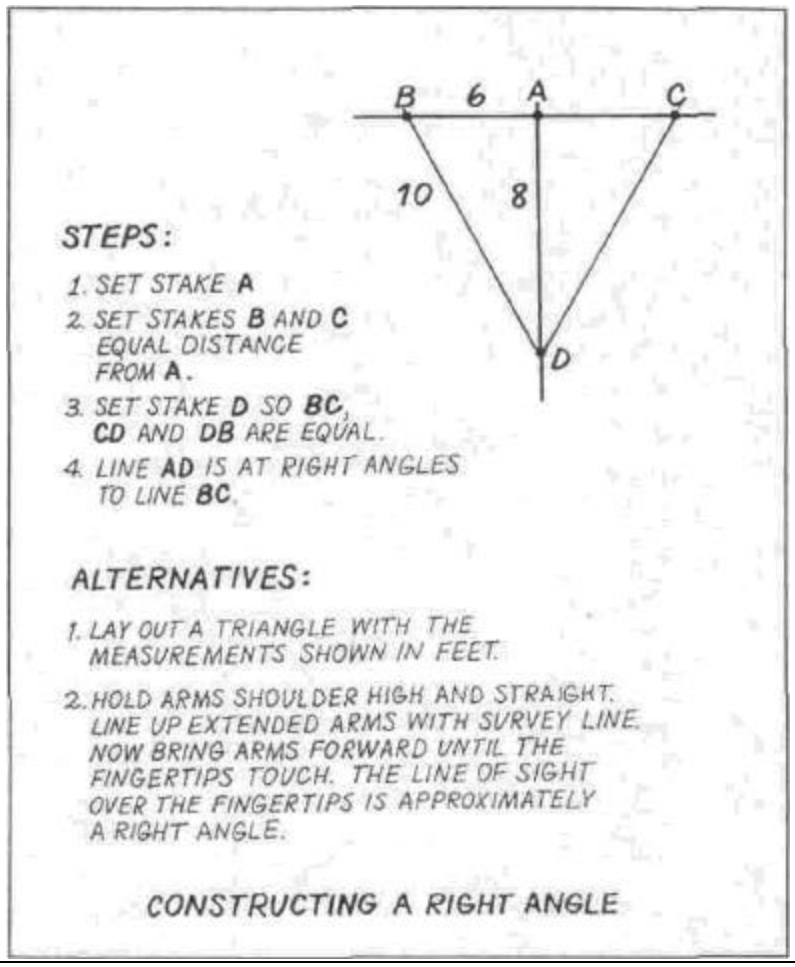
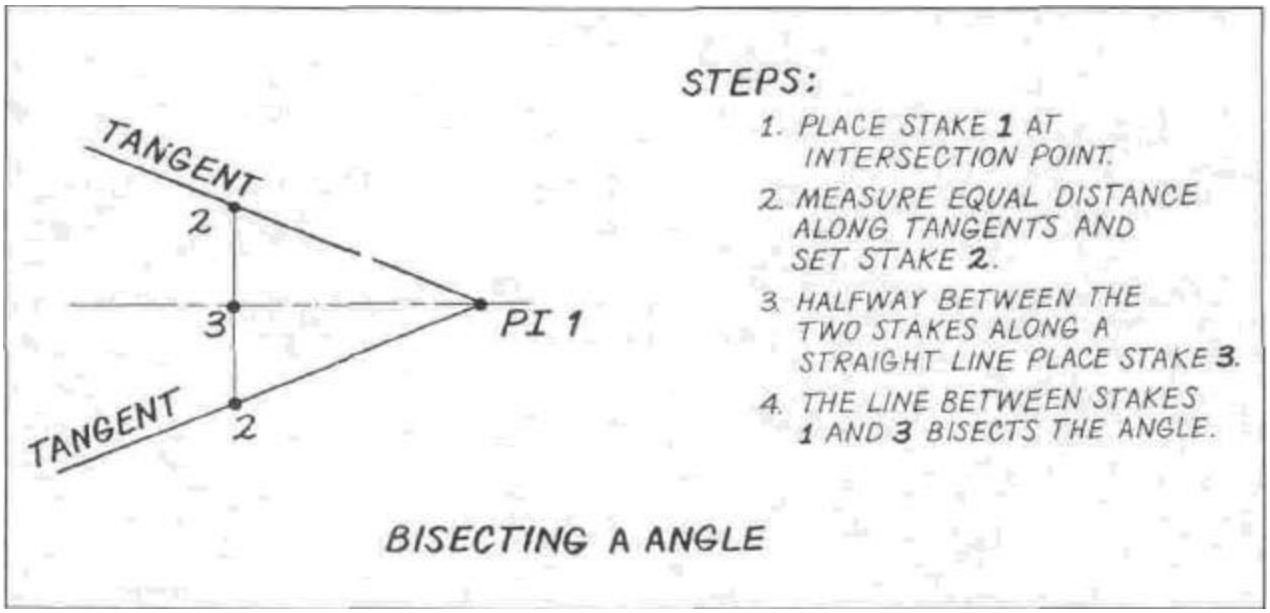


Figure D-5.



APPENDIX E: ESTIMATING CULVERT LENGTHS

Determining needed culvert lengths

The following simplified procedure 1 can be used to determine culvert lengths needed for installation of a new stream crossing or a ditch relief drain. Refer to the following diagram for specific locations and distances described in the step-by-step procedure. A complete example follows the step-by-step instructions.

STEP DO THIS...

1. **Estimate the depth of the fill (F) at the running surface on the inside of the road above the culvert inlet (point "a").**
2. **Additional width (C) due to fill is then estimated as 1.5 times the fill depth (F) (that is, all fill slopes are assumed to be 1.5:1 in steepness)**
3. **Add half the road width (½ W) and the fill width (C). Measure this distance <u>horizontally</u> upstream from the center line of the road and place stake at location A. The horizontal distance must be converted to slope distance before you can tape it off on the ground. Converting horizontal distance to slope distance (on-the-ground distance) is simple using the following chart.**
4. **Repeat steps 1 through 3 for the culvert outlet side of the crossing and place stake at location B.**
5. **Measure the slope length between stakes A and B. This measurement, plus two to four extra feet, is the length of culvert needed for the installation. The extra several feet are added to extend the inlet and outlet beyond the edge of the fill.**

1 Method for estimating required culvert lengths described in USDA (1981).

Slope correction factors to convert horizontal distance to slope distance			
Hillslope or stream channel gradient (%)	Correction factor (multiplier)	Hillslope or stream channel gradient (%)	Correction factor (multiplier)
10	1.00[1]	45	1.10
15	1.01	50	1.12
20	1.02	55	1.14
25	1.03	60	1.17
30	1.04	65	1.19
35	1.06	70	1.22
40	1.08	75	1.25

1 for a slope of 10% or less, no correction factor is needed.

For example: 44 feet horizontal distance equals 52.4 feet slope distance on a 65% slope.

horizontal distance **X** **correction factor** **=** **Slope distance**

(44ft) **X** **(1.19)** **=** **52.4ft**

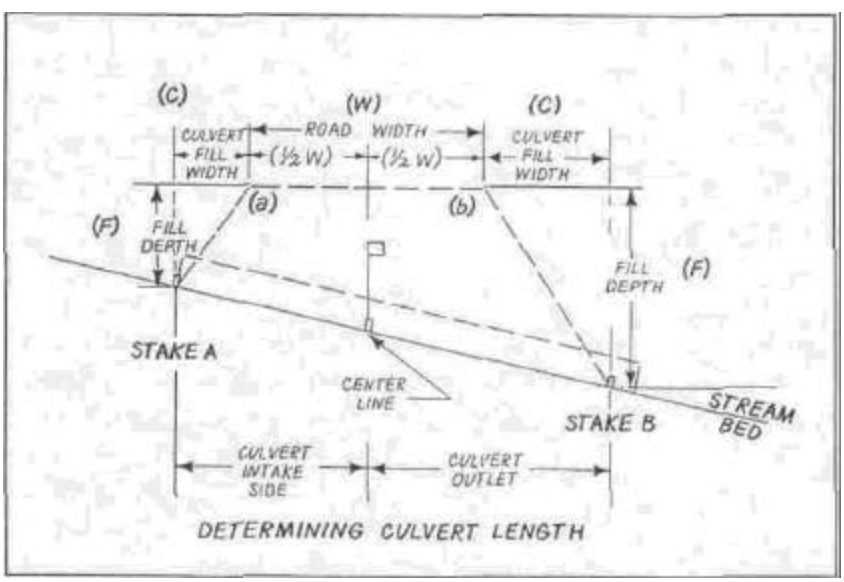


Figure E-I.

Example problem: ***What culvert length is needed for a 14 foot wide road crossing a stream with a 55% gradient. The estimated inside/ill depth, above the cmp inlet, will be 6 feet and the fill depth above the outlet will be 13 feet.***

Step 1: Estimated depth of fill (F) at culvert inlet = 6 feet

Step 2: C = 1.5 x 6 = 9 feet

Step 3: Want 14 foot wide road (W), so ^ x 14 = 7 feet

Stake A (the location of the culvert inlet) should be placed on the ground a distance of (9+7) = 16 horizontal feet up the stream channel from the flagged centerline of the road. According to the correction table, 16 feet horizontally on a 55% slope is **18.2 feet** slope distance (16' x 1.14 = 18.2'). ***Place the inlet stake** (A) **18.2 feet up the channel from the centerline of the road.***

Step 4: Estimated depth of fill (F) at culvert outlet =13 feet

Step 5: C = 1.5x13 = 20 feet

Step 6: Want 14 foot wide road (W), so ½ x 14 = 7 feet

Stake B (the location of the culvert outlet) should be placed on the ground a distance of (13 + 20) = 33 horizontal feet down the stream channel from the flagged centerline of the road. According to the correction table, 33 feet horizontally on a 55% slope is **37.6 feet** slope distance (33' x 1.14 = 37.6'). ***Place the outlet stake** (B) **37.6 feet down the channel from the centerline of the road.***

Step 7: Length of culvert needed = 18.2' + 37.6' = 55.8' or about **56** feet. Approximately two to four feet should be added to this length to make sure the culvert inlet and outlet extend sufficiently beyond the base of the fill.

Final culvert length to be ordered and delivered to the site = 56' + 4' = 60 feet

PART X

UPSLOPE EROSION INVENTORY AND SEDIMENT CONTROL GUIDANCE

This manual describes methods and techniques used with varying degrees of success by watershed restoration specialists. The methods and techniques described here represent only a starting point for project design and implementation. They are not a surrogate for, nor should they be used in lieu of, a project design that has been developed and implemented according to the unique physical and biological characteristics of the site-specific landscape.

The techniques and methods described in this manual are not a surrogate for acquiring the services of appropriate professionals, including but not limited to licensed professional engineers or licensed professional geologists, where such expertise is called for by the Business and Professions Code section 6700 et seq. (Professional Engineers Act) and/or section 7800 et seq. (Geologists and Geophysicists Act).

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ACKNOWLEDGMENTS

The principle authors of *Part X, Upslope Erosion Inventory and Sediment Control Guidance* are Dr. Bill Weaver, Danny Hagans and Eileen Weppner, Professional Geologist, of Pacific Watershed Associates (PWA). Dr. Weaver and Mr. Hagans are widely recognized as leading authorities in watershed assessment methods and the implementation of cost effective erosion prevention work throughout Northern California and the Pacific Northwest.

The editors of Volume II of the Manual wish to thank the many individuals who reviewed the text and provided comments or ideas on topics covered in *Part X*. From the California Department of Fish and Game these include: Gary Flosi, Bob Coey, Barry Collins, Scott Downie, Doug Albin, Bob Snyder, Marty Gingras, Mark Moore, Phil Warner, Mark Wheetley, Allan Renger, Trevor Tollefson, and Paul Divine. Kris Vyverberg, DFG Senior Engineering geologist, provided a detailed technical review of *Part X* that has improved the content and utility of the final document. Special thanks to Chris Ramsey and Shirley Lipa (DFG) for their work in editing and formatting.

Also reviewing the text were Steve Thompson and Mike Devany, NMFS; Ross Taylor, Ross Taylor and Associates; and Richard Harris, from the University of California, Cooperative Extension.

Funding for the development of *Part X* was provided by Proposition 70 funds, through the support of the Proposition 70 Review Committee. Special recognition goes to the members of the Coastal Salmon Recovery Program Advisory Committee for funding the first printing of *Part IX* and *Part X*. Without their financial support and that of the Proposition 70 Review Committee, the development and printing of Volume II of the Manual would not have been possible.

INTRODUCTION

Watersheds and streams have a natural background rate of erosion. Delivery of eroded sediment to stream systems occurs through various transport processes that operate in all watersheds. Natural erosion and sediment delivery varies from relatively low amounts in stable watersheds underlain by resistant rock types, to comparatively high amounts in watersheds that have soft rock types that erode more easily. During large storm events, mass wasting or landsliding, large-scale gully erosion, and stream bank erosion are more likely to occur. Between large disturbance events, erosion rates are generally lower and overall sediment delivery is low, although sediment may still enter the stream from various erosion processes. This can increase due to human influences. Native anadromous salmonids have evolved and successfully adapted through eons to stream habitat conditions produced by these natural processes within this dynamic environment. Excessive sediment delivery to streams can have a deleterious effect on anadromous salmonids by filling in pool habitat and burying spawning substrate.

Purpose

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. These treatments focus on erosion prevention and control on managed lands. The goal is to reduce the human influences and restore erosion to a level more consistent with the natural background rate. *Part X* discusses several components of watershed restoration:

- Sediment production and delivery;
- Upslope erosion assessment;
- Analysis and reporting of assessment data;
- Implementing sediment control work;
- Quality control, documentation of projects, and project monitoring.

The erosion assessment protocols included in *Part X* are for the identification and quantification of existing and potential sediment sources in upslope and stream bank locations. The inventory data forms include problem identification, quantification of existing and potential sediment sources, and the selection of proper treatment options. To conduct a successful assessment, the survey team must understand basic upslope erosion processes and be familiar with basic erosion control and erosion prevention techniques applicable to a particular setting. They must also be familiar with the heavy equipment used, its application for the various restoration techniques, and have the ability to estimate production rates. The general erosion control techniques presented must be adapted to site-specific conditions. Additional topic-specific publications and manuals for erosion prevention and control are included in the list of references.

Scope and Limitations

Part X has been prepared to provide the reader with an overview of basic information on watershed erosion processes (especially road-related erosion). This includes: how to identify and conduct a basic or simplified inventory of the erosion features associated with these processes; and some of the most common, less technical methods by which these processes and their impacts can be prevented or controlled. Only the most straightforward and most common of erosion

control and erosion prevention treatments have been described. Because this is not a comprehensive technical guidance manual, and because of the highly varied site specific conditions that are likely to be encountered in the field, not all the information needed to identify, evaluate and treat complex erosion processes or mass wasting features has been included.

Steps for identifying potential and existing landslides are outlined. After following these steps, the restoration practitioner should be able to recognize whether a landslide problem exists within a specified area, and then to seek the expertise of a geotechnical specialist for further analysis of the problem, assessment of risk, and recommendations for control and correction. Consultation with licensed and experienced professionals may also be required in situations that require a more detailed evaluation of field conditions, prescription options and treatment methods to address complex geomorphic processes or in situations that require highly technical analyses or employ complex treatment methods. This is especially true for situations involving all but the smallest mass wasting features (e.g., cutbank failures, minor embankment failures) and treatment areas located in steep and potentially unstable hillslope areas. Identification and prescriptive treatment of all but the most simple of earth failures is outside the scope of this document.

Audience

This guide has been written in non-scientific terms and is intended for persons conducting field inventories to identify areas that may be contributing excessive sediment to streams. Among others, this may include contractors, equipment operators, watershed planners, field technicians, and landowners. This guide is not intended to supplant, nor is it capable of supplanting, trained, experienced, and skilled watershed scientists and workers. It is intended as supplemental guidance on inventory and erosion control methods for the specialist. It is also intended to provide a basic knowledge of erosion control and prevention, and road and culvert removal planning and implementation techniques for persons without specialized training but an interest or need to participate in watershed protection activities.

LEGAL REQUIREMENTS

Upland erosion control and erosion prevention work typically involves earth moving and other work in around stream channels and on lands that often have other environmental limitations and restrictions. Permits for such activities are a normal component of restoration work. When working on Fisheries Restoration Grant Program (FRGP) projects, the Department of Fish and Game generally takes the lead role in securing the necessary California Environmental Quality Act (CEQA) permits.

For all projects that modify the bed or banks of a stream channel or divert the flow of a watercourse, no matter how small, a Streambed Alteration Agreement will be required from DFG. The Agreement spells out the permitted activities, the allowed timing of project work and the on-the-ground mitigations and protections that must be applied. Typical activities covered by the Streambed Alteration Agreement process include installation of stream crossing culverts, armored fill and bridge installations, installations of rock armor on a stream bank, and excavations of stream crossing fill.

Other CEQA clearances typically handled by DFG may include field surveys by trained experts in several disciplines and include archaeological surveys, listed plant surveys and surveys for threatened or endangered animal species. These surveys may identify listed species or areas of particular sensitivity that result in operating restrictions or exclusions of operations in certain portions of the project area. All of the biological surveys must be conducted at key times of the year (e.g., plant surveys are conducted during blooming periods), so pre-project planning is critical.

On the field level, federal and state water quality and pollution regulations are administered and enforced by Regional Water Quality Control Boards. Depending on the type of project being considered, consultation with a Regional Board may be required. The DFG Streambed Alteration Agreement contains requirements for controlling sediment and other pollution from a project site, but the Regional Boards enforce water quality violations through Stop-Work Orders, Clean Up and Abatement Orders, and Waste Discharge Requirements. Regional Board staff can provide technical information on how to control project-related pollution.

If trees will be cut during restoration activities and the logs and wood sold as byproducts of the restoration work, the project will also be subject to the California Forest Practices Act. A licensed forester can assist with preparation of the required permits needed for commercial forestry operations. If, on the other hand, the wood will not be sold but used in the project (e.g., to place in the stream channel or to use as bank protection), a timber harvest plan may not be necessary. In either case, consultation with a local office of the Department of Forestry and Fire Protection is recommended.

Finally, if the preliminary survey of an erosion area suggests that a failure area of unknown type and depth may be present, characterization of the problem and any treatment prescriptions must be developed in consultation with a licensed geotechnical specialist. All but the smallest landslides can be very complex features and the development of effective treatment options more often than not will require consultation with a licensed geotechnical specialist. The Board for Geologists and Geophysicists (BGG) examines and licenses Professional Geologists, Certified Engineering Geologists and Certified Hydrogeologists in California. The Board and licensed professionals in the field can provide information on circumstances that require professional advice.

SEDIMENT PRODUCTION AND DELIVERY

Land use activity can accelerate the natural background rate of erosion. It may also result in chronic delivery of sediment to stream channels. Three geomorphic processes are responsible for most sediment delivery from upland areas (Figure X-1). These are:

- Chronic surface erosion from bare soil areas;
- Fluvial erosion, including gully and stream channel erosion;
- Mass wasting or landsliding.

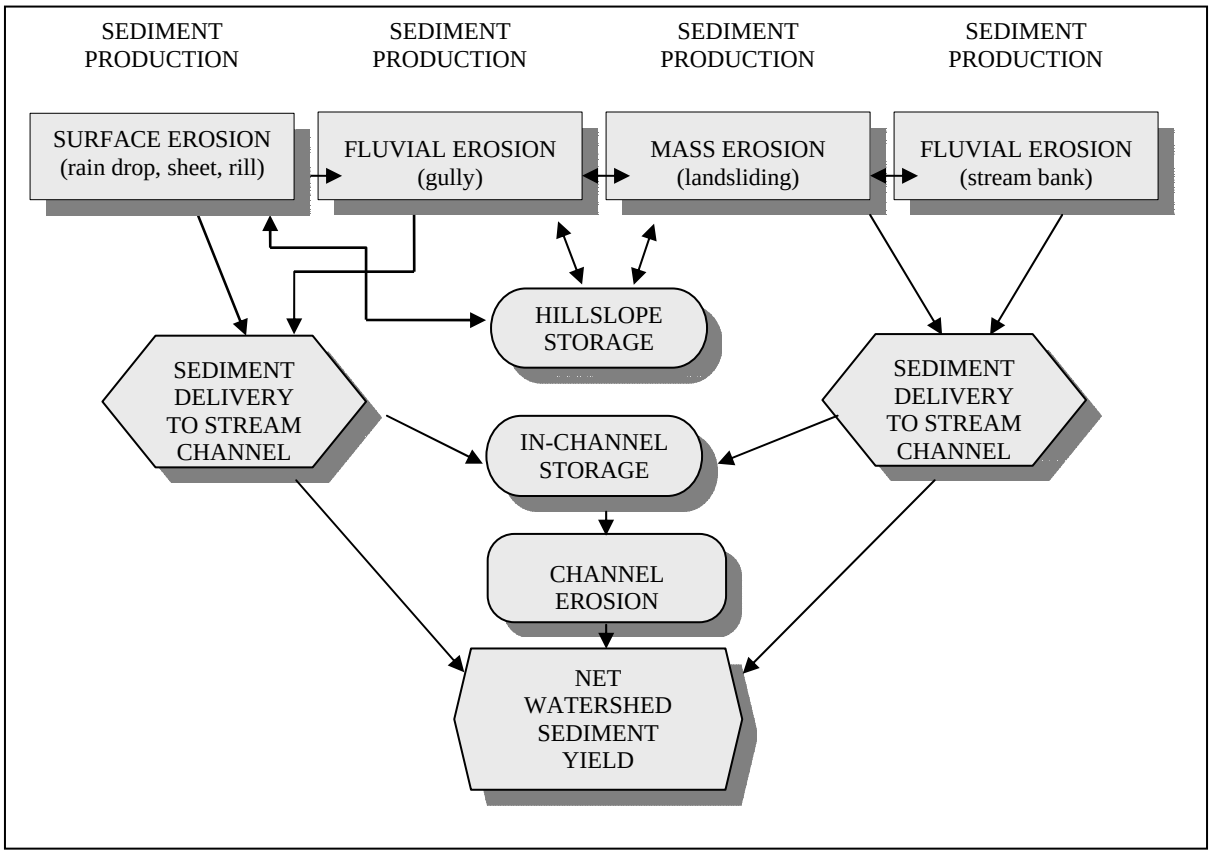


Figure X-1. Flow chart of erosion and sediment delivery to stream channels.

Understanding these processes is necessary for conducting successful upslope assessment and restoration (Table X-1). Most of these processes, once initiated, result in erosion of sediment, which transports to hillslopes or stream channels. Whether the sediment remains in storage, either on the hillslope or within the channel, depends on the sediment types; and the timing, magnitude and frequency of storm events within a watershed. Once sediment suspends in water, or is mobile within the streambed, it becomes part of the net watershed sediment yield.

Watershed erosion processes are neither simple nor easily controlled by human intervention. Some conditions are not restorable, reversible, or correctable. Successful treatments for erosion prevention and erosion control should be designed to address the erosion process (surface erosion, fluvial erosion, or mass wasting), not the land use. Thus, gully control practices are generally the same whether they are applied on agricultural areas, grazed land or for road-related erosion sites.

Finally, it is generally not possible, nor necessarily desirable, to stop all erosion. The preferred approach is one that reduces the risk of erosion or reduces the volume of eroded sediment delivered to a stream by the most effective and cost-effective method.

Process	Typical upslope sediment source locations	Sediment source characteristics and restoration opportunity					
		Nature of erosion processes	**Aggregate sediment delivery**	**Sediment type**	**Preventable erosion?**	**Controllable erosion?**	**Preventable sediment delivery?**
Surface erosion	Surface erosion from bare soil areas (road surfaces, construction sites, burned areas, etc.)	Chronic	Moderate	Fine Grained	Sometimes	Rarely	Usually
Mass wasting	Road fillslope failures	Mostly episodic, triggered by large storm events	Low to Moderate	Fine to Medium Grained	Usually	Rarely	Usually
	Landing failures		Low to Moderate	Fine to Medium Grained	Usually	Rarely	Usually
	Road cutbank failures		Low	Fine to Medium Grained	Rarely	Sometimes	Usually
	Stream bank landslides		Low to Moderate	All Grain Sizes	Sometimes	Rarely	Rarely
	Non-road (hillslope) debris landslides		Low to High	All Grain Sizes	Sometimes	Rarely	Rarely
	Earthflows and large, slow moving landslides		Low to Moderate	All Grain Sizes	Rarely	Rarely	Rarely
Fluvial erosion	Stream crossing washouts (gullies)		Low to Moderate	Fine to Medium Grained	Usually	Usually	Rarely
	Stream diversions (gullies)		Low to Moderate	Fine to Medium Grained	Usually	Usually	Rarely
	Other road-related gullying		Low	Fine to Medium Grained	Usually	Usually	Usually
	Non-road gullying		Low	Fine to Medium Grained	Sometimes	Sometimes	Rarely
	Stream bank erosion		Low to Moderate	All Grain Sizes	Sometimes	Sometimes	Rarely

Table X-1. Sources, magnitude and restoration potential of sediment production and delivery mechanisms in upland watersheds.

To accurately identify upslope sediment sites and recommend effective and cost-effective treatments, restoration practitioners must have a clear understanding of the following:

- How erosion processes operate and lead to sediment delivery to streams;
- How land use affects erosion processes in predictable ways;
- Which erosion processes are preventable and controllable, and which are not;
- How the recommended erosion treatment will result in reduced sediment delivery to a stream.

Surface Erosion

Surface erosion results from raindrop impact and un-channeled water flowing over bare soil during and after rainstorms. Exposed soil is a direct consequence of almost all land use activities. Anywhere there is bare soil there will be potential for surface erosion. Runoff and surface erosion from bare soil areas depends on rainfall intensity and duration, the frequency of disturbance, the length of time exposed, soil type and grain size. Often, surface erosion from bare soil areas diminishes after the first rain event, except on unsurfaced roads and other bare soil areas where disturbance and resultant surface erosion can become a chronic problem.

Rates of surface erosion vary from watershed to watershed. In some watersheds where mass wasting is relatively uncommon, but soil easily erodes, surface erosion can be the predominant sediment delivery process. Surface erosion turns into sediment delivery when the runoff discharges into a stream channel, often through rills or small gullies. The development of rills, defined as channels smaller than 1' x 1' in cross section, is included with surface erosion processes.

Characteristics of Surface Erosion

- Surface erosion is greatest in fine granular soils such as silt and sand. Areas of decomposed granitic bedrock are particularly susceptible. It is typically lowest in rocky or clay-rich soils.
- Surface erosion is greatest in the first year after exposure and usually diminishes greatly thereafter unless the area is chronically disturbed as on unsurfaced roads.
- Surface erosion moves and delivers mostly fine sediment such as clay, silt or fine sand.
- Eroded sediment does not move long distances unless transported by rills, gullies or other concentrated flow channels such as road ditches or ruts.
- Sediment delivery to a stream requires direct connection of bare soil areas with stream flow channels such as rills, gullies, and ditches.
- Site-by-site, surface erosion volumes are often comparatively small, but cumulatively, over time, or over large watershed areas, volumes can be very large.

Restoration and Protection Principles for Surface Erosion

- Keep bare soil to an absolute minimum when conducting land use activities. This is the single most effective method for preventing land use related surface erosion.

- Mulch or revegetate bare soil adjacent to stream channels, or other flow transport paths, to the break-in-slope near those areas. Mulching is the single most effective and cost-effective method for controlling surface erosion.
- Keep runoff from bare soil areas well dispersed. Dispersing runoff keeps sediment on-site and prevents sediment delivery to streams.
- Direct any concentrated runoff from bare soil areas into natural buffers of vegetation or to gentler sloping areas where sediment can settle out.
- Prevent rills by breaking large or long bare areas up into smaller patches that can be effectively drained before rills can develop.
- Disconnect and disperse flow paths, including roadside ditches, which might otherwise deliver fine sediment to stream channels. This prevents most sediment delivery.

Fluvial Erosion

Fluvial erosion includes gully erosion and stream bank erosion. It occurs when concentrated flowing water scours and erodes soil along its path, whether it is within a natural stream channel, or on a previously un-channeled slope. The amount of erosion that occurs is a combined function of the energy of the flowing water and resistance of the flow path to scour. Thus, the greater the flow volume or flow velocity, the greater is the erosive power. Similarly, the more erodible the soil type, the more soil loss will occur. Fine grain granular soils like silt and sand are most likely to erode; and rocky soils and bedrock are the least likely to erode.

Fluvial erosion can also be a chronic source of sediment, where gullies gradually increase in size or stream banks continue to erode, with routine runoff events. However, most erosion and sediment delivery from fluvial processes occurs during episodic storm events. The largest storm events usually trigger greatly increased fluvial erosion, as new gullies form and existing gullies enlarge. Periods between episodic storm events are usually times of lower fluvial erosion rates.

Fluvial erosion is usually a very efficient sediment delivery mechanism. The larger a gully system, the more likely the eroded sediment will be delivered directly to a stream channel. Fluvial erosion rates can vary greatly between watersheds, depending on soil types, land use and land management practices.

Fluvial erosion may be accelerated by land use activities that result in increased runoff, or allow runoff to concentrate and discharge onto hillslopes prone to erosion. Fluvial erosion commonly occurs at gullies developed on hillslopes at culvert outlets, diverted streams, washed-out stream crossings, inboard ditches, and stream channels exposed to increased runoff.

Stream crossings are common sites of gully erosion along road systems. They commonly fail in the following ways:

- Overtopping, which may occur when a culvert plugs, or its capacity is exceeded and water flows over the road;
- Stream diverts when a culvert plugs or its capacity is exceeded, and the stream flow is diverted down the road, instead of over-topping the stream crossing fill;

- The crossing collapses when the stream flow tunnels through the fill, as occurs with Humboldt log crossings, and rusted out culverts;
- Stream crossing fills without culverts on abandoned roads gradually erode and wash out.

Characteristics of Fluvial Erosion

Although minor scour may occur and banks may locally collapse and erode between storms, a gully formed by a large runoff or flow event may not grow significantly, until an equal or larger event occurs. The following are characteristics of fluvial erosion:

- Sediment delivery from fluvial erosion can be both chronic and episodic. Fluvial erosion produces, transports, and delivers both fine and coarse sediment to stream channels.
- Stable gullies can serve as conduits for fine sediment delivered from other sources, such as roads. Any sediment delivered to a gully system from another sediment source such as road surface runoff, is likely to deliver to a stream channel somewhere down slope.
- Gullies are channels that have a cross sectional area over one square foot (1' x 1'). Gullies are like conveyor belts; they are very efficient sediment delivery mechanisms that can transport eroded sediment long distances over varied terrains and slopes.
- Gullies in rocky soils tend to eventually armor themselves and become increasingly resistant to continued down cutting and enlargement.
- Individual fluvial erosion sites may be small (less than 10 yd^3) but huge gullies (greater than 1,000 yd^3) can also develop on unstable hillslopes. Concentrated runoff and diverted streams can create large gullies, and may trigger the formation of landslides on otherwise stable hillslopes.

Restoration and Protection Principles for Fluvial Erosion

- Prevent gullies by dispersing runoff from roads, ditches and construction sites, by correctly designing, installing and maintaining drainage structures (e.g., road shape, rolling dips and culverts) and by keeping streams in their natural channels. No single point of discharge from a road or other disturbed area should carry sufficient flow to create gullies. If gullies continue to develop, further disperse the runoff.
- Direct any concentrated runoff from bare soil areas, such as road surfaces, into natural buffers of vegetation, or to areas where sediment can settle out of the runoff.
- Dewater active gullies to prevent their enlargement and to reduce their capacity for sediment transport.
- When dewatering is not possible, options include channel armoring and grade control structures. These specialized erosion control techniques are more costly and less effective than prevention and dewatering, and do not stop sediment transport. They typically require an engineered design, proper installation, and a commitment to maintenance (*Part VII*).

Mass Wasting

In many watersheds in north coastal California, mass wasting is the most common geologic process of sediment production. Common types of landslides in the natural environment range from large rotational and translational landslides and earthflows, to large and small debris slides,

to small slumps. Landslides typical in steep forested terrain of coastal California have been described (CGS 1999) and mapped (CGS 1982-95) in many coastal watersheds of northern California. CGS Note 50, *Factors Affecting Landslides in Forested Terrain*, provides descriptions and illustrations of the various types of landslides that have been identified on the north coast. The California Geological Survey (CGS) landslide inventory maps (CGS Note 40) can be used to locate basic landslide features that have been identified and mapped in many salmonid watersheds of Del Norte, Humboldt, and Mendocino counties, as well as selected other watersheds of the State (CGS 1982-95). These maps can help restorationists identify unstable and potential unstable terrain within watersheds that are targeted for erosion inventories and development of erosion control plans.

Landsliding is a gravitational process. Soil slides down slope when the gravitational forces exceed the forces that hold it in place (friction). Factors affecting landslide sediment delivery include proximity to a stream, slope steepness, slope shape, moisture content, and soil composition. Landsliding occurs in the natural environment, but land management activities that cause increased driving forces or decreased slope resistance can accelerate it. Road construction and its associated spoil disposal is an example of a land management activity that may trigger landsliding. Land management activities that cause or increase landsliding include:

- Slopes undercut and destabilized during road or other construction activities;
- Un-compacted and unstable spoil materials disposed of onto steep slopes;
- The diversion and collection of water on otherwise stable slopes.

There are a number of indicators of unstable or potentially unstable slopes. In the field, potentially unstable ground often, but not always, displays direct evidence of instability such as cracks, scarps, and leaning or pistol-butted trees. Previous failures in similar locations in nearby areas may also suggest the potential for addition slope instability. Slopes may also exhibit indirect evidence or a suite of contributing factors that can lead to slope instability. These factors include but are not limited to steep or oversteepened slopes, convergent topography, colluvial soils on impermeable shallow bedrock, emergent groundwater, hydrophillic (water loving) vegetation and mottled soils indicative of elevated ground water, known unstable soils and geologic formations, and proximity to faults and shear zones.

Water in and on hillslopes is usually a key contributing factor to the occurrence of landslides. Landslides often occur in close geographic proximity to springs, seeps and other forms of emergent groundwater. Roads intercept subsurface flow paths, with water either emerging from the cutbank (contributing to cutbank failures) or being blocked by overburden and uncompacted earthen materials disposed of downslope of the road (sidecast materials). Subsurface damming of groundwater contributes to fillslope failures and to larger debris slides where topographic swales and colluvial hollows fail by the build up of water pressures in the subsurface.

In general, the smaller the landslide, the more easily it can be prevented or controlled. In contrast, larger management-related landslides may be preventable, but they are rarely controllable once they begin sliding (TRB 1978; GSA 1987). Landsliding rates can vary greatly between watersheds, depending on natural slope stability, land use and management practices. Landsliding becomes sediment delivery when material slides or flows into a stream channel. Some types of landslides are efficient at delivering sediment to streams while others rarely result

in sediment delivery. Both timing and location in the watershed determine this. For example, streamside debris slides are infrequent but may result in substantial direct delivery of sediment, whereas cutbank landslides along roads are notoriously frequent, but typically lack major amounts of sediment delivery. Very few landslides deliver all their material to a stream; some sediment is generally stored on the hillslope.

Characteristics of Mass Wasting

- Sediment delivery to stream channels from landsliding occurs primarily as episodic inputs as the result of direct landsliding. Some slide surfaces, such as those on large landslides along roads or stream channels may remain largely un-vegetated for years, but surface erosion and gulling of the slide surface usually produces far less sediment delivery than the landslide event itself.
- Landsliding is predominantly an episodic process that occurs during or in response to rainfall and runoff events. Large storm events typically cause more and bigger landslides.
- Steep hillslopes, weak rock types and certain soils are more prone to landsliding than other soil types. In general, steeper hillslopes have a higher potential for landslides. Diverted runoff or slopes undercut by migrating streams can cause landslides to form on previously stable hillslopes.
- Sediment delivery is largely controlled by slope steepness, slope shape (i.e., concave, convex or planar), landslide volume, water content (fluidity), and proximity to the stream. Not all landslides deliver sediment to a stream channel. This depends on the failure mechanism, the distance between the failure area and the stream channel, and the overall mass of the slide.
- Some landslides that start out as small volumes can quickly increase in volume as they move down slope. Other landslides may quickly lose material as they move down slope. Water content, hillslope steepness and shape, landslide mass and the type, size and amount of vegetation in the landslide's path largely control the distance sediment moves.
- Landslides that do result in direct delivery, deliver any trees and other organic material present in the area of failure along with all sediment grain sizes that are present on the hillslope and in the underlying soil and bedrock material.

Restoration and Protection Principles for Mass Wasting

- Prevent accelerated landsliding by identifying, avoiding and protecting potentially unstable slopes through appropriate land management.
- Only treat landslides that have the potential to deliver sediment to a stream channel.
- Divert surface and subsurface drainage to stable areas away from steep, unstable slopes.
- Revegetation is a valid long-term restoration technique for unstable and potentially unstable slopes, but revegetation is sometimes very difficult and the benefits will take decades to develop.
- Small landslides, especially those that occur in sidecast materials, are often most effectively prevented or controlled by direct excavation of all or most of the potentially unstable material. This is often the most effective and cost-effective technique for preventing road-related landsliding.

- In some instances, sediment delivery from some medium and large size landslides can be controlled by excavating and removing material at the head of the slide. Removal of mass from the top of a slide may unload the slide sufficiently to stabilize the remaining mass. Projects to stabilize landslides must consider the size and volume of the slide, the volume of sediment to excavate, and the predicted volume of sediment prevented from delivery to a stream. The amount of unloading required is a technical assessment that requires professional analysis. The California Business and Professions Code requires that such a determination be made by a registered Professional Geologist, a Certified Engineering Geologist, or geotechnical Professional Engineer working within their area of expertise.
- The most cost-effective restoration treatment for large, uncontrollable landslides is often direct excavation and removal of slide material poised for delivery to a stream. This technique reduces sediment delivery but does not attempt to prevent or control landslide movement. Corrective actions and control measures for medium and large landslides are outside the scope of this document and require the assistance of appropriately trained and experienced Professional Geologists, Engineering Geologists and Geotechnical Engineers.
- Large landslide scars can be slow to revegetate, and although highly visible for many years after the initial failure, the scars may be an artifact of past landsliding and not an indication of future landslide potential. In many cases, most future sediment delivery from bare landslide scars will come from surface erosion and gullying. These processes are often not cost-effective to control due to the difficulty of access, extremely steep slopes, and harsh site conditions.
- Vertical head scarps and tension cracks around the top of old landslides are usually signs of stress relief that developed during or immediately after the original landslide failure. They are usually not sites of future sediment delivery because the potential sediment volumes are comparatively small and any material that does fail is usually redeposited immediately down slope on the original slide mass. Head scarp areas of old landslide scars should only be considered for treatment if there is the potential for future sediment delivery, and then only in consultation with licensed and experienced geotechnical professionals.

UPSLOPE EROSION ASSESSMENT

Determining which watersheds have the greatest potential for salmonid restoration is critical in identifying candidate watersheds for erosion assessment. Impacted watersheds with restorable salmonid populations are obvious targets for erosion assessment. Recovery of ecosystem function will be most successful where there is both restoration and prevention efforts. There is no easy, quick, or cheap way to restore most watersheds.

Healthy watersheds with strong salmon and steelhead populations are also in need of erosion assessment, for they will be the seat of future stock recovery for nearby degraded watersheds (Bradbury et al 1995). Although healthy watersheds may serve as refugia for salmonid populations, consider the potential for future sediment-related degradation. This dictates the inventory of healthy watersheds, and inclusion of sediment reduction measures in future land use activities.

Assessment Scales and Priority Criteria

Watershed problems and restoration treatments vary across the landscape. It is important to set priorities for both upslope assessment and for resultant protection and restoration actions. In the context of this manual, salmonid conservation biology drives the need for upslope assessment and restoration. For this reason, it is important to develop a biologically based strategy for setting watershed assessment, protection and restoration priorities (Bradbury et al 1995).

Watershed Categorization

Divide watersheds into logical assessment and restoration units. Prioritize both upslope assessment and actual restoration treatments on these land units (Figure X-2). From large to small, these assessment land units include:

- River basins - large land units with an integrated drainage system often exceeding 300 square miles in area and containing many named subbasins and watersheds and many miles of fish bearing (or Class I) stream channels (e.g., Mattole River, 396 mi^2);
- Subbasins - intermediate to large size land units, consisting of integrated drainage systems with an area generally ranging from 50 to 300 square miles or more and generally including many named watersheds and Class I stream channels and tributaries (e.g. Western Mattole Planning Subbasin, 89 mi^2);
- Watersheds - intermediate sized land units, consisting of integrated drainage systems with an area generally ranging from 10 to 50 square miles with a number of named tributaries and few to many sub-watersheds and Class I stream channels (e.g., Honeydew Creek, 17.2 mi^2);
- Sub-watersheds - smaller watershed units generally ranging from 1 to 10 square miles with few or no Class I stream channels (e.g., Bear Trap Creek, 1.7 mi^2);
- Hillslope units - logical topographic or management units within a watershed or sub-watershed that may be defined by natural boundaries (such as ridges and streams) or by management features (such as roads);
- Sites - individual treatment sites of on-going or future sediment delivery ranging in size from 100 ft^2 (or less) to 100 acres. This includes individual stream crossings, gullies, stream banks, road reaches, landslides and other erosion sources.

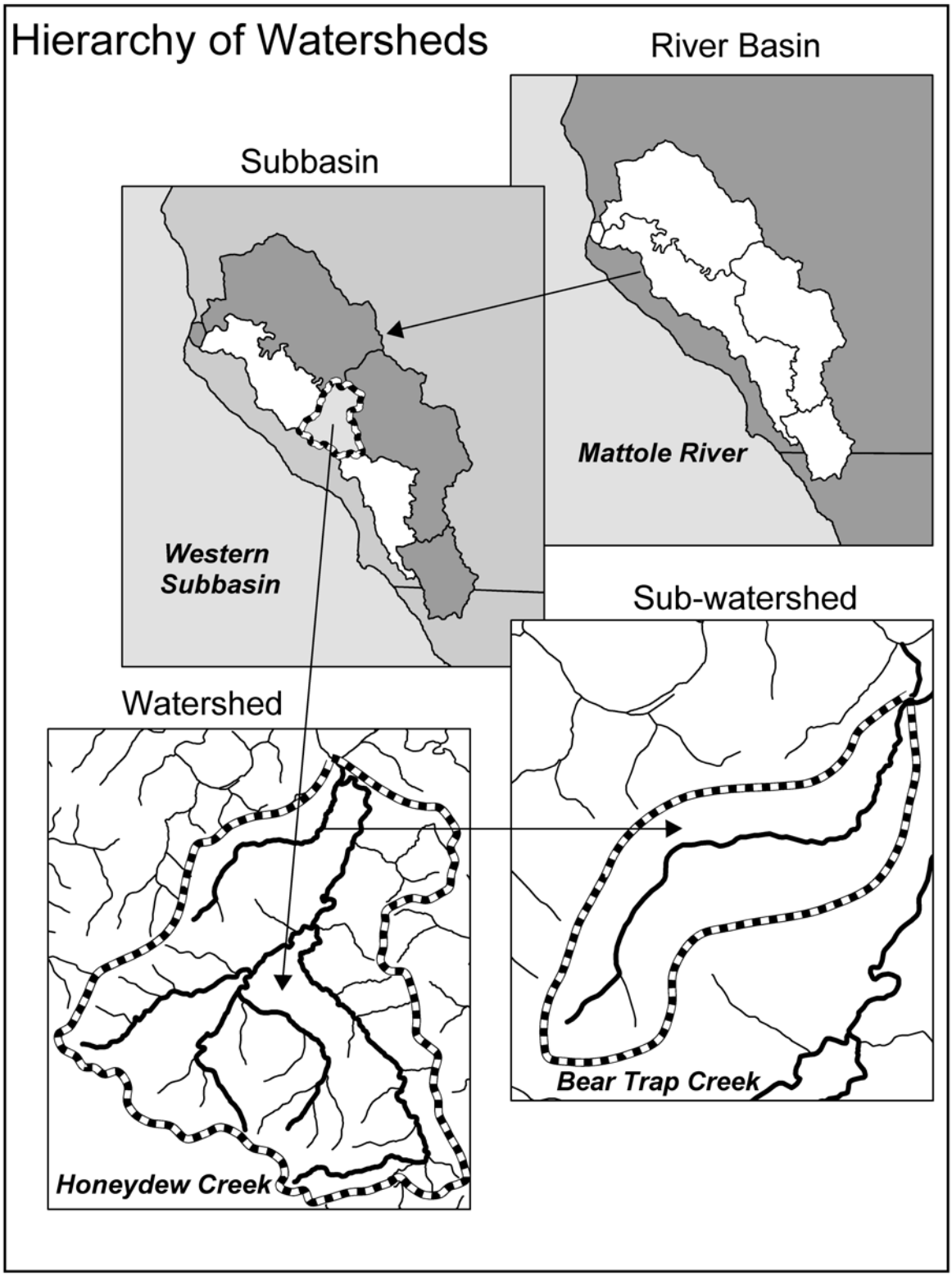


Figure X-2. Watershed hierarchy.

Priority Criteria

Prior to conducting an upslope assessment, research the relative health of the salmonid populations and habitat conditions in the assessment area of interest. Base the assessment on known or suspected limiting factors for salmonids, as well as on potential resources at risk where the aquatic system is not severely impaired but where watershed threats may be imminent. This dual focus will direct assessments to watersheds where the best benefit to the resources are achievable. Information that would support this conclusion, and the decision to proceed with an upslope assessment, is often available from DFG or other professionals who are most familiar with watershed conditions, historic and present use by salmonids, limiting factors, threats and the overall health of the aquatic system. A restoration and protection strategy can then be employed which makes logical and biological sense.

1st Priority - Habitat Protection

Aim initial efforts at protecting the best remaining refuge watersheds; that is, those areas with the best habitat, and healthiest and most diverse populations of fish and other forms of aquatic life. This may also include areas where special at-risk populations are present. The success of the protection effort is dependent on the effective use of protective land use practices and preventative land management.

2nd Priority - Habitat Restoration

This includes impacted watersheds that still have the potential for recovery. In these watersheds, use restoration as a tool to enhance or recover fish populations and aquatic ecosystem function over the intermediate term. These watersheds include streams that have had historic fish runs but do not currently support viable fish populations. Because of relatively few limiting factors, restoration activities should focus on the causes, not symptoms, to improve watershed and habitat conditions and processes. These sites, when improved, will become logical areas for fish to re-colonize most rapidly. Even though protective land use practices are undertaken, full recovery of these watersheds could take decades.

3rd Priority - Water Quality Restoration

This includes those sub-watersheds and headwater areas where access for anadromous fish is naturally limited due to increased stream gradient or natural barriers. These areas nonetheless perform vital ecological function for the entire aquatic ecosystem, by providing cool, clean water, large woody debris, and food (nutrient) products for aquatic species. Example treatments include upslope and riparian restoration to reduce sediment inputs and to lower summer water temperatures to larger connecting streams utilized by anadromous fish.

4th Priority – Mainstem River Restoration

Estuary enhancement, adult and juvenile salmonid migration improvements and riparian restoration are projects done directly to improve the main channel of most large river basins to improve fish and aquatic habitat. These areas are critical for anadromous fish.

5th Priority or Last Priority Watersheds

It may be best to consider watersheds with multiple limiting factors non-restorable. These watersheds could absorb most of the money that is available for watershed restoration, with little or no chance for noticeable recovery within the time span of several human generations (Frissell

1993). Identify non-restorable watersheds early in the planning process. Consider work in these areas after protection and completion of erosion prevention in the more productive watersheds is accomplished.

Site Specific Assessment Strategies

When not all of a watershed or sub-watershed can be completely inventoried with the available funding and resources, there are other strategies that can be employed to help direct assessment efforts. Certain sub-watershed areas and management conditions are more likely to contain problems than others; these are usually the best places to focus on when inventory resources are limited. Two recommended areas to focus on are:

- Sensitive landscape areas**:** Lower hillslope areas; steep hillslopes; riparian zones; fish bearing stream channels; areas with a high density of stream channels; and areas of highly erodible or unstable soil. These areas are sensitive because of their susceptibility to erosion and/or mass wasting, or because they are so close to stream channels that any significant erosion would deliver sediment to streams and adversely affect fish habitat.
- Common sediment producing areas in managed landscapes: This considers roads of all types, including railroad grades, jeep trails, and logging skid trails; quarries and rock pits; cultivated agricultural areas on hillslopes; all terrain vehicle (ATV) and livestock trails; development and construction sites; and recently burned or cleared areas.

Assessment Scales

When possible, assess a watershed in its entirety. If social and economic factors necessitate a partial assessment, then assess the most biologically important sub-watersheds first, with completed inventories developed into prioritized restoration plans for the inventoried sub-watersheds as the assessment progresses. Alternately, if funds are limited, assessment of low risk areas (e.g., ridge tops) in these same sub-watersheds can be deferred while those portions of the landscape that are most likely to contain significant, treatable sediment sources (e.g., lower and middle hillslope areas with high road densities and/or abandoned roads and numerous stream crossings) can be inventoried first. Sometimes, landowner access will partially dictate which watershed areas can be inventoried.

The following list outlines some examples of high and low priority assessment areas or features used to stratify a watershed or sub-watershed for partial assessment.

Higher priority assessment areas in watersheds typically include such features as:

- Roads in sensitive hillslope locations (steep, unstable slopes);
- Roads built in highly erodible terrain (decomposed granite and erodible grassland soils);
- Roads with numerous and/or volumetrically large stream crossings;
- Old roads and abandoned roads with stream crossings;
- High use, unsurfaced or rock surfaced roads;
- Hillslopes exhibiting diverted streams and skid trails;
- Class I stream channels;
- Recent construction areas, rock pits and borrow sites.

Lower priority assessment areas typically include such features as:

- Ridge tops and ridge top roads;
- Upper hillslope roads with gentle or moderate slope gradients (<35%);
- Hillslopes with roads but few or no streams;
- Roads built on moderate or gentle hillslope areas anywhere in a watershed;
- Harvested hillslopes that have been cable yarded or helicopter logged;
- Hillslope areas with little or no recent land management.

If portions of a watershed or sub-watershed are selected for assessment, as opposed to the entire area, have the plan reviewed by an experienced restoration specialist or DFG biologist before proceeding. Partial assessments run the risk of improperly ignoring or excluding portions of a watershed that may be affecting or threatening salmonid spawning and rearing habitat.

Landowners have found sediment source inventories to be very useful for conserving both natural resources, and time and money. For example, the landowner can query the resultant database to determine how many sites exist and how much future erosion could occur along each particular road. If erosion at a number of sites is uncontrollable, then the landowner may choose to decommission the road and access that portion of the property through a new, more stable route. Through this analysis, the landowner may decide some roads may be worth upgrading while targeting others for permanent or temporary decommissioning.

Upslope Sediment Source Assessment Elements

Watersheds where salmonid resources are impaired or threatened by sediment derived from land use impacts are important candidates for upslope assessment and treatment. Conduct upslope assessments only after securing written permission from landowners or land managers. Two important watershed conditions to identify and consider include:

- Watersheds where degraded instream or riparian habitat limits salmonid populations and the problems have been caused by excessive sediment from the watershed to the streams;
- Watersheds where the instream habitat and riparian zone is not presently impaired, but stream resources are at potential risk because impacts may be imminent due to upslope instability and/or disturbance.

This dual focus will direct upslope assessment to watersheds where assessments will most likely lead to treatments that benefit salmonids and the overall health of the aquatic system. This methodology for upslope assessment promotes proactive watershed restoration for salmonids. It identifies significant sources of ongoing or future erosion that will lead to sediment delivery to streams in the watershed and that are amenable to treatment. This is termed a “forward looking assessment of sediment delivery”. Not all potential sediment sites may be treated, but their identification is an important first step to developing a cost-effective restoration plan.

Base a forward-looking upslope assessment upon field assessments that use logical, standardized, science-based observations, measurements, and deductive reasoning. The goal of this uniform data collection and resultant inventory is to deliver a watershed restoration plan that:

- Identifies the nature and magnitude of the erosion problems in the watershed;

- Provides quantified risk assessment data;
- Estimates the volume of sediment potentially prevented from delivery to streams;
- Develops a prioritized list of site-specific treatment prescriptions and associated cost estimates.

Assessment of past erosion and sediment delivery can provide an estimate of the relative magnitude and causes of various past sources of sediment delivery. This will provide some understanding of the importance of human-caused sediment sources over which there could be some control. Such an analysis may also provide insight about which land use practices contribute to increased sediment delivery, and might still be a factor in accelerated erosion.

Transportation Planning

The process of identifying a long-term strategy for road and erosion management is termed a transportation plan. Such a plan is developed by working closely with the landowner, and includes and integrates an estimate of the capital expenditures needed to upgrade and/or decommission elements of the present road network as well as the expected reduced long-term maintenance costs once all erosion prevention work has been undertaken.

In developing and implementing a transportation plan, consider all existing roads for either decommissioning or upgrading, depending upon their utility to the landowner and their risk to the aquatic ecosystem. Not all roads are high-risk roads and those that pose a low risk of affecting aquatic habitat may not need immediate attention. It is therefore important to rank and prioritize roads in each sub-watershed based on their potential to impact downstream resources, as well as their importance to the overall transportation system and management needs of the landowner.

Quality Assurance and Quality Control in Upslope Assessment

Quality assurance is an important component of both the assessment and the implementation phase of watershed restoration. Sediment source assessments, and the subsequent erosion prevention activities, are expensive. In the assessment process, the use of quality assurance measures minimizes the likelihood that incorrect interpretations will lead to unnecessary or overly expensive implementation. Quality assurance during a sediment source assessment ensures that the assessment is as thorough and accurate as possible. To achieve quality assurance it is required that:

- Inventory personnel are properly trained;
- Crew size is a minimum of two persons for efficiency and safety;
- Data are collected in a systematic and standardized format;
- Established protocols are followed;
- Significant sediment sources are not overlooked or ignored;
- Sediment savings volume estimates are accurate;
- Treatment cost-estimates are accurate and reasonable.

Quality control during implementation treatments represents another critically important component of effective and cost-effective upslope restoration and sediment control. Quality control measures utilized during the on-the-ground erosion prevention and control work helps

ensure that the most effective and efficient techniques are applied, and that the completed project meets the design standards established during the inventory process.

Technical Oversight of Inventory Crews
The work of inventory crews should receive regular technical review by qualified erosion control or watershed assessment specialists to verify the thoroughness, accuracy and consistency of problem identification, field interpretations, volume calculations, delivery estimates and treatment prescriptions.

Review of Field Assessments and Treatment Prescriptions
Once the field component of the inventory is completed, conduct a review of the preliminary assessment data. Include in the review the crew supervisor, affected landowners, and the erosion control or watershed assessment specialist(s). The review should consist of field site inspections and review of the products of the assessment including:

- Adherence to established assessment protocols;
- Accuracy in problem site identification;
- Accuracy in problem site quantifications (e.g., volume measurements and delivery estimates);
- Correctness in proposed restoration treatment prescriptions;
- Precision of heavy equipment and labor prescriptions, and associated cost estimates.

On large watershed assessments, or in cases where there are significant revisions identified during the review, more than one field visit may be warranted. The crew supervisor should write a brief report describing the revisions and attached it to the *Upslope Inventory Data Form*.

Review of Prioritized Restoration Plan and Cost Analyses
Review the draft restoration plan before it is finalized, to assure the cost analysis is accurate and correct, and that the prioritized restoration plan for the watershed is supported by the inventory results. Reviews conducted by qualified and experienced agency personnel or qualified specialists should include a brief narrative or checklist confirming the content, accuracy, and thoroughness of the inventory and the restoration plan, as well as the appropriateness, effectiveness and cost-effectiveness of the proposed restoration treatments.

Assessment Preparation

Prior to conducting field inventory work, several preliminary tasks will make the subsequent fieldwork easier and more meaningful.

Review Available Information

Contact DFG fisheries staff to see if there is a watershed assessment report or stream inventory report for the assessment area. Contact other public resource agencies, private landowners, watershed groups and any other potential data sources to gather all relevant information on land use, erosion, stream conditions and aquatic resources for the area. Review existing maps, data and reports that might be useful in conducting the assessment and preparing the plan.

Obtain Supplies and Equipment

Prior to beginning the sediment source assessment, assemble the necessary office and field supplies and equipment (Table X-2).

Complete Contractor and Field Crew Trainings

Project personnel should complete DFG-approved basic field training in sediment source assessment. The trainers are qualified and experienced erosion control and watershed assessment specialists. The training includes erosion site identification, site description methods and classification, problem quantification, prescription development, cost-effectiveness analysis, air photo analysis, map making, field sketching, monitoring techniques and database analysis procedures. The training also includes discussion about and typical examples of complex erosion problems and mass wasting features likely to require consultation with a licensed, experienced geologist, engineering geologist, geotechnical engineer, hydrologist or qualified erosion control specialist.

Conduct Analysis of Stereo Aerial Photos

Prior to going into the field, conduct an air photo analysis of the assessment area to help identify the location of sensitive roads and other high priority areas for field mapping, analysis and potential treatment. Potential sources for air photos include:

- California Department of Forestry (CDF);
- Department of Conservation/California Geological Survey (CGS);
- Department of Fish and Game (DFG);
- Regional Water Quality Control Boards (RWQCB);
- County Assessor or Planning departments;
- United States Geological Survey (USGS);
- National Resource Conservation Service (NRCS);
- Bureau of Land Management (BLM);
- Environmental Protection Agency (EPA);
- US Forest Service (USFS);
- Private industrial landowners;
- Commercial air photo vendors.

Public resource agencies are likely to know the best sources of available photography for a particular watershed. Select historic aerial photographic coverage from a number of years (perhaps one flight per decade) to bracket major storms. Photos are available beginning in the 1940's or 1950's for most watersheds.

Air photo analysis is useful to develop a general basin background and land use history, including a road construction history. It is important to identify maintained and abandoned roads, and landings that are potential or on-going sediment sources. Air photos can also be used to develop an optional landslide history for the watershed, as well as an historical assessment of stream channel conditions, although in most streams only major areas of bank erosion or channel aggradation will be visible.

Necessary or desirable items:

- Aerial photos (1:12,000 or larger scale; laminated if using in the field)
- Mylar (3 mil, frosted on one side cut to 9" x 9"; for mapping sites on photos)
- Data form, on waterproof paper
- Computer with database software (e.g., MS Access)
- Clipboards
- Mechanical pencils (several per person)
- Scientific calculators, with trigonometric functions (solar powered preferable)
- Permanent markers, fine point (for marking information on flagging at sites)
- 150 foot tape with marks in 10ths of feet (one per crew)
- Pocket rulers (with 10ths and 50ths scale; one per person)
- Clinometers (marked in degrees and percent; one per person)
- Flagging - color(s) to be identified by crew (several boxes)
- Vests (one per person)
- Good field boots (treated waterproof)
- Drafting tape
- First aid kits, first aid supplies and survival supplies (e.g., matches, knife)
- Day packs
- Pocket stereoscopes (one per crew is probably sufficient)
- Map wheel (for measuring distances on maps and photos)
- Planimeter or dot grid (for measuring areas on maps and photos)

Optional items:

- 4x4 field vehicle(s)
- Distance measuring computer(s) for vehicles
- Geographic Positioning System (GPS) unit (portable, for mapping site locations)
- Electronic range finder (laser hand-held distance measuring device)
- Small chain saw, axe, brush hook or equivalent
- Rope (for going down steep slopes)
- Tow rope, cable or chain (for moving downed trees)
- Increment borer (for dating trees on landslides)
- Laptop computer (for field data entry, database and data analysis)
- Software for calculating stream crossing volumes
- Geographic Information System (GIS) mapping software
- Pocket rods marked in 10ths of feet (one per person)
- Compass
- Colored pencil set
- Rain gear and rubber boots
- Table stereoscope
- Monopod
- Digital camera and batteries, or 35mm camera and film, with 28mm zoom lens (wide angle required)
- Radio (CB, mobile phone or other for emergencies and communication)

Table X-2. Field equipment and material needed for upslope watershed assessments.

Results of the air photo analysis should be represented on a large format hard copy map (scale 1" = 1000', or larger), or in electronic GIS format so that future field inventoried sediment sites can be accurately plotted. The map will show roads by type, time of construction and past use, and status. Once fieldwork is completed, this base map will show all inventoried sites and it will form an important component of the watershed restoration plan.

Collect Field Data

Use the *Upslope Inventory Data Form* and the *Stream Bank Inventory Data Form* to record information in the field. Collect data on paper data forms or electronically in hand held or laptop computers. Paper data forms provide the security of a hard copy of the original data and the flexibility of allowing for developing field sketches and collecting other non-database information. Collecting data on waterproof paper forms is generally the preferred method.

Data Format

Collect field data in both qualitative and quantitative formats, depending on the question. Enter the data in a relational database with all data fields in unique, pre-established formats. Exceptions are where a descriptive response is necessary, or where other types of information are recorded that cannot be entered in the database, such as a sketch map of the site (Figure X-3). Collect data measurements in predefined units (feet, inches, meters, cubic yards, etc.).

Site Definition Criteria

Most watersheds have many locations of existing and potential erosion. It would not make sense to inventory them all, because some are very small and some will not deliver sediment to a stream channel.

- Inventory only sites of future sediment delivery. When working for DFG, do not inventory an erosion site if it is unlikely to deliver sediment to a stream in the event of future erosion or hillslope failure.
- Prior to the start of a sediment source inventory, establish a minimum sediment delivery volume to qualify a site as a measurable site. Typically, the minimum volume will be between 10 and 50 yds^3 of sediment delivery. Smaller sites should be located on a map or photo, but not described on a site data form. Use the *Upslope Inventory Data Form* to record sites that meet or surpass the established minimum volume criteria.
- For chronic road-related sediment sources, there is no minimum site volume. Inventory all sites of chronic sediment delivery.

Some sites of past erosion remain as eyesores. Often, large bare soil areas are mistaken to be more important than they really are. Define sites not by appearance, but by an analytical evaluation of the potential for future sediment delivery by erosion processes.

Upslope inventories often focus on road-related erosion because of its comparative importance, accessibility, and the relatively high cost-effectiveness of erosion prevention and erosion control treatments at road sites. In road-related inventories, include all stream crossing sites. Stream crossing sites normally have extremely high potential for direct sediment delivery to streams in the event of a culvert failure or stream diversion.

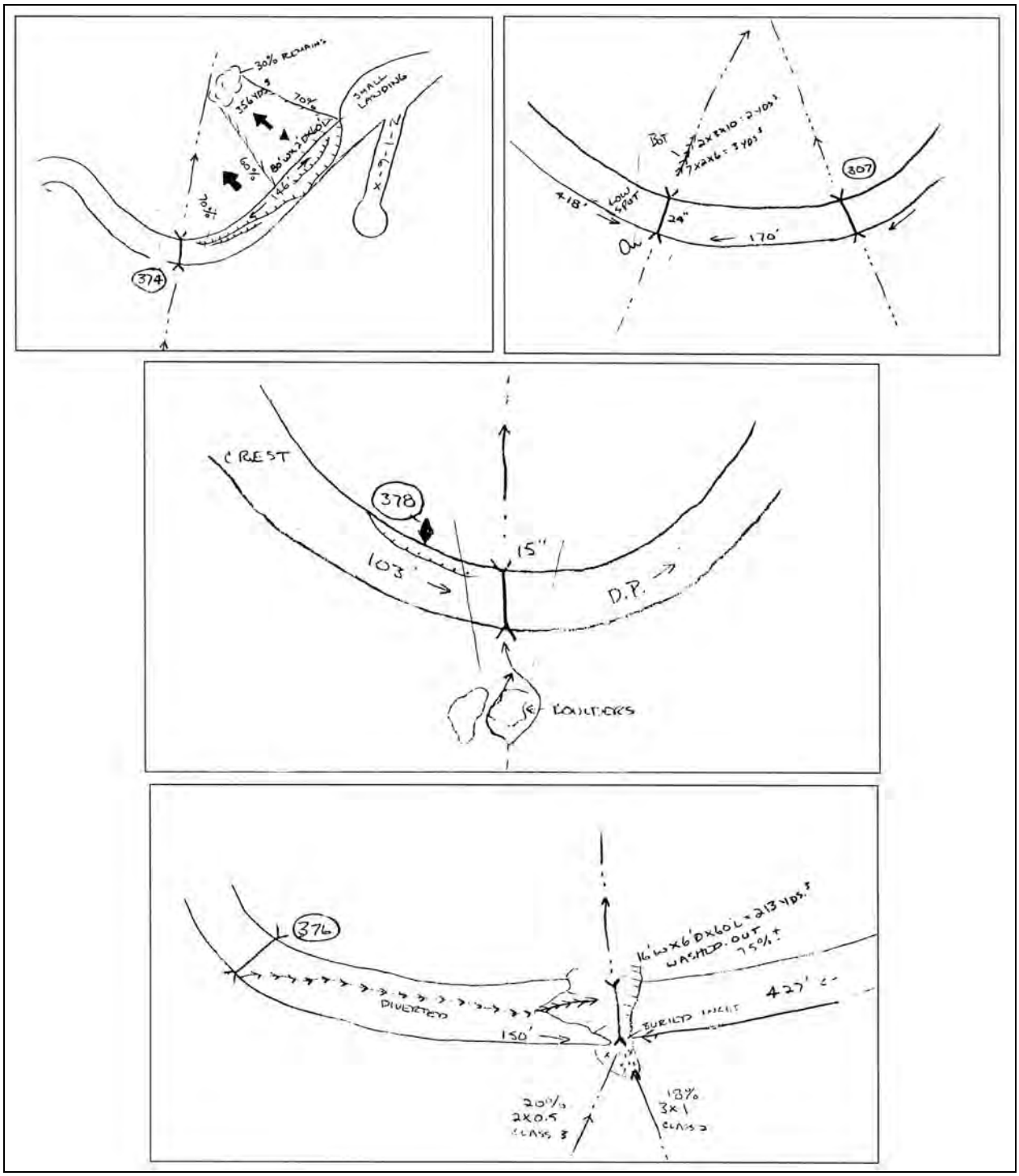


Figure X-3. Sample sketch maps of potential restoration sites, as portrayed on the *Upslope Inventory Data Form*.

Map Data

As field inventory proceeds, the potential sites identified can be numerous. Map the location of each site on a Mylar overlay, on the most recent aerial photo or map of the assessment area. Laminated copies of air photos work well for this purpose (Figure X-4). Enlarged aerial photos work well to map sites accurately. If aerial photos are not available, map site locations on the best available large-scale topographic or road map. For site identification, include GIS map coordinates or GPS satellite coordinates, where possible.

Use a standardized set of mapping symbols for recording site locations on air photo overlays or maps (Table X-3). Include these same symbols on field site marker flagging ribbons to identify the site and designate its type. Sketch in as accurately as possible abandoned roads not shown on the map.

Geology maps are available for the entire state and CGS Watershed Maps are available for many of the coastal areas. The maps are intended for the public for uses aimed ultimately at the reduction of erosion and landsliding, and the enhancement of water quality. The maps and explanations will enable users to: 1) recognize and "flag" areas of potentially unstable ground, and 2) foresee and minimize potential problems in these areas. The maps should be most useful for identifying unstable and erosion-prone areas on a regional scale, and in the preparation of large scale, long-range management plans that use geologic information to minimize environmental impacts. The maps are not a substitute for on-the-ground site-specific studies, but rather for identification of possible problem areas that may require consultation with a professional geotechnical specialist.

The watershed maps provide essentially the same information for each of the watersheds studied. Physical characteristics that can be correlated to landslide potential, soil erosion potential, and stream bank erosion potential are mapped at a scale of 1:24,000. The maps may be purchased from the California Geologic Survey, and are available for downloading in PDF format at http://www.consrv.ca.gov/cgs/thp/watersheds.htm.

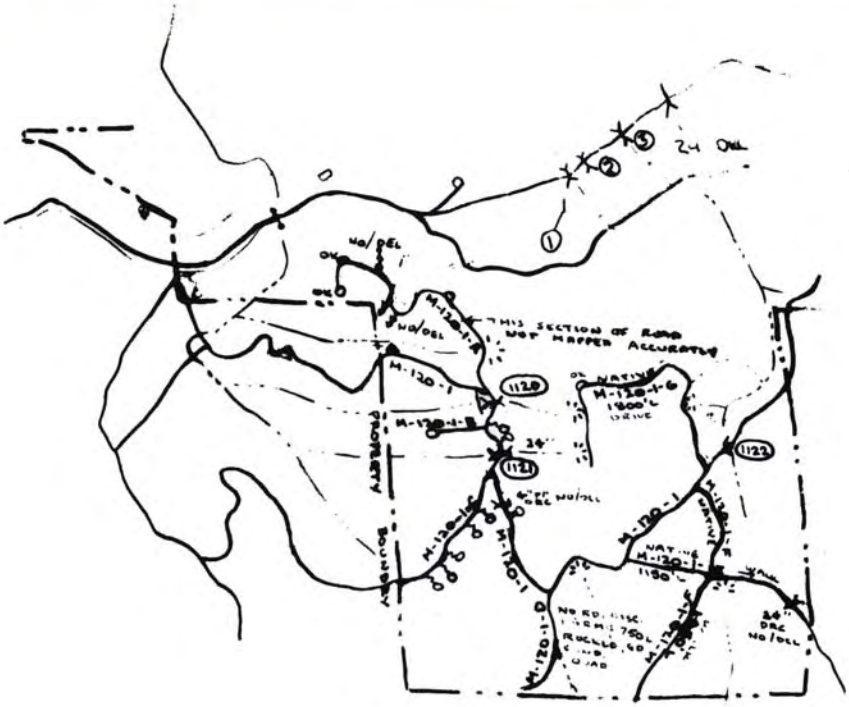


Figure X-4. Aerial photo and matching copy of Mylar overlay map showing roads and sites.

Standardized mapping symbols for use on site sketches, air photo overlays, report maps and flagging in the field.		
Symbol	**Site map symbols**	
5	Site Number	
	Stream crossing	Culverted stream crossing
	Stream crossing	Humboldt log crossing
	Stream crossing	Ford or armored fill
	Stream crossing	Unculverted stream crossing (unculverted fill)
	Stream crossing	Bridge
	Landslide	Potential landslide with delivery potential
	Landslide	Potential landslide with low or no delivery potential
	Landslide	Past landslide with delivery
	Landslide	Past landside with no delivery
3/2	Other	Gully (with width/depth dimensions in feet)

General map symbols			
	Ditch relief culvert		Spring or seep
	Plugged culvert (stream crossing/ditch relief culvert)		Swale or headwall swale
	Road (maintained or open)		Waterbar
	Abandoned road		Cross road drain
	Gate		Rolling dip
	Class 1 stream		Earth berm
	Class 2 stream	6"	Scarps (with visible offset)
	Class 3 stream		Cracks (little or no visible offset)

Table X-3. Standardized mapping symbols.

The Inventory Process

The field inventory process is straightforward, once the assessment preparation is completed. Visit each site once. Collect all data needed to describe, quantify and recommend potential treatments for each site on the first visit.

Inventorying Hillslope Areas and Roads

Fieldwork for sediment source assessments concentrates on inspecting hillslope areas most likely to contain sites of preventable or controllable management-related sediment delivery. This may include a variety of managed areas. Usually, most of the treatable sites are located on road systems where problems are abundant and access for treatment is good. Therefore, the assessment requires a walking inventory of all active and abandoned roads in the assessment area. All existing and potential sediment delivery sites that fit the minimum sediment delivery criteria are then identified and quantified in the *Upslope Inventory Data Form*. If it meets the minimum definition of a site then it should be mapped, inventoried and added to the database. At this point, make no assumptions about which sites will or will not be treated.

Inventorying Stream Channels

A second component of the erosion assessment involves stream channels. Usually, bank erosion sites are the primary stream channel locations of future erosion and resultant sediment delivery to streams. Regardless, it is generally not practical to survey all the stream channels in a sub-watershed due to poor or difficult access. However, DFG can often provide stream inventories as described in *Part III* of this manual for fish bearing streams.

High priority areas for conducting stream bank inventories are: stream channels where reasonably good equipment access exists from nearby roads, open areas proximate to the stream, and reaches along larger Class 1 streams. In areas where access is a problem, conducting a sample inventory may determine if stream channels are likely candidates for future cost-effective restoration projects, and worthy of further inventory and analysis.

Completing the Upslope Inventory Data Form

Use the *Upslope Inventory Data Form* to record the location, nature and magnitude of sites of future or potential sediment delivery, and include the description of recommended treatments to prevent erosion and/or sediment delivery. Develop the erosion prevention and erosion control prescriptions concurrent with the identification and inventorying of sites of current and future sediment delivery in the watershed.

There is no substitute for practical experience in the selection and construction of effective erosion control treatments. Previous work supervising or operating heavy earth moving equipment and labor crews provides grounding for what is possible to accomplish. With more experience, the better this judgment becomes. With a job fully described by a completed upslope assessment, many heavy equipment operators can provide feedback on project feasibility, safety, appropriate equipment types, and reasonable production rates (times) and costs. Refer to restoration implementation methods and cost-estimating techniques, later in *Part X*, to complete the analysis.

The *Upslope Inventory Data Form* is on page X-29. For detailed instructions to complete the form, see Appendix X-A.

Data collected includes information in the following categories:

- **General site data***:* Collect and record general site information, including site number, site location, road name, maintenance status, name(s) of inventory crew, date of inventory, and other relevant data site location and site description information.
- **Site characterization***:* Characterize problem areas by their type (e.g., stream crossing, gully, landslide, etc.) and by variables that describe their main characteristics. Completely fill out the data form for the relevant problem type. That is, for stream crossings, complete the 23 data fields listed under stream. Do not fill out questions under the landslide category. For landslides, complete only those questions listed under landslide. The data form requires the user to collect qualitative and quantitative data for:
    - Landslide sites – 4 data fields;
    - Stream crossings – 23 data fields;
    - Fish passage– 3 data fields.
- **Erosion quantification***:* Evaluate the erosion potential (likelihood of erosion). Measure the site for potential future erosion, and estimate sediment delivery volumes.
- **Comment(s) on problem***:* Fully explain site conditions, apparent processes, relationships or quantities to more completely describe individual answers provided in the data form. Concisely describe the nature of the problem, as a quick abstract of the site and its problems.
- **Treatment***:* Estimate of the urgency or priority for treating the erosion site. Identify possible treatment options. Describe and quantify the erosion prevention and erosion control treatments identified as the most likely to correct the problem(s). The treatment section of the data form contains the most common types of erosion prevention and erosion control treatments encountered, as well as measures that quantify the number or magnitude of the proposed treatments (e.g., cubic yards of rock armor or length of outsloping). Note: if you have identified a failure area of unknown type and depth (see footnote on data form), treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.
- **Heavy equipment excavation data***:* Provide a quantitative calculation of excavation volumes. Identify the volume of the spoil material to be used or stored locally, or if it must be endhauled by dump trucks. Excavation volumes and the excavation production rate are important elements of this section, as they will determine the estimated equipment times that will be required to complete the site work (pages X-39 and X-40).
- **Equipment and labor hours***:* Based on the tasks performed, the volumes excavated and moved, and the equipment and labor production rates outlined above. List the number of hours required for each piece of heavy equipment and for labor.
- **Comment(s) on treatment***:* Note any details in the proposed treatments that a contractor or equipment operator needs to know to complete the treatment. Include any specific information or insights that describe how to perform the job. Provide this comment section to the operator or contractor to guide them in completing the details of the project work for each site. It might include such information as the number of needed dump trucks, the endhaul distances and spoil locations, the specific labor tasks to be completed and other notes on completing the work at that particular site.

- **Survey data***:* On the back of the data form, fill in the spatial measurements for all stream crossings inventoried in the project area. For stream crossings only, enter the survey data. Use these measurements to calculate potential erosion volumes and excavation volumes required to perform the decommissioning or upgrading treatments. The equations for calculating these volumes are in Measuring and Estimating Future Erosion Volumes.
- **Site sketch***:* Make a sketch of the site, including any obvious landmarks and features that will identify the relationships between features described in the data form. Include such elements as roads, streams, springs, slope gradients, drainage structures (e.g., culverts) and erosion features. Examples of site maps are included in Figure X-3. Use standardized mapping symbols (Table X-3).

UPSLOPE INVENTORY DATA FORM

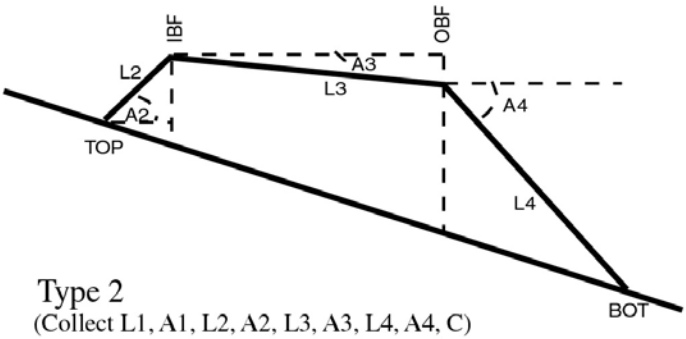
ASAP (Y, N)_____

GENERAL	Site no:	Treat (Y/N):	Watershed:	Quad:	
	GPS:		CALWAA:	Photo:	
	T/R/S:		Road name/#:	Drivable (Y/N):	
	Mileage:		Inspector(s):	Date:	Year built:
	Surface: □ rock □ native □ paved		Status: □ maintained □ abandoned □ decommissioned		
	Proposed: □ upgrade □ decommission			Sketch (Y/N):	
PROBLEM	Stream crossing (Y/N):		Landslide: □ fill □ hill □ cut	Roadbed: □ bed, □ ditch, □ cut	
	□ ditch relief culvert		□ gully □ bank erosion	Road related (Y/N):	
	Other non-road related site: □ home □ agricultural □construction □ mining □ other site				
LANDSLIDE	□ road or landing fill		□ hillslope debris slide[1]	□ other hillslope landslide (depth unknown)[1]	
	□ cutbank slide		□ potential failure	□ past failure	Slope (%):
	Distance to stream (ft):				
STREAM	□ culvert □ bridge		□ Humboldt □ fill	□ ford	□ armored fill
	□ excavated crossing		% excavated:		
	Ditch road length (ft): Left:		Right:	Culvert diameter (in):	
	Pipe condition (O, C, R, P): Inlet:		Bottom: Outlet:	□ separated	
	Headwall (in):		Culvert slope (%):	Stream class (1,2,3):	
	Culvert rust-line (in): Inlet:		Outlet:	Culvert undersized (Y, M, N):	
	Washed out (%):		Diversion potential (Y/N):	□ currently diverted	
	Road grade (%):		Plug potential (H, M, L):	Plugged (%):	
	Channel gradient (%):		Channel width (ft):	Channel depth (ft):	
	Sediment transport (H, M, L):		Drainage area (acres):		
FISH PASSAGE	Culvert outlet drop (in):		Bankfull drop (in):		
	Pool size bankfull width (ft):			Pool size bankfull depth (ft):	
EROSION	Erosion potential (H, M, L):		□ potential for extreme erosion		
	Volume extreme erosion (<500, 500-1,000, 1-2K, 2-5K, >5K):			Past erosion (yd^3) (optional):	
	Past delivery (%) (optional):		Total past delivery (yd^3):		
FUTURE EROSION	Future erosion (ft): Width:		Depth: Length:	Future erosion(yd^3):	
	Future delivery (%):		Total future delivery (yd^3):		
COMMENT(S) ON PROBLEM:					

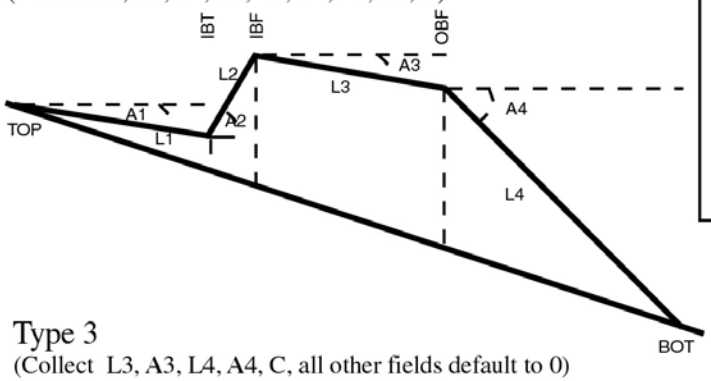
TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		
	check culvert size (Y/N):		□ bridge	□ no treatment	Mulch (ft^2):
TREATMENT OPTIONS	□ excavate soil	□ critical dip	□ ford	□ armored fill	Sill height (ft):
	Sill width (ft):	□ trash rack	□ Add downspout: Length (ft):		Diameter (in):
	□ repair culvert	□ clean culvert	□ install/replace culvert		
	Culvert: Diameter (in):		Length (ft):	□ flared inlet: Diameter(in):	
	□ reconstr. fill	□ armor fill face (U, D, B):		Armor area (ft^2): U: D:	
	□ clean or cut ditch, (ft):		□ remove ditch, (ft):		
	□ outslope road, (ft):		□ outslope & remove ditch, (ft):		
	□ outslope & retain ditch, (ft):			□ inslope road, (ft):	
	□ rolling dip, (#):		□ remove berm, (ft):		
	□ ditch relief culvert, (#):		Length (ft):	□ rock road surface, (ft^2):	
	□ cross road drain, (#):		□ other:		
HEAVY EQUIPMENT EXCAVATION DATA	Total vol. excavated (yds^3):		Volume put back in (yds^3):		
	Volume removed (yds^3):		Volume stockpiled (yds^3):		
	Volume endhauled (yds^3):		Distance endhauled (yds^3):		
	Excavation production rate: (yds^3/hr):				
EQUIPMENT HOURS	Excavator:	Dozer:	Backhoe:	Grader:	Loader:
	Dump truck:		Labor:	Other:	
COMMENT(S) ON TREATMENT:					

[1] *Consultation with a licensed geotechnical specialist is required to estimate slide volumes and to evaluate or develop treatment options. The location of these features should be noted on the field form and on maps, but the inventory crew should not estimate the sediment volumes for calculation of cost-effectiveness.*

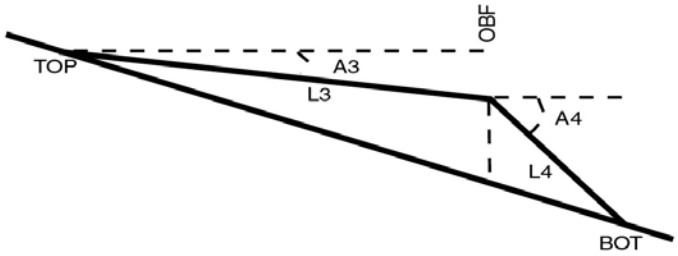
Type 1
(Collect L2, A2, L3, A3, L4, A4, C, all other fields default to 0)



Type 2
(Collect L1, A1, L2, A2, L3, A3, L4, A4, C)



Type 3
(Collect L3, A3, L4, A4, C, all other fields default to 0)



Field data

Length of sediment fan (L1): _____ ft

Angle of sediment fan (A1): _____ degrees

Length of inboard fillslope (L2): _____ ft

Angle of inboard fillslope (A2): _____ degrees

Length of road bed (L3): _____ ft

Angle of road bed (A3): _____ degrees

Length of outboard fillslope (L4): _____ ft

Angle of outboard fillslope (A4): _____ degrees

Channel width (C): _____ ft

Sketch

Completing the Stream Bank Inventory Data Form

Use the *Stream Bank Inventory Data Form* to assess past, ongoing and potential stream bank erosion, including anything that can be said about the nature, cause, and magnitude of the problem, and potential treatment options. In addition, use the inventory form to identify and classify erosion problems along stream channels, prioritize potential work sites, and prescribe specific treatments aimed at protecting stream channels and fish habitat. *Part III* describes methodologies for stream channel classification and inventory protocols for assessment of stream habitat, large woody debris, and riparian inventories.

The *Stream Bank Inventory Data Form* provides the standardized DFG protocol for evaluating stream-related erosion and identifying erosion control options. Use it to evaluate all types of riparian sediment sources. Where roads are in close proximity to a stream channel, there may be individual sites described by both an *Upslope Inventory Data Form* and a *Stream Bank Inventory Data Form*. If the proposed treatments are sufficiently different, retain both forms to describe the same location. However, do not duplicate recommended treatments and treatment times. Using the *Stream Bank Inventory Data Form*, field personnel can measure, describe and make initial interpretations about landforms and erosion problems in a consistent and uniform manner. Enter the data into an electronic database. Prepare a prioritized erosion control plan.

The data collected should provide information that both quantifies sites of future erosion and leads to a cost-effective treatment of stream bank sites. The form is on page X-33. The detailed instructions for completing each field are in Appendix X-B.

The data collected includes information in the following categories:

- **General site data***:* Record the general site information, including site number, site location (station number and bank side), stream name, names of inventory crew, date of inventory, other relevant data site location, and site description information.
- **Problem type***:* Characterize the apparent nature of the problem (e.g., debris slide, hillslope failure of unknown depth, bank erosion, log jam, etc.) and by variables that describe their main characteristics, such as activity level, age, gradient of eroding hillslope, land use and the degree of stream undercutting.
- **Erosion quantification***:* Classify the erosion potential (likelihood of future erosion). Record measurements of expected future erosion and sediment delivery volumes, as well as measurements of length, width and depth of past erosion scars.
- **Comment(s) on problem***:* Explain any site conditions, processes, relationships or quantities needing more detail than the individual answers provided in the data form. In addition, use this space to describe the nature of the problem, as a quick abstract of the site and its problems.
- **Treatment***:* Evaluate and record the urgency or priority of the proposed treatment (Treatment Immediacy), the expected complexity of the project work, heavy equipment and labor needs, access difficulty, and material needs.
- **Treatment options***:* Describe and quantify the specific erosion prevention and erosion control treatments thought most likely to correct the problem identified. List the recommended treatment(s) for the site, including excavation volumes (except as noted for debris slides and deeper hillslope failures), structures, fencing, and likely vegetation

measures. The treatment section of the data form contains many common types of erosion prevention and erosion control treatments for stream banks. If necessary, design specific solutions for sites that require unique erosion control treatments. Describe these treatments in the Comment(s) on Treatment section. Provide a full accounting of material needs for the project. Note: if you have identified a failure area of unknown type and depth (see footnote on data form), treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.

- **Equipment and labor hours:** Based on the required tasks, the excavation volumes, and the equipment and labor production rates, list the number of hours required for each piece of heavy equipment and for the labor to construct structures and/or plant the site.
- **Comment(s) on treatment***:* Note any details in the proposed treatments that a contractor or equipment operator needs to know to perform the treatment. Include any specific information or insights that describe how to complete the job. Provide this information to the operator or contractor to guide them in completing the details of the project work for each site. Include such information as the number of dump trucks needed, the endhaul distances and spoil locations, the specific labor tasks to be completed and other notes on completing the work at that particular site.
- **Site sketch***:* Make a sketch of the site, including any obvious landmarks and features that will identify the relationships between features described in the data form. Include such elements as roads, streams, springs, slope gradients, log debris accumulations, bedrock exposures, and erosion features. Use standardized mapping symbols (Table X-3).

STREAM BANK INVENTORY DATA FORM

GENERAL	Site no:	Distance (ft):		Date:	Inspector(s):	
	Watershed:			Stream:		
	Air photo:		Location (LB, RB, B):		☐ road related	Treat (Y/N):
PROBLEM	Type:	☐ debris slide ☐ debris torrent[1] ☐ hillslope failure of unknown depth and activity[2] ☐ torrent / debris flow channel[1] ☐ bank erosion ☐ LDA [3] ☐ other				
	Delivery:	☐ past	☐ future	☐ both	Apparent activity (A, IA, W):	
	Age (decade):		Stream bank slope (%):			
	☐ land use	☐ undercut by stream				
PAST EROSION	Width (ft):	Depth (ft):	Length (ft):		Volume (yd^3):	
FUTURE EROSION	Future erosion potential (H, M, L):		Width (ft):		Depth (ft):	
	Length (ft):			Volume (yd^3):		

COMMENT(S) ON PROBLEM:

TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		Equipment or labor (E, L, B):
	Equipment access (E, M, D):		☐ local materials		☐ import materials
TREATMENT OPTIONS	☐ excavate soil	Width (ft):	Depth (ft):	Length (ft):	Volume (yds^3):
	☐ rock armor/buttress		rock armor size (ft or ton):		rock armor area (ft^2):
	☐ log protection		Log size: Length (ft): Bank length protected (ft):		Diameter (ft): Bank area to cover (ft^2):
	☐ remove logs/debris				☐ boulder deflectors
	Deflectors (#):		Deflector (yd^3):		☐ bio-engineering
	☐ plant erosion control		☐ riparian restoration		Area planted (ft^2):
	☐ exclusionary fencing		Length of fence (ft):		☐ other
EQUIPMENT HOURS	Excavator:	Dozer:	Dump truck:	Backhoe:	Labor: / Other:

COMMENT(S) ON TREATMENT:

[1] A debris torrent is a mudflow that originates as a debris slide and then fluidizes (through the addition of water) and flows down a stream channel. It typically ends as a deposit or dam of poorly sorted sediment and woody debris in a lower gradient section of channel. The process is the mudflow; the evidence of that process is the scoured channel through which the flow passed, and the sediment and debris that is deposited at the end of the flow path. The activity level is typically that of the potential debris slide that would form the source of the mudflow. Note: if you have identified a potential hillslope debris slide, treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.

[2] If a failure of unknown type and depth is identified, treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.

[3] LDA is a log jam or accumulation of logs and woody debris in the channel; that is causing bank erosion or other erosion and sediment delivery problems.

Sketch on back.

Measuring and Estimating Future Erosion Volumes

A critical step in conducting a sediment source inventory is the quantification of erosion and sediment delivery volumes. Sediment delivery volumes and excavation volumes are the key variables needed for the computation of treatment cost-effectiveness and creating a watershed restoration plan. Excavation volumes are important for the derivation of heavy equipment times and costs for restoration work.

Surface Erosion Volumes

It is difficult to estimate sediment delivery volumes from surface erosion processes, because different soils have markedly differing propensities for erosion, and because surface erosion is a chronic process that may occur every storm. Use the following surface lowering rates (erosion rates in feet/year) to provide a gross estimate of erosion from bare soil areas:

- Cutbanks and continually bare soil areas — Low-0.01; Moderate-0.03; High-0.05
- Native surfaced (unimproved, dirt) roads — 0.03
- Rock surfaced roads — 0.02

Any unusual circumstances, such as high amounts of runoff or the presence of highly erodible soils, such as sand, may increase the surface-lowering rate. Use local site conditions and field evidence when assigning these rates. Calculate chronic surface erosion volumes from persistently bare areas on an annual basis, assuming overall conditions and use patterns remain unchanged. Estimate sediment delivery volumes from surface erosion processes as follows:

- $Q_s = [(A \times E)/27] \times T \times D$, where
- Q_s = sediment delivery (yds^3) from surface erosion;
- A = exposed area (ft^2);
- E = erosion or lowering rate (feet/year);
- T = time (years);
- D = delivery ratio (percent of erosion that is delivered to the stream).

For example, estimate 10 years of sediment delivery from a 500-foot section of actively used, rock-surfaced, 18 feet wide insloped road; that is 10 feet high; with a 50% bare, moderately erodible cutbank; that drains to the inlet of a stream crossing with a culvert, as follows:

- Road surface: A = 500' x 18' = 9,000 ft^2
  E = 0.02 ft/yr
  T = 10 years
- Cutbank: A = (500' x 10') ft^2 x 0.50 (only 50% of the cutbank is bare and eroding)
  E = 0.03 ft/yr
  T = 10 years
- $Q_s = [((500 \times 18) \times 0.02)/27 + ((500 \times 10 \times 0.50) \times 0.03)/27] \times 10 \text{ years} \times 100\%$
  $= (6.7 + 2.8)\ yds^3 \times 10 \text{ years} \times 100\%$
  $= 95\ yds^3$ (assumes 100% delivery from the contributing areas)

This generalized methodology of estimating sediment delivery from road surfaces allows for an order-of-magnitude estimate of sediment delivery that is suitable for use in evaluating the cost-effectiveness of proposed restoration work. Modify assumptions and rates according to local conditions. Sediment delivery rates for surface erosion can be variable. If the area encompassed by the analysis is limited to that which drains directly into a stream channel, delivery rates of 100% are reasonable.

Fluvial Erosion Volumes

Estimate future fluvial erosion volumes for the following:

- The expansion of existing gullies (including culvert outfall erosion);
- The creation of new gullies (usually from predicted stream diversions);
- Stream crossing washouts;
- Stream bank erosion.

Existing Gullies

Existing, active gullies can continue to enlarge by lengthening, widening and deepening until they become stable. These final dimensions, and hence future erosion, involve estimating future increases in gully width and depth. If flow conditions are unchanged, then the potential for future gully expansion can be inferred based on observed dimensions and behavior. If the gully is no longer down cutting, most erosion will be limited to gradual bank retreat and collapse. In this case, future erosion consists of vertical gully walls (side slopes) laying themselves back to a stable slope angle of about 1:1. If the gully still exhibits potential for future down cutting, then estimate how much deeper the gully will get over the length of gully. The gully will still be assumed to eventually develop 1:1 side slopes, and the amount of additional down cutting can be quantified as a rectangle (i.e., length x width x depth).

New or Future Gullies

In cases where it is predicted that a new gully will form, such as from a predicted stream diversion, then gully dimensions and lengths must be estimated from analogous sites nearby, or from thoughtful and well documented assumptions. Estimating future gully erosion is very difficult because the future path of the gully is hard to predict, gully erosion rates are generally unknown and variations in soil depth and erodibility, which control gully volumes, vary greatly. Estimates of gully erosion must be reasonable compared to similar documented sites nearby or in comparable areas. Delivery rates are typically high (75% - 100%) for gullies formed by stream diversions, but the figure should be supported by site observations and conditions.

Stream Crossings

Measure stream crossing fills to determine washout volumes, excavation volumes, and equipment times needed to perform various upgrading or decommissioning tasks. Crossing geometries are complex; therefore, estimating the volume of fill material contained in stream crossings requires a systematic approach and technique. There are three acceptable methods:

- Using field measurements, determine average dimensions and multiply width, depth and length to estimate volume (divide ft^3 by 27 to get yds^3);
- Taking systematic field measurements, use equations of plain geometry and end-area computations to calculate crossing volumes;

- Utilizing simple field surveys and a specialized computer program perform volume calculations and design treatments.

The more rigorous and systematic the computational method, the better will be the outcome of the calculations and volume estimates. Use the diagrams, measurements and equations shown in Figure X-5 and Figure X-6 to develop a quantitative estimate of stream crossing volume. Figure X-7 and Figure X-8 give examples of Type 1 and 2 volume calculations. The *Upslope Inventory Data Form* contains the data fields needed to perform volume calculations for each of three types of stream crossing geometries (Type 1, Type 2 and Type 3).

Stream Crossing Washouts

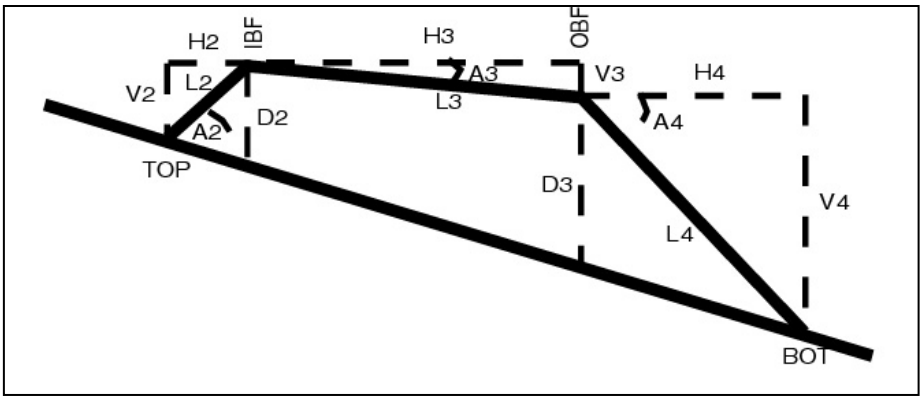
Base the predicted volume of a stream crossing washout on field measurements and geometric calculations that determine the volume of fill in the crossing (Figure X-5 and Figure X-6). Unless there are local indications to the contrary, assume that the gully, which forms from a full stream crossing washout, will eventually scour down to and assume the original pre-road channel profile. In addition, assume that it will have the same width dimensions as the natural high flow channel upstream from the crossing, and that the left and right side slopes to the washed out crossing will form a 1:1 slope (45E or 100%). From these assumptions, use geometry to calculate the predicted washout volume. Because the majority of potential sediment delivery sites in a watershed may occur at stream crossings, the accuracy and reproducibility of the volume estimate is critical. Perform simple tape and clinometer surveys, combined with geometric calculations, to ensure accuracy and reproducibility. Assume 100% delivery of sediment to the stream for washed out stream crossings.

Material used to fill-in a stream channel when a road is constructed is often irregular in shape. Generally, most of the fill would eventually be lost if the culvert plugged and the crossing fill washed out. Use simple geometry to develop an estimate of the stream crossing volume for the three basic types of stream crossings (Figure X-5 and Figure X-6). The volume of fill material contained in a Humboldt crossing is sometimes significantly more difficult to estimate because of uncertainties in the depth and volume of the logs and slash buried when the crossing was built. The volume of material in landings constructed in stream channel valleys prior to implementation of the Forest Practices Act (1973) is also difficult to estimate using simplified field measurement techniques. This is primarily because the original stream valley configuration has been obliterated by earthmoving.

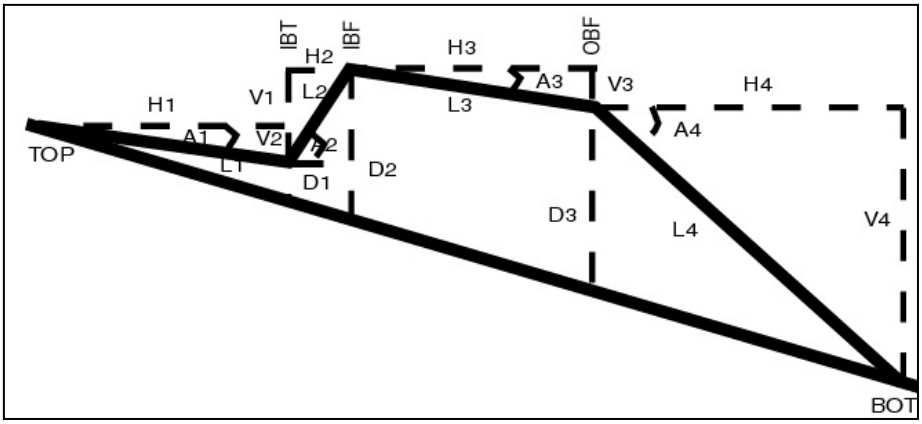
Stream Bank Erosion

Base the predicted erosion volume at each stream bank site on documented site conditions and measurements that support logical assumptions and observed bank retreat rates or erosion dimensions from comparable sites nearby. Assume all stream bank erosion will result in 100% sediment delivery (since the erosion is occurring within a stream channel). Calculate stream bank erosion by assuming a bank retreat rate (i.e. depth of erosion landward from the creek) and multiplying this by the length and height of the eroding bank.

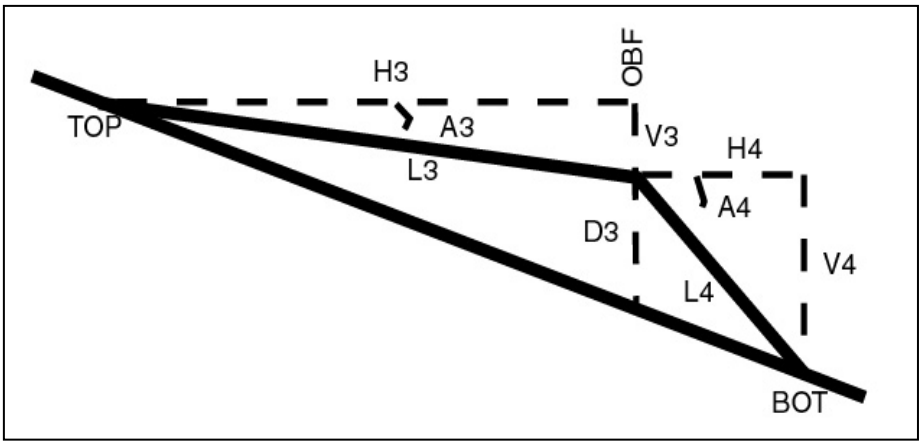
Type 1
(Collect L2, A2, L3, A3, L4, A4, C, all other fields default to 0)



Type 2
(Collect L1, A1, L2, A2, L3, A3, L4, A4, C)



Type 3
(Collect L3, A3, L4, A4, C, all other fields default to 0)



Field data		
	Length of sediment fan (L1):_____ft	Angle of sediment fan (A1):_____degrees
	Length of inboard fillslope (L2):_____ft	Angle of inboard fillslope (A2):_____degrees
	Length of road bed (L3):_____ft	Angle of road bed (A3):_____degrees
	Length of outboard fillslope: (L4):_____ft	Angle of outboard fillslope (A4):_____degrees
	Channel width (C):_____ft	

Figure X-5. Geometric designs for determining typical stream crossing volumes and excavation volumes for upgrading and decommissioning the three main types of crossings.

Calculations	
Horizontal components	H1 = L1(cosA1) = _____'*(cos(_____)) = _____ft H2 = L2(cosA2) = _____'*(cos(_____)) = _____ft H3 = L3(cosA3) = _____'*(cos(_____)) = _____ft H4 = L4(cosA4) = _____'*(cos(_____)) = _____ft
Vertical components	V1 = L1(sinA1) = _____'*(sin(_____)) = _____ft
	V2 = L2(sinA2) = _____'*(sin(_____)) = _____ft
	V3 = L3(sinA3) = _____'*(sin(_____)) = _____ft
	V4 = L4(sinA4) = _____'*(sin(_____)) = _____ft
Fall rate	F = (V1+V2+V3+V4)/(H1+H2+H3+H4) = (_____+_____+_____+_____)/(_____+_____+_____+_____) =____ft
Depth calculations	D1 = V1-(F*H1) = _____-(_____*_____) = _____ft D2 = (V1+V2)-(F*(H1+H2)) = _____-(_____*(_____+_____)) = _____ft D3 = (V1+V2+V3)-(F*(H1+H2+H3)) = ((_____+_____+_____)-(_____*(_____+_____+_____)) = _____ft
Cross section area calculations	XSA1 = C*D1+$(D1)^2$ = (_____*_____)+(_____)^2 = _____ft^2
	XSA2 = C*D2+$(D2)^2$ = (_____*_____)+(_____)^2 = _____ft^2
	XSA3 = C*D3+$(D3)^2$ = (_____*____)+(_____)^2 = _____ft^2
Volume Calculations	
Type 1 Crossing	Vol TOP to IBF (T2) = 1/3*(XSA2*H2) = 1/3*(_____*_____) = ____ft^3 Vol IBF to OBF (T3) = 1/2*(XSA2+XSA3)*H3 = 1/2*(_____+_____)*_____) = _____ft^3 Vol OBF to BOT (T4) = 1/3*(XSA3)*H4 = 1/3*(_____*_____) = ____ft^3
Type 2 Crossing	Vol TOP to IBT (T1) = 1/3*(XSA1*H1) = 1/3*(_____*_____) = ____ft^3 Vol IBT to IBF (T2) = 1/2((XSA1+XSA2)*H2) = 1/2*(_____+_____)*_____ = _____ft^3 Vol IBF to OBF (T3) = 1/2*(XSA2+XSA3)*H3 = 1/2*(_____+_____)*_____ = _____ft^3 Vol OBF to BOT (T4) = 1/3*XSA3*H4 = 1/3*_____*_____ = _____ft^3
Type 3 Crossing	Vol TOP to OBF (T3) = 1/3*(XSA3)*H3 = 1/3*(_____*_____) = ____ft^3 Vol OBF to BOT (T4) = 1/3*(XSA3)*H4 = 1/3*(_____*_____) = ___ft^3
Total Volume Calculation	T(t) = (T1+T2+T3+T4)/27 = (_____+_____+_____+_____)/27 =____ yds^3

Figure X-6. Calculations for determining typical stream crossing volumes and excavation volumes for upgrading and decommissioning the three main types of crossings.

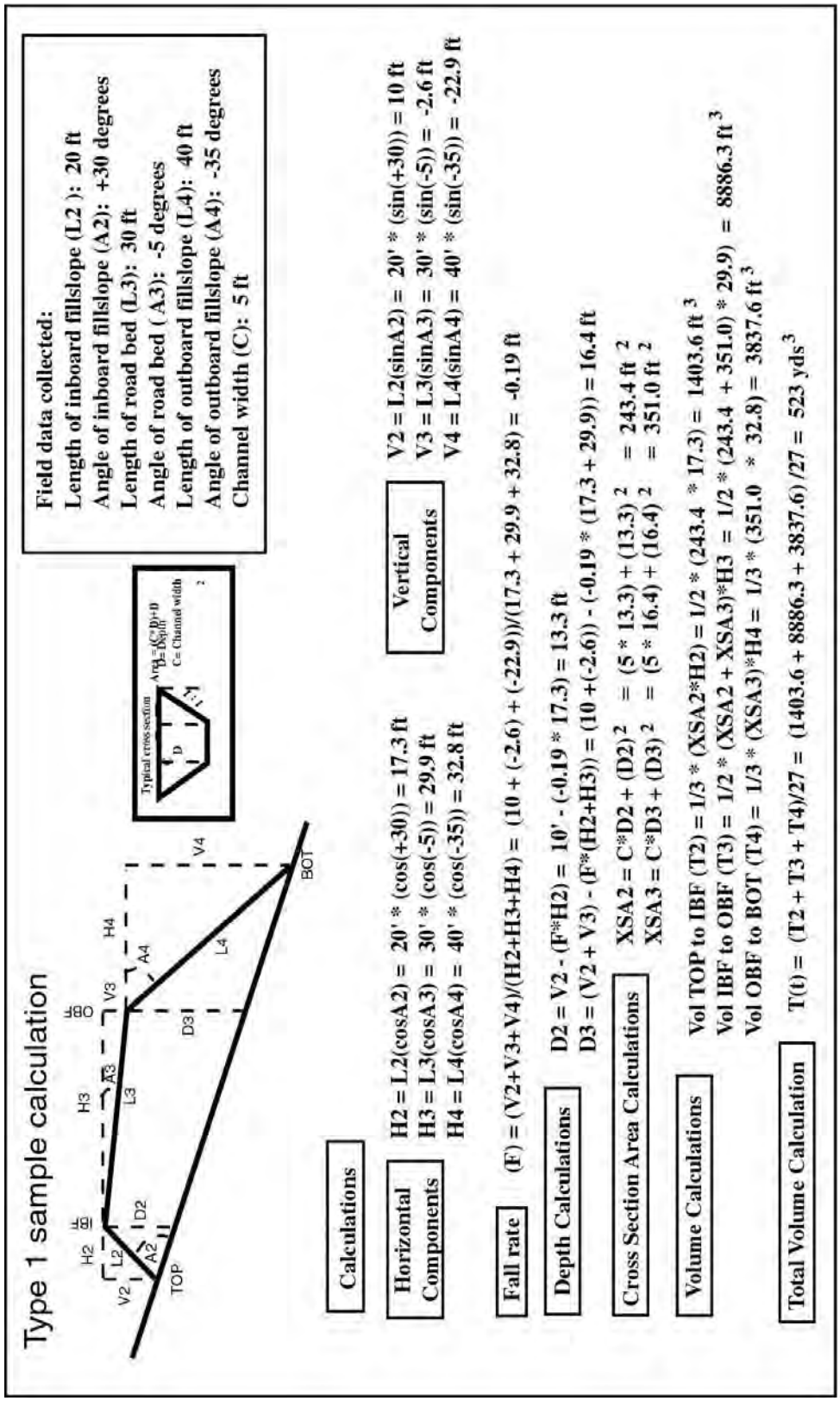


Figure X-7. Sample calculations showing derivation Type 1 stream crossing volumes.

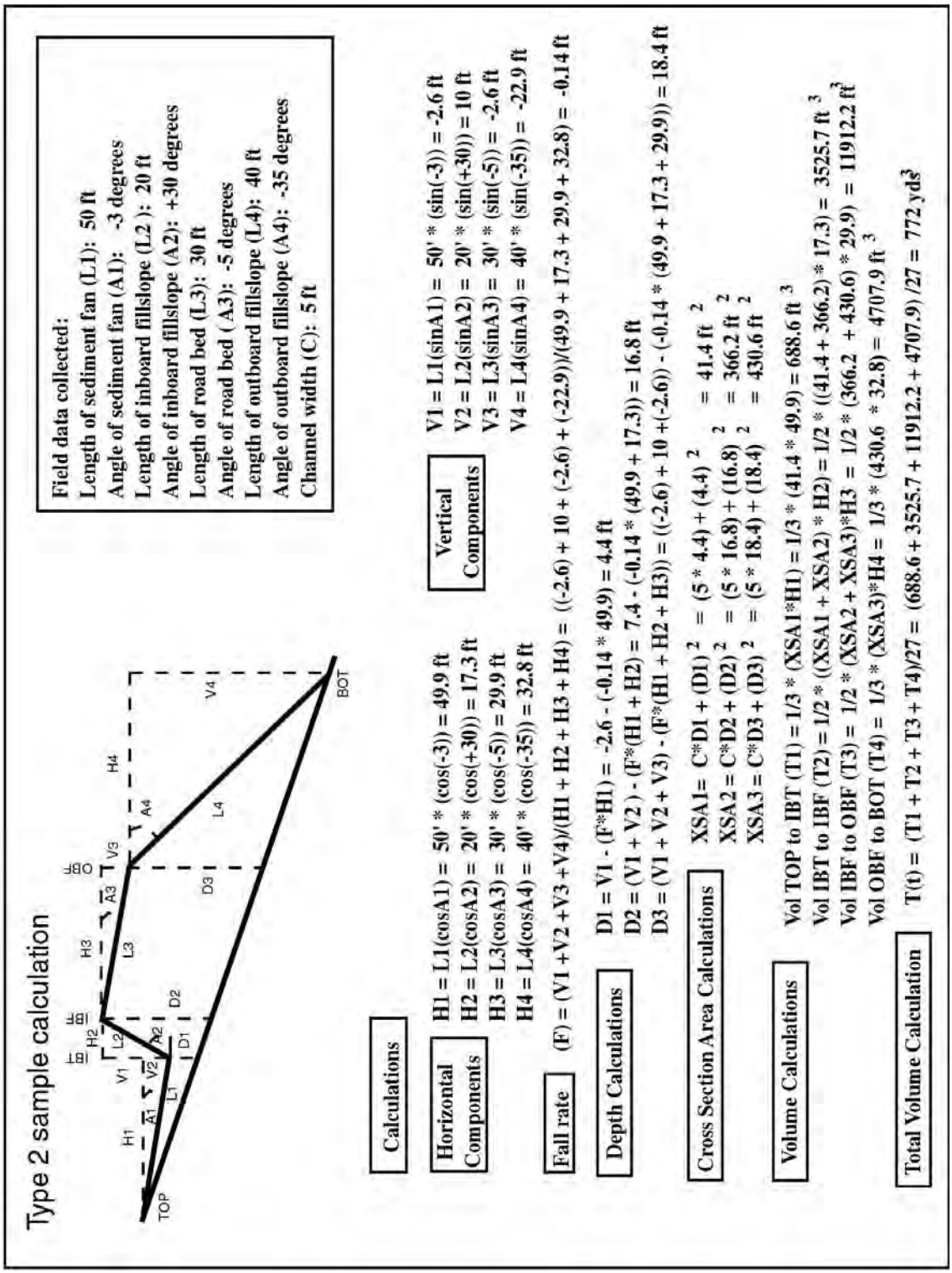


Figure X-8. Sample calculations showing derivation Type 2 stream crossing volumes.

Landslide Erosion Volumes

Landslide stabilization is generally outside the scope of this document. CGS Notes 50 (CGS 1999) and 40 (CGS 1983-1995) provide descriptive information on larger landslide types in steep forested terrain, and where these have been mapped as a part of the Watershed Mapping Project, respectively. These can be used for general planning purposes, and to identify watershed areas that have been mapped as unstable. They are generally not suitable for the measurement of landslide volumes, as the slides that have been identified and mapped are large and outside the scope of straightforward erosion and sediment control practices. However, the volumes of some of the simplest and smallest types of landslides can be measured from voids or "holes" left in the ground after the failure occurs or from field evidence of the boundaries of such landslides before they completely fail and move off site (e.g., small slides that occur on road fillslopes).

Except for debris flows and hillslope failure areas of unknown depth (as previously noted), compute future landslide volumes from estimated length, width and depth measurements taken in the field. The estimated sediment delivery to a stream is difficult to estimate and can range from 5% to 95%. Factors such as the distance the sediment must travel to the stream, hill shape and slope, soil moisture, vegetation and other factors influence the expected range of sediment delivery. A useful technique is to ask if the slide would deliver more or less than fifty percent of the potential slide mass to the stream. Often, the answer is obvious and it will provide a focus for making finer estimates by continuing to divide the remaining volumes in a like manner until the answer becomes uncertain. At that point of uncertainty, stop the division process and use the last confident answer for the estimate of delivery volume. This simple line of questioning will generally produce an acceptable estimate for determining sediment delivery volumes at each potential landslide fill failure. All but the smallest landslides can be very complex features and the development of effective treatment options more often than not will require consultation with a licensed geotechnical specialist.

Over-steepened Road and Landing Fills

Over-steepened fills typically consist of un-compacted sidecast materials, bulldozed onto steep, potentially unstable fillslopes. Unstable sidecast usually involves limited volumes of sediment when they fail by debris sliding, and these quantities can be estimated easily using simple geometric measurements of length (down slope), width (distance along the road) and average depth. The most common type of preventable or controllable landslide is the failure that develops from road or landing sidecasting on steep slopes. It is also the most common and most treatable source of road-related sediment delivered to streams in many watersheds.

The volume of a potential road-related sidecast failure is not difficult to estimate because the minimum average depth of the potential slide is typically the average depth of the sidecast material placed on the hillslope. The length of the potential slide is the length of the fillslope's sidecast material from the crown scarp to the base of the fill. Estimate the potential landslide width based on the boundaries of the over-steepened and visibly unstable sidecast material, or based on visible cracks and scarps that bound the potentially unstable material.

Headwater Swales (Potential Landslides)

Unlike simple sidecast failures, debris slides from steep headwater swales are more difficult to predict. They usually incorporate original ground beneath the road fill and often grow much

larger as they move down the steep swales and channels, scouring debris from the channel bed. This makes their final volumes frequently much larger than that estimated at the initiation site itself. Often, the occurrence and volume of such slides is highly uncertain and requires professional geologic analysis. Because it is difficult to accurately identify and quantify such sites of extreme erosion, note their potential location on the field form and on maps, but do not estimate their volumes for calculating treatment cost-effectiveness. Later in the process, query the database for the sites that exhibit a potential for extreme erosion and include them in the development of the final implementation plan only after review by a licensed geotechnical specialist.

Large Earthflows and Landslides of Unknown Depth and Activity

The future volumetric yield of deep-seated landslides can be equally difficult to estimate largely because they move episodically, at unpredictable rates and they occasionally self-stabilize over time. These types of landslides are often natural features and may not be affected or caused by a road or other land use (the road may be simply going along for the ride). Evaluating and developing treatment options will require consultation with a licensed geotechnical specialist. Typically, there are few cost-effective treatments that will slow or prevent these slides from moving or delivering sediment to the stream.

ANALYSIS AND REPORTING OF ASSESSMENT DATA

Use data analysis to convert field inventory information into conclusions. Use the conclusions to assemble a prioritized summary report (Appendix X-C). Set up the database, enter and clean the data, then complete the analysis. Analysis steps include generating erosion volume calculations, treatment volume calculations, costing out projects, cost-effectiveness analyses and sorting for prioritization prior to initiating restoration work.

Database Management

Data analysis can be complicated, but it is a critically important part of an assessment project that leads to restoration. To efficiently sort, analyze and prioritize a large number of work sites in an assessment area it is important to utilize an electronic database. To prepare a database for data analysis;

- **Set up database structure**: Set up the database structure on paper, based on the field forms presented on pages X-29 and X-33 and then program the electronic database. Perform this step as a part of the initial preparations for the watershed assessment.
- **Complete any blank data fields:** Fill any blank database fields left unanswered from the field inventory prior to data entry and analysis. This could include data that was not available during the field inspection, such as drainage area measurements or volume calculations that were available only after the field inventory, as well as inadvertent omissions (which might require a second field visit).
- **Enter data in database:** Enter the data for analysis. Analysis of partial data sets may be useful to break down the assessment area into smaller management units, such as an individual landowner, a logical hillslope unit or high priority sub-watershed as stand-alone elements of the larger assessment area. This is most useful when conducting very large watershed assessments. In this manner, individual restoration plans can be developed for the smaller management area as the larger assessment effort is still underway, and

prioritized treatments can begin in areas where early assessment work has already been completed.

- **Clean data:** Once entered, perform preliminary data searches to identify any blank data fields and any mistakes in data entry. Data cleaning is the last step prior to analysis. Perform data cleaning to make sure the necessary data is both present and internally consistent. Electronic data searches (reports) involving a number of related data fields (such as all questions related to stream crossings, or all questions related to treatments) should be viewed on the screen or in printed format as data tables so that any data inconsistencies or blank data fields will be visibly obvious. It may take several data searches, involving a variety of interrelated fields and combinations of fields to determine if all the data is there, and that it is present in the correct format.
- **Revisit selected sites and complete database:** Enter data that is missing or inconsistent and needs correction. Errors in data entry are easy to correct. Inadvertent omissions during field inventory work can sometimes be clearly determined from the other information that is on the paper form. If important data is missing from the form or it is clearly inaccurate a re-inspection of the site is necessary. For efficiency, it is generally best to schedule site re-inspections after all data cleaning has occurred.

Analyzing the Inventory Data

Data analysis can only occur when all the inventory information has been collected, properly entered in the database, and cleaned. The use of a database allows for rapid data analysis. Perform searches to isolate the nature, frequency and magnitude of a host of problems and treatments. Specific searches might include analyses that look at the frequency and cause of potential sediment delivery associated with each sediment source (landsliding, fluvial erosion and surface erosion). Searches might include an analysis of all stream crossings, looking for the frequency of undersized culverts, stream crossings with a diversion potential, or active culvert outlet erosion, among others.

Data tables developed for the summary report contain information regarding the number of sites recommended for treatment, erosion potential, treatment immediacy (priority), sediment savings, recommended treatments, excavation volumes, estimated heavy equipment and labor hours and costs. Proposed restoration plans may be grouped a variety of ways, for example geographically, according to the number of high priority sites they contain, the expected volume of future sediment delivery, or the number of undersized culverts on stream crossings with a high diversion potential. Appendix X-C contains examples of a number of assessment data tables that are useful for displaying the results of the sediment source inventory.

Estimating Costs

Use the sediment source assessment to develop cost estimates by employing the following steps:

- Problem identification - determine the population of potential treatment sites;
- Problem quantification - accuracy in calculating excavation volumes is critical in predicting heavy equipment times and project costs (Figure X-5 and Figure X-6);
- Determine equipment needs - select heavy equipment based on desired capabilities and types. Picking the wrong equipment can severely inflate costs above predicted levels;

- Estimate production rates and equipment times – selection of appropriate equipment production rates is critical in determining heavy equipment times for each site;
- Estimate equipment costs - use locally appropriate rates for heavy equipment rental (cost/hour), and a logistic multiplier of 20% to 30% for prescribed site treatments (number of hours x 0.2 or 0.3). This should cover equipment travel times, consultations with the operator and most unforeseen complications. Finally, develop cost estimates that cover all needed road drainage work between sites;
- Estimate road opening costs (hours x cost rate) for either upgrading or decommissioning abandoned roads or for treating off-road sites. Access costs will be dependent on maintenance status and degree of revegetation on the abandoned road;
- Estimate equipment mobilization costs - mobilization costs include lowboy transportation for moving heavy equipment to the project area and are dependent on equipment availability and lowboy rental rates;
- Calculate materials costs including culverts, road rock, riprap sized rock, filter fabric, seed, mulch, tools, etc.;
- Calculate labor costs and apply to the labor hours itemized on the data forms for each site. Use a locally reasonable labor rate (cost/hour);
- Calculate indirect costs including coordination, ordering, field layout, technical oversight (such as by restoration specialists, or professional engineers and geologists) reporting, monitoring, administrative and contracting costs. This requires an assessment of the hours for each task and the labor rate applied to the work. The required amount of on-the-ground supervision time with the heavy equipment or with labor crews will depend on the experience of the work crews. Inexperienced operators and laborers need more oversight.

Predicting Cost-effectiveness

Define the cost-effectiveness of treating a restoration work site as the average amount of money spent to prevent the delivery of one cubic yard of sediment from entering the stream system (Weaver and Sonnevil 1984). Cost-effectiveness is determined by dividing the cost of accessing and treating one site, or group of sites, by the volume of sediment delivery prevented to a stream channel. For example, if it would cost $3,500 to access and treat an eroding stream crossing that would have delivered 250 yds^3 (had it been left to erode), the predicted cost-effectiveness would be $14/$yd^3$ ($3500/250 yds^3). The key elements in determining cost-effectiveness are a fair and accurate estimate of future sediment delivery (in the absence of treatment) and a reasonable estimate of treatment costs.

Controls on Cost-effectiveness

A variety of factors control the ultimate cost-effectiveness of the restoration work that is being proposed (Weaver et al 1981). Some of these are predictable and controllable, and others are not. Ultimately, factors that affect either the cost of the work, the potential volume of sediment delivery or the effectiveness of sediment control treatments will control cost-effectiveness. The more that is done to reduce costs, decrease sediment delivery and increase treatment effectiveness, the greater will be the cost-effectiveness of the restoration project.

Costs

Of all the factors controlling cost-effectiveness, cost factors are the most amenable to manipulation. Controls on restoration costs include many obvious factors and some more subtle elements. These include:

- Goals and objectives of the restoration: goals and objectives establish the level of effort that will be undertaken, and ultimately control cost-effectiveness;
- Hourly equipment rental or contract rates: all else equal, the higher the rental rate, the lower will be the cost-effectiveness of the resultant restoration work;
- Choice of heavy equipment types and sizes;
- Skill and experience of the equipment operator;
- The magnitude of indirect costs, such as administration, contracting, overhead, profit, supplies and other indirect expenses that diminish cost-effectiveness;
- A large influence on treatment cost-effectiveness can result from incorrect identification of the problem, incorrectly estimating potential sediment delivery volumes, and/or recommending inappropriate or ineffective treatments;
- The design standards of the treatment: culvert sizing and excavation geometry (side slope steepness for decommissioned crossings have a substantial influence on restoration costs - the higher the standard, the higher the cost);
- The method of contracting including fixed price, hourly rental, or cost-plus. There is often a significant difference between total restoration project costs under fixed price (minimum bid) contracting and hourly equipment rental; the former frequently being more costly;
- Road reopening and other mobilization costs: these include the costs of clearing and opening access on abandoned roads and for hauling equipment to or within the project area. The higher these indirect expenses are, the greater their negative effect on cost-effectiveness;
- Choice of specific treatments used to prevent or control erosion: even if a number of methods are equally effective at preventing or controlling sediment delivery, the more costly approaches will be less cost-effective;
- Secondary treatments: if secondary erosion control treatments (e.g., check dams, rock armor or other hand labor treatments) are recommended, primary project cost-effectiveness will diminish because these treatments are typically expensive compared to the amount of sediment prevented from delivery to a stream channel (Weaver and Sonnevil 1984).

Sediment Delivery Estimates

Variables that affect estimated sediment delivery and project cost-effectiveness include the interpretation of a potential site, the inventory methods, assumptions, and measurement accuracy reported and used. Inflated sediment delivery volumes exaggerate the sediment savings and cost-effectiveness. Similarly, if the volume of future delivery is understated, then the project will not look as cost-effective as it might actually be. Achieve controls on sediment delivery estimates using appropriate:

- Volume calculation methods (assumptions and methods for calculating or estimating potential failure volumes for landslides, and potential erosion volumes for stream crossings, gullying and surface erosion). Volume calculations should be repeatable and sufficiently accurate;
- Sediment delivery estimates (methods and assumptions for determining the delivery ratio for potential landslides, fluvial erosion and surface erosion processes);
- Sediment loss assumptions (assumptions made about how much erosion and sediment delivery would actually occur at a site before the problem was corrected);
- Erosion rate and amortization assumptions (assumptions made about the rate of erosion and the duration over which erosion and sediment delivery is calculated, especially for large landslides, gullying, stream crossing washouts, bank erosion and surface erosion).

Treatment Effectiveness

The effectiveness of erosion prevention and erosion control measures has a significant influence on sediment delivery to stream channels from inventoried sites. Certain techniques are nearly 100% effective at preventing sediment delivery (such as completely excavating a potentially unstable fillslope). Others are partially effective (e.g., disconnecting road surface runoff from stream channels to cut off road drainage and prevent fine sediment delivery). Measure treatment effectiveness by the volume of sediment prevented from delivery to a stream, not on the amount of dirt moved by heavy equipment or by the volume of soil erosion that is controlled or prevented. Treatment effectiveness varies according to the process and the erosion prevention technique that is applied.

Surface Erosion

Surface erosion processes are sometimes controllable and preventable (through the application of mulching and seeding). More importantly, controlling sediment delivery from surface erosion sites is usually highly effective (through diversion and dispersion of runoff).

Fluvial Erosion

A number of cost-effective treatments can effectively prevent most gullies. For example, dewatering existing gullies can be nearly 100% effective in preventing continued erosion and sediment delivery. Gully control is less effective and more costly than gully prevention, and preventing sediment delivery from an eroding gully is very difficult.

Landslides

Landslide size and accessibility influence treatment cost-effectiveness. Streamside landslides, non-road landslides (i.e., poor access) and large landslides have low treatment cost-effectiveness and are very difficult to treat. Treating small potential landslides or excavating a large proportion of the material on larger landslides can result in a high level of effectiveness.

Evaluating Treatment Priorities

Evaluate treatment priorities by considering factors and conditions associated with each potential sediment delivery site:

- Delivery volume - the expected volume of sediment to be delivered to streams;

- Erosion potential - the potential for future erosion (high, moderate, low);
- Access and access costs - the ease and cost of accessing the site for treatments;
- Treatment costs - recommended treatments, logistics and costs;
- Treatment immediacy - the urgency of treating the site;
- Treatment cost-effectiveness - money spent per cubic yards saved.

Proposed work should meet pre-established cost-effectiveness criteria, and this often forms the basis for restoration prioritization. However, other local factors may also be considered. For example, factors such as the protection of potable water supplies, sensitive resources at risk, or other beneficial uses may assume a significant role when developing final restoration priorities. The prioritization criteria will be a function of the goals of the restoration project.

Prioritizing Restoration by Cost-effectiveness

Cost-effectiveness calculations directly and indirectly integrate a number of the most commonly employed factors used for prioritizing restoration work. By using the cost-effectiveness formula, a comparison of proposed projects is possible using the same criteria: reducing accelerated erosion and keeping the greatest volume of eroded sediment out of the watershed's streams for the least amount of money. The sites selected for eventual treatment are the ones expected to generate the most cost-effective reduction in sediment delivery to the drainage network and the mainstem stream channel. The larger the potential future contribution of sediment to streams, the more important it becomes to evaluate the project for cost-effectiveness.

After prescribing treatments and evaluating all costs, employ cost-effectiveness calculations and other criteria to prioritize all the sites for actual treatment. Use cost-effectiveness as a tool to prioritize potential treatment sites throughout the assessment area. Sites, or groups of sites, that have a predicted marginal cost-effectiveness value for the particular region, or have a lower erosion potential or treatment immediacy, or low sediment delivery rates, are less likely to receive funding from agencies that administer cost share grant programs. Address these sites when conducting future management activities, or if heavy equipment is performing routine maintenance or restoration work on nearby, higher priority sites.

Criteria for Cost-effective Treatments

For consideration of priority treatment, a site should typically exhibit:

- Potential for significant sediment delivery to a stream channel that directly or ultimately results in delivery to a fish-bearing stream. Significance of delivery is guided by the minimum inventory volume established for the watershed assessment;
- A high or moderate treatment immediacy;
- Favorable cost-effectiveness. Project cost-effectiveness is different for similar projects in different areas of California. This rate varies regionally, and changes over time due to inflation and changes in related costs. For example, the cost of similar projects is generally lower in the northern-most counties such as Humboldt or Del Norte as compared to the Bay Area from Sonoma to Monterey County. Furthermore, in the case of high value refuge streams and/or watersheds with listed species, domestic water supplies or

other high value downstream resources, exceptions to cost-effectiveness criteria can be justified. Consultation with DFG fisheries staff can help with this determination.

Site Groupings

In most cases, apply cost-effectiveness to a group or groups of sites so that the most cost-effective groups of projects are undertaken first. For example, during road decommissioning, groups of sites are usually considered together because there will be only one opportunity to treat potential sediment sources along the road. Even if an individual site is highly threatening to the protected resources, recommending treatment priorities based on the cost-effectiveness of one site is generally discouraged. This would lead to a costly shotgun approach to restoration.

Treatment of Abandoned Roads

Another factor influencing a site's treatment priority is the difficulty (cost and environmental impact) of reaching the site with the necessary equipment to treat the potential erosion. Many sites found on abandoned or un-maintained roads require brushing and tree removal to provide access to the site(s). Other roads require minor or major rebuilding of washed out stream crossings and/or existing landslides in order to reach potential work sites farther out the alignment. Road reconstruction adds to the overall cost of erosion control work and reduces project cost-effectiveness. Potential work sites with lower cost-effectiveness, in turn, may be a lower priority. However, just because a road or potential work site is abandoned and/or overgrown with vegetation is not sufficient reasoning to discount its assessment and potential treatment. Treatments on heavily overgrown, abandoned roads are often both beneficial and cost-effective.

Prioritizing Restoration Projects

Once treatment priorities and cost-effectiveness standards are established, it is important to review the restoration plan and prioritize projects for implementation. Not all sub-basins within a large watershed will merit the same type or intensity of protection or restoration measures. Through field inventories, identify areas where there is a potential for cost-effective watershed protection and restoration for fisheries recovery.

Design protection and restoration options for sites in watersheds with the most potential of restoring productive conditions and protecting against future catastrophic damage or persistent degradation. For most sediment assessments, a large number of potential treatment sites are identified and classified into individual treatment priorities. Strategies for prioritizing groups of sites for treatment include:

Prioritize Sub-watersheds

Prioritize and treat sub-watersheds according to their biological importance, not necessarily according to the magnitude of the potential threat that exists in the basin. High quality sub-watersheds may only need a small amount of upslope restoration work or erosion prevention but it is critically important to perform this work and secure the drainage before moving to other sub-watersheds.

Prioritize Hillslope Units

There are many ways to group sites in a watershed or sub-watershed for treatment. Each watershed may warrant a different approach to grouping sites for treatment. This will depend on the sensitivity of the resource, the nature and magnitude of the upslope erosion threat and access to the sites. All groupings should be practical; that is, they should consist of groups or clusters of sites in relatively close proximity and be treatable in a timely, coordinated and cost-effective manner. For example:

- Treatment immediacy – Group based on the identified clustering of high priority units in the watershed. Treat these cluster units according to the magnitude and immediacy of the threat they pose (high priority clusters contain concentrations of high priority sites, but may also include other lower priority sites). Examples might include roads or groups of roads that contain many high priority sites, or many sites immediately adjacent Class 1 stream channels. This strategy will focus on the most immediate threats to the aquatic system, but the unit groups might not be the most cost-effective ones that could be addressed.
- Threat of future sediment delivery-Group based on their volumetric threat to the stream system, as determined by the inventory results.
- Logical treatment units - Sites can be grouped on the basis of logistic considerations, similar work effort requirements, natural topographic boundaries, equipment access points, restoration type (e.g., road decommissioning or road upgrading), or other factors. This is the most basic grouping, and in fact all groupings should fit the definition of logical treatment unit.
- Cost-effectiveness - Group sites based on the average cost-effectiveness of restoration treatments that have been calculated from the inventory and prescription data. This strategy assures the most bang for the buck with restoration funds, but it does not assure treating the highest biological priority units first.

Prioritize Critical Sites

Identify, target and treat individual, extremely high priority sites that if not immediately treated are likely to fail and deliver significant volumes of sediment to the stream system. These sites are likely widely dispersed across the watershed. They may be termed “ASAP” sites. In watersheds with high value aquatic resources, it may be worth going after individual, isolated sites even though there may be a decrease in the relative cost-effectiveness of this restoration strategy due to the higher logistic costs (e.g., multiple staging and increased equipment hauling).

Preparing the Summary Report

Reports for upslope inventory and assessment projects should contain the following information: (Appendix X-C).

- Project identification #
- Project location (descriptive location)
- Map of watershed (location map, showing relationship of project area to the region)
- Map of project area with inventoried sites and roads, which shows:

  - Base information, (streams, roads, sections, contours (optional), scale, north arrow, labels for stream names, road names and cultural features)
  - All roads within the inventory area with current maintenance status:
    - Maintained roads, and
    - Abandoned (un-maintained) roads
  - All stream crossings by type (Humboldt, culvert, unculverted fill, armored fill, ford or bridge)
  - Potential and active landslides with sediment delivery potential if left untreated
  - Ditch relief culverts and other ditch drains
  - Gullies and other fluvial erosion features
- Map of all sites recommended for treatment (with site numbers)
- Map of all sites according to treatment priority (high, moderate, low)
- Project report which contains the following:
  - Introduction (setting, problem, purpose of assessment project)
  - Methods (office, field inventory and data analysis - discuss map data and database)
  - Results and discussion of sediment source assessment
  - Results of transportation planning (discussions with landowner)
  - Future erosion and sediment delivery data (if sites were left untreated)
  - Restoration plan
  - Description of overall treatment plan (upgrading and decommissioning)
  - Road upgrading (show and describe roads planned for upgrading)
  - Road decommissioning (show/describe roads for decommissioning)
  - Describe treatments and sites recommended for treatment, by road
  - Stream crossings, landslides, surface erosion treatments
  - Cost analysis, including:
    - Estimated equipment rates (for all heavy equipment)
    - Estimated labor rates (cost/hr)
    - Total estimated site costs (all site costs added together)
    - Equipment move-in and move-out costs (lowboy) for project
    - Other project costs not listed above (specify)
    - Total estimated costs for entire project (equipment + labor + materials + other)
    - Cost-effectiveness analysis
    - Total estimated sediment savings (delivery prevented in yds^3)
    - Total project cost-effectiveness (cost/yd^3 of sediment delivery prevented).
- Project report appendices including database and data sheets from field surveys, containing the following information for each site recommended for treatment:
  - Site # (as flagged or marked in the field)

- Problem type (stream crossing, landslide, roadbed, ditch relief culvert, gully, other)
- Problem description (narrative or data describing the apparent nature of the problem)
- Erosion activity (active and/or potential)
- Erosion potential (likelihood of erosion, if not treated - high, moderate, low)
- Future erosion (yds^3 of erosion likely to occur if problem is not treated)
- Future delivery (yds^3 of eroded sediment that would be delivered to a stream left untreated)
- Recommended treatment (quantitative description of proposed treatments, e.g., yds^3 of soil to be excavated, or classification of treatment type from a list of possible standard treatments)
- Treatment immediacy or priority (high, moderate, low)
- Equipment times (hours for each category of equipment used at each site)
- Labor times (for each site)
- Materials per site (e.g., culvert, downspout, rock, etc.).

IMPLEMENTING RESTORATION WORK

Restoration Strategies

Upland watershed restoration can take several basic forms: prevention (through avoidance or altered management practices), control, mitigation and/or cleanup. The goal of upslope restoration is to prevent or substantially reduce sediment delivery to streams from accelerated erosion sources. Accomplish this through the implementation of protection measures, restoration measures, and improved land use practices designed to result in more natural sediment yield rates. As with other forms of watershed conservation practices, erosion prevention is usually far more effective and cost-effective than trying to control erosion once it has begun.

Prevention

Accomplish prevention by altering and improving land use practices that would otherwise result in sediment delivery to streams; avoiding sediment producing activities or locations; and treating existing potential sediment sites. The latter includes traditional upland watershed restoration, erosion prevention and erosion control, as described throughout *Part X*.

Reduce the risk of failure or erosion by treating existing sediment sites. This type of preventive restoration, to reduce or eliminate erosion, includes decommissioning of abandoned or unnecessary roads, excavation of potentially unstable fillslopes and small landslides, upgrading road stream crossings, installing critical dips to prevent stream diversions, and dispersing surface runoff.

Erosion Control

Employ erosion control to reduce accelerated sediment delivery to a stream. However, traditional erosion control techniques are naturally limited in their ability to be widely effective and cost-effective. Erosion control is only applicable to erosion processes that are actively occurring, and

not to sediment sources that have not yet developed. It is difficult to conduct erosion control for processes that are episodic and for processes that generally cannot be cost-effectively controlled (e.g., large landslides). Some processes are just too large or complex to control once they have begun. Reserve control treatment for erosion processes that are amenable to cost-effective treatment.

Mitigation and Clean-up

These strategies are limited in their utility. Mitigation to counter balance the expected impacts of sediment producing land use activity is difficult. Clean up may be impossible to apply in many circumstances (sediment is difficult to remove once it is in the stream channel) and is typically of limited effectiveness.

Modification of Land Use Practices

The most cost-effective tools for minimizing future erosion and sediment delivery to streams are preventive land use practices and protection measures that limit watershed disturbances. Certain combinations of land use practices and site variables (soils, slope gradient, bedrock geology, slope position, etc.) have been documented to contribute to, or influence, the magnitude or location of watershed erosion. As the result of the watershed assessment and collection of inventory data, recommended modifications to land use practices may provide passive protection to downstream aquatic resources, especially from impacts that occur during infrequent floods.

Practical protection measures related to road networks should address issues such as improved road location and design standards; limiting operations on steep inner gorge slopes, other suspect geomorphic locations and riparian corridors; improved road construction and drainage practices; proper stream crossing installation; frequent road maintenance; and road decommissioning. Seasonal road use restriction is a passive measure to lessen the potential for sediment-related impacts to stream channels. Protection measures for grazed lands include; grazing allocations, riparian planting and fencing, localized enclosures, and other seasonal restrictions.

Road Related Restoration Techniques

Roads are typically a common and disproportionately significant source of accelerated sediment delivery in managed watersheds. Most significant and common erosion problems occurring along roads are predictable and cost-effective to prevent or treat.

There are two basic techniques for road risk reduction and restoration:

- Decommissioning (closure);
- Upgrading.

Following are generic treatment descriptions for a variety of preventive treatments for both decommissioning and upgrading roads. These treatments are collectively referred to as “storm-proofing” (Figure X-9) (Weaver and Hagans 1999). The treatments described for roads or hillslopes have been tested, documented and evaluated in similar erosion control and erosion prevention projects. They have been shown to be generally effective in reducing sediment delivery from managed forest and ranch lands when used in a properly planned and constructed project (California State Parks 2001; Harr and Nichols 1993; Sonnevil and Weaver 1981; USDA

Forest Service 1996; USDI Park Service 1992; Weaver and Hagans 1996; Weaver and others 1981; Weaver and others 1987a,b; Weaver and Sonnevil 1984). In every case, the road upgrading and decommissioning treatments listed in *Part X* must be informed by, and customized by, an evaluation of the characteristics of each potential treatment site.

Road Decommissioning

Decommissioning is the same as road closure. It can be permanent or temporary, but the treatments for both are similar. Decommissioning is defined as removing those elements of a road that reroute hillslope drainage and present slope stability hazards. Another term for this is "hydrologic obliteration" (USDA 1993). It involves such tasks as decompacting road surfaces and installing road surface drainage (e.g., cross road drains or road out sloping) (Figure X-10 and Figure X-11), excavating unstable sidecast and road fill (Figure X-11), and fully excavating stream crossing fills (Figure X-12) (not just culvert removal). Decommissioning essentially involves reverse road construction, except that full topographic obliteration of the roadbed is rarely required to accomplish sediment prevention goals. In order to protect the aquatic ecosystem, hydrologically decommission the road by dispersing runoff, reestablish drainage patterns and remove or stabilize any potential sources of sediment delivery along the alignment. Estimating the sediment savings and treatment cost-effectiveness of such projects will help identify which roads in the watershed are truly the best targets for decommissioning (Table X-4).

Roads with High Priority for Decommissioning

Relative to potential threats to the aquatic ecosystem, certain roads frequently qualify as a high priority for decommissioning. These include poorly built roads in riparian areas, on steep inner gorge slopes, across unstable or highly erodible soils, in tributary canyons where stream crossings and steep slopes are common, roads with high short-term or long-term maintenance costs and requirements, and abandoned roads containing large or numerous sediment delivery sites.

Roads with Low Priority for Decommissioning

Roads that are of low relative priority for decommissioning includes those that follow low gradient ridges, traverse large benches or low gradient upland slopes, and have few or no stream crossings. Roads no longer needed for land or resource management may or may not be a high priority for removal depending on where they are located in the watershed. These would include dead-end spur roads with no stream crossings located high on the hillslope.

Road Decommissioning Treatments

The following tabulated and diagrammed treatments do not represent rigorous specifications, but rather descriptions of basic techniques that must be informed by site-specific evaluations.

Decommissioning consists of three basic tasks.

- Complete excavation of stream crossing fills, including 100 year flood channel bottom widths and 2:1 or otherwise stable side slopes;
- Excavation of unstable or potential unstable sidecast materials that could otherwise fail and deliver sediment to a stream;
- Road surface treatments (ripping, outsloping and/or cross draining) to disperse and reduce surface runoff.

Road Decommissioning Effectiveness

The effectiveness of road decommissioning tasks is usually expressed over two time periods: 1) the volume of sediment that has been prevented from being delivered to stream channels (long term effectiveness) and 2) the volume of sediment that is eroded from the decommissioned sites and delivered to local stream channels in the first several years after decommissioning activities (short term effectiveness). The goal of a decommissioning project is to maximize long-term effectiveness (sediment savings) and to minimize short-term sediment release from the site.

Treatment of road surface runoff (hydrologic connectivity) and excavation of potentially unstable fillslopes have been shown to be highly effective sediment control techniques (PWA 2005). Excavating stream crossings using protocols outlined in *Part X* also proved highly effective (PWA 2005). Most short-term sediment loss from decommissioned sites originated at excavated stream crossings. The primary sources of this sediment delivery, accounting for 91% of the soil loss, were channel incision, surface erosion, and slumps on the sideslopes of excavated stream crossings. Operator error (mostly consisting of leaving unexcavated fill in the stream crossing) accounted for 40% of the potentially avoidable erosion. The remaining 60% of sediment loss was judged to be unavoidable. The single most effective erosion prevention practice, measured by the reduction of post-decommissioning erosion and sediment delivery, was the correct application of recommended treatment prescriptions as outlined in *Part X*.

Role of Emergent Groundwater

Emergent groundwater along roads scheduled for decommissioning plays an important role in the eventual effectiveness of the road closure treatment. Perform road erosion inventories during the wet season, when springs on the roadbed and cutbank are most likely to be active and identifiable. If inventories are conducted during dry summer conditions, hydrophyllic (water loving) vegetation or mottled and discolored soils can be used to indicate the presence of seeps and springs.

Design treatments of wet areas to allow free drainage of springs and other emergent water and connection of these flow sources with downslope channels and swales. Do not place spoil material against cutbanks or cover springs that occur on the roadbed; spoil endhauling may be required. Some springs may not be visible during the assessment phase of the project, even if conducted during wet winter conditions. For example, some natural springs are buried during road construction and are only revealed when the road is decommissioned (typically during dry summer months). Excavated stream crossing sideslopes occasionally expose pre-existing springs, and these sources of emergent water can cause soil saturation and gullying or slope instability. In cases where embankment materials are saturated, as evidenced by winter surveys, excavation may be indicated even where no other signs of potential failure are identified. At the same time, excavation methods must be designed for wet and potentially hazardous conditions where equipment or laborers are working near wet cuts and fills[1]. Saturated materials need to be properly stored where they will not enter a watercourse.

[1]Applicable worker health and safety regulations include but are not limited to sections: 29, the Code of Federal Regulations (CFR) 1926.650, 601 (b)(6) of and Title 8, Sections: 1540, 1541, 1541.1 of the California Code of Regulations.

Characteristics of Storm-proofed Roads

Storm-proofed stream crossings

- All stream crossings have a drainage structure designed for the 100-year flow (with debris).
- Stream crossings have no diversion potential (functional critical dips are in place).
- Stream crossing inlets have low plug potential (trash barriers & graded drainage).
- Protect stream crossing outlets from erosion (extended, transported or dissipated).
- Culvert inlet, outlet and bottom are open and in sound condition.
- Undersized culverts in deep fills (greater than backhoe reach) have emergency overflow culvert.
- Bridges have stable, non-eroding abutments and do not significantly restrict 100-year flood flow.
- Fills are stable (unstable fills are removed or stabilized).
- Road surfaces and ditches are "disconnected" from streams and stream crossing culverts.
- Class I stream crossings meet DFG and NMFS fish passage criteria (Part IX).

Storm-proofed fills

- Unstable and potentially unstable road and landing fills are excavated or structurally stabilized.
- Excavated spoil is placed in locations where it will not enter a stream.
- Excavated spoil is placed where it will not cause a slope failure or landslide.

Road surface drainage

- Road surfaces and ditches are "disconnected" from streams and stream crossing culverts.
- Ditches are drained frequently by functional rolling dips or ditch relief culverts.
- Outflow from ditch relief culverts does not discharge to streams.
- Gullies (including those below ditch relief culverts) are dewatered to the extent possible.
- Ditches do not discharge (through culverts or rolling dips) onto active or potential landslides.
- Decommissioned roads have permanent drainage and do not rely on ditches
- Fine sediment contributions from roads, cutbanks and ditches are minimized by utilizing seasonal closures and installing a variety of surface drainage techniques including berm removal, road surface shaping (outsloping, insloping or crowning), rolling dips, ditch relief culverts, water bars and other measures to disperse road surface runoff and reduce or eliminate sediment delivery to the stream.

Figure X-9. Common characteristics of storm-proofed roads.

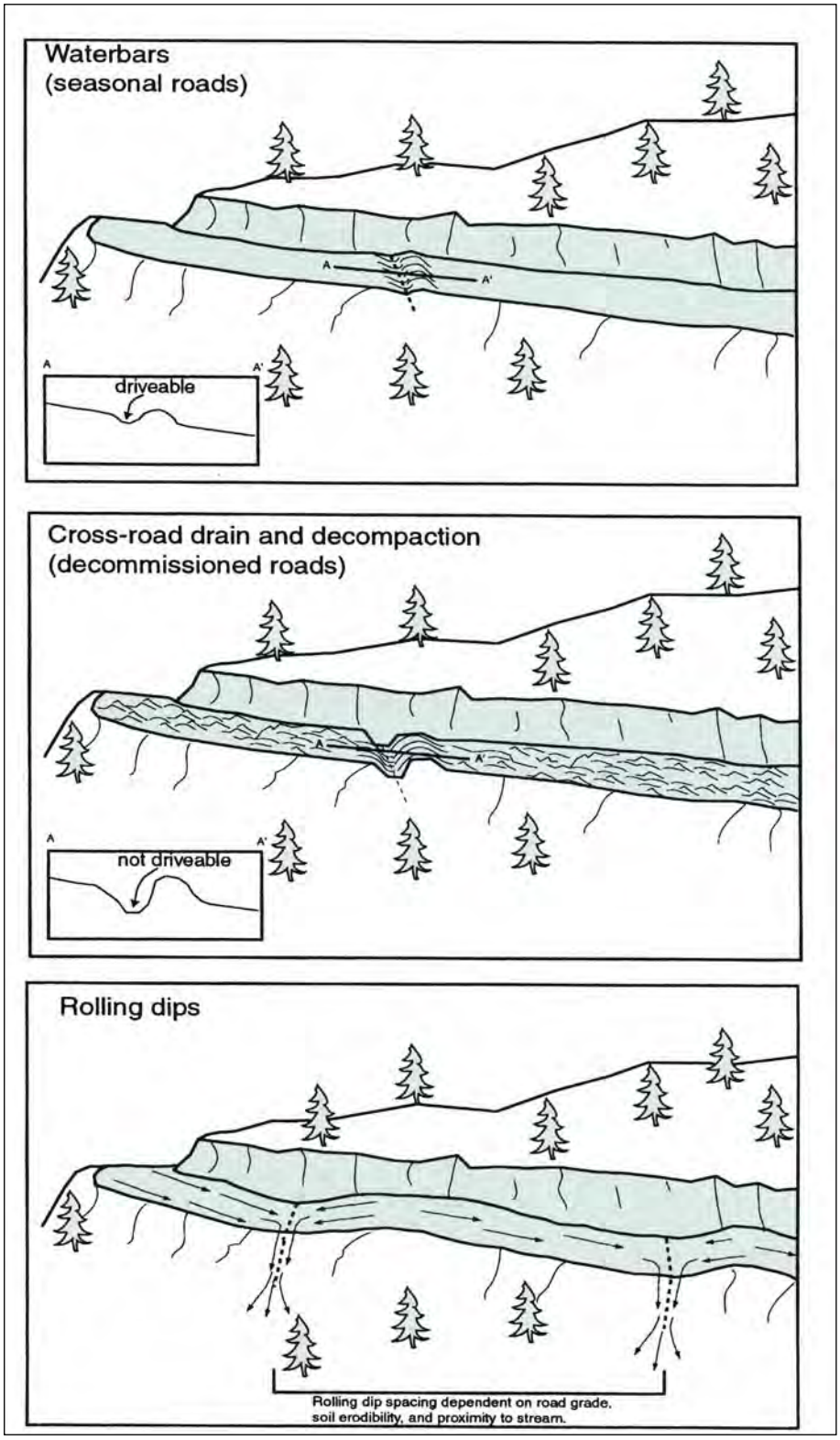
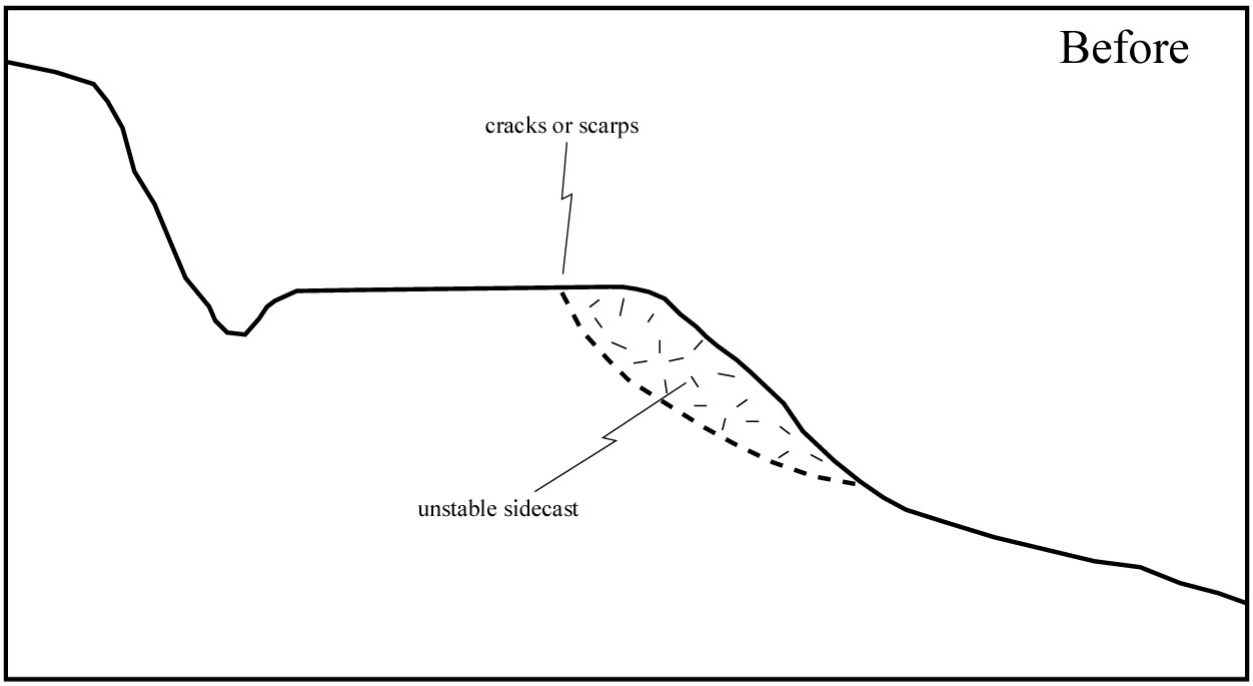


Figure X-10. Techniques for dispersing road runoff.



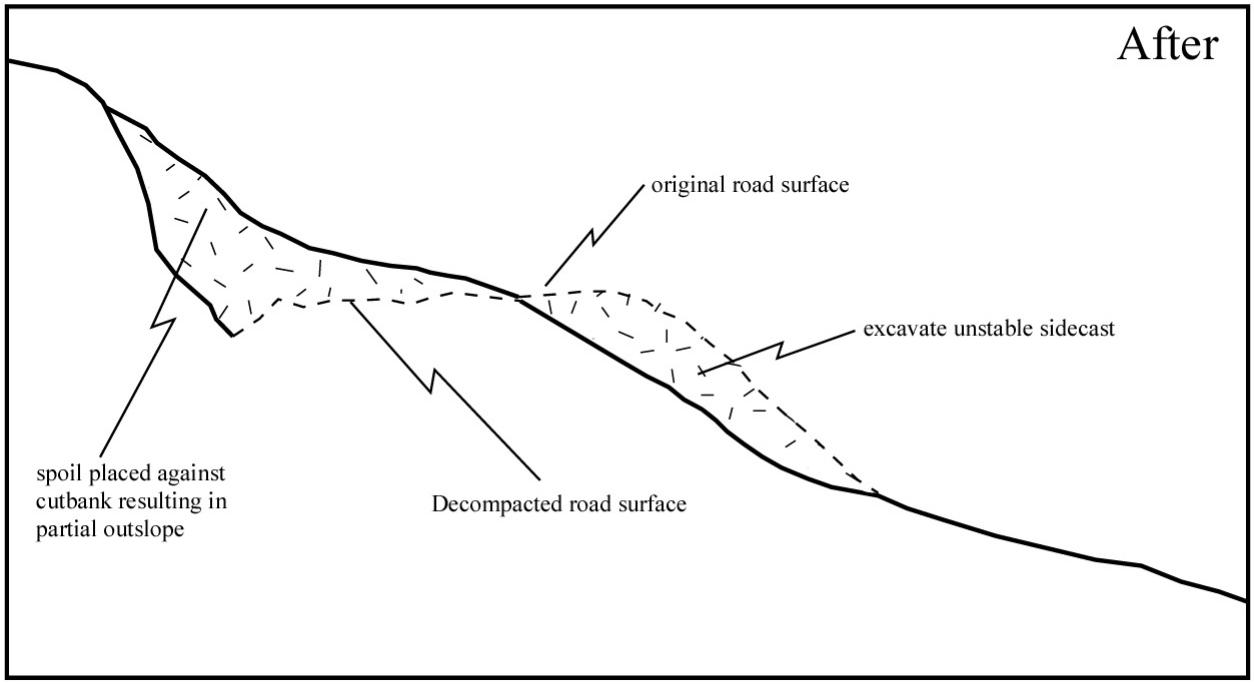
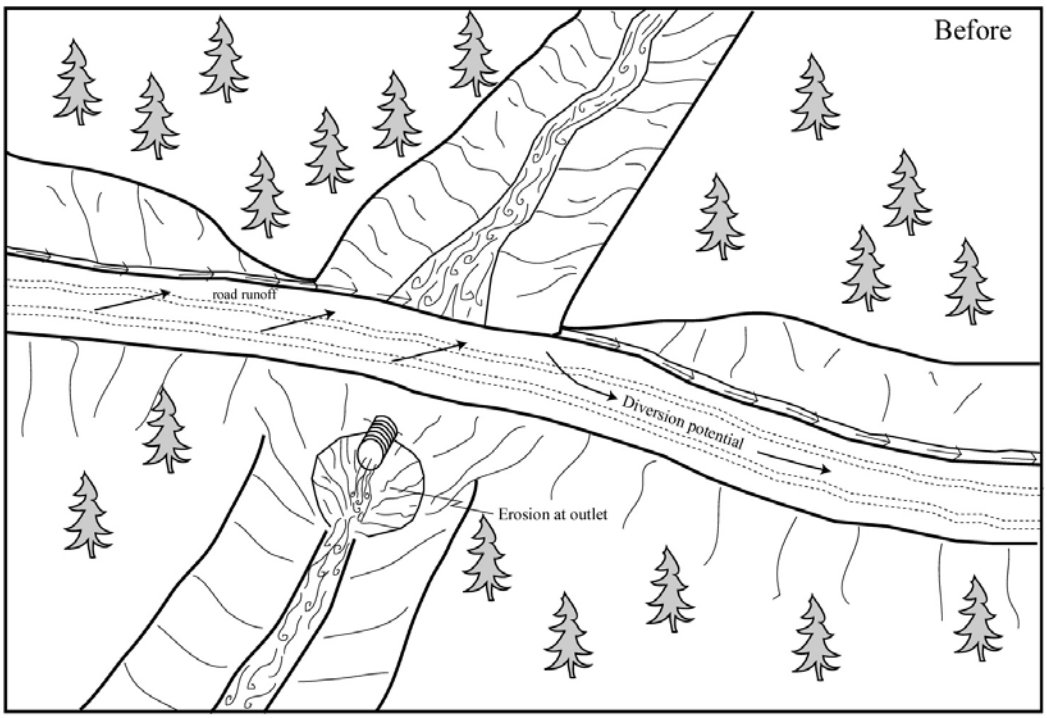


Figure X-11. Partial outsloping for road decommissioning.

Condition

- Diversion potential
- Road surface and ditch flows drain to stream
- Undersized culvert high in fill with outlet erosion and elevated plugging potential



Treatment

- Road surface decompacted
- Cross road drains on old road
- Stream crossing fill completely excavated
- Excavated spoil used to outslope adjacent road

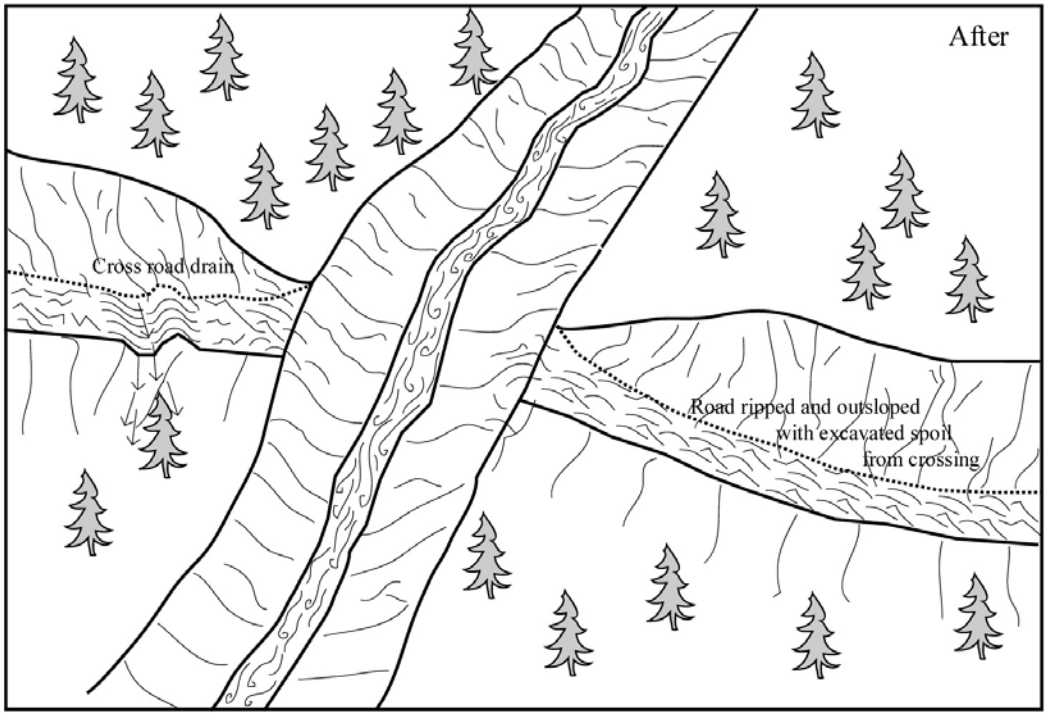


Figure X-12. Typical stream crossing excavation on a decommissioned road.

Treatment	Typical Application	Typical Actions	Typical Costs[1]
Ripping or Decompaction	Improve infiltration; decrease runoff; assist revegetation	Rip roads, landings and compacted areas with multiple passes to average depth of 18".	$1,000 - $2,000/mile
Construction of cross-road drains	Drain springs; drain insloped roads; drain landings	Drains deeper and wider than waterbars, extending from cutbank to outside edge of road (captures ditch flow).	$1/ft ($25-$50 ea)
Partial outsloping (local spoil site; fill against the cutbank)	Remove minor unstable fills; disperse cutbank seeps and runoff	Road should be ripped before adding spoil for outsloping. Springs should not be covered. Ditches can be filled.	$2,500 - 12,500+ /mile
Complete outsloping (local spoil site; fill against the cutbank)	Used for removing unstable fill material where nearby cutbank does not include seeps or springs	Road should be ripped before adding spoil for outsloping. Springs should not be covered. Ditches can be filled.	$10,000 - 75,000+/mile
Exported outsloping (fill pushed or hauled away and stored down-road)	Used for removing unstable road fills where cutbanks have springs and cannot be buried	Spoil site should be located in stable area where sediment will not be delivered to stream.	$2 - $5/yd^3, depending on haul distance
Landing and fillslope excavations (with local spoil storage)	Used to remove unstable material around landing perimeter	Landing should be ripped and spoil placed on inside half of landing. Springs should not be covered.	$2 - $5/yd^3, high organics can increase costs
Stream crossing excavations (with local spoil storage)	Complete removal of stream crossing fills (not just culvert removal)	Excavate all fill from crossing, down to original channel bed with straight or concave profile; original or 2:1 side slope gradient; natural channel width	Averages $3 - $10/yd^3 but can vary considerably
Truck endhauling (dump truck)	Hauling excavated spoil to an offsite spoil disposal site	Haul to a stable site not near stream channels. Place spoil where it is stable and will not deliver to a stream.	$2 to $5/yd^3 on top of basic excavation work

[1] These are estimated treatment costs for equipment working at a site. Heavy equipment treatments performed using D-7 tractors and hydraulic excavators with average 2 yd^3 bucket size. They do not include transportation, moving from site-to-site, overhead, project supervision by or consultation with restoration or professional geotechnical specialists, layout, or any other costs. Costs can vary considerably from these typical figures, depending on operator skill and experience, equipment types, local site conditions, and regional location. Example costs are from 2004 data for north coastal California and are not based on prevailing wage rates. Production rate data from from PWA (unpublished) and NPS (1992).

Table X-4. Typical techniques and costs for decommissioning forest and ranch roads.

Road Upgrading

Managed watersheds need roads to provide for long-term resource management and access to private properties or recreational areas. Good land stewardship requires road systems be protective of fish habitat and the aquatic ecosystems in the watershed. Transportation planning requires that landowners or land managers consider the erosion consequences of retaining the road and the expressed needs for management activities. Retained roads should be located on stable terrain, where the risk and impacts of fluvial erosion, stream crossing failure, storm damage

and mass soil movement is low. Roads should be largely self-maintaining or require low levels of maintenance. To facilitate this, many existing roads will likely need to be upgraded.

For fisheries protection and restoration, the goal of road upgrading is to minimize the contributions of fine sediment from roads and ditches to stream channels, as well as to minimize the risk and impacts of episodic erosion and sediment delivery when storms and floods occur.

Road upgrading or storm-proofing involves a variety of treatments designed to make a road more resilient to runoff from large storms and flood flows (Figure X-9 and Table X-5)(Weaver and Hagans 1999). The most important of these include upgrading stream crossings for the 100-year flood flow, elimination of stream diversion potential, removal of unstable sidecast and fill materials from steep slopes, and the application of drainage techniques to improve dispersion of road surface runoff. Newly constructed roads may not need as much corrective treatment as older roads. For example, timberland owners and foresters are now required by the Forest Practice rules, as amended by the California State Board of Forestry and Fire Protection in 2000, to design all new and reconstructed permanent watercourse crossings to accommodate an estimated 100-year flood flow, including wood and sediment loads. They are also required to design stream crossings such that there is no chance of future stream diversion.

Road Upgrading Treatments

In general, road upgrading consists of stream crossing upgrades, excavation of selected unstable or potential unstable fillslopes, and dispersion of road runoff (Figure X-9).

The following guidance, typical diagrams and tables summarize common road upgrading techniques, including road surface shaping (insloping and outsloping), berm removal, rolling dips, ditch relief culverts, and non-fish bearing culvert installation. For more detail, see *Handbook for Forest and Ranch Roads* (PWA 1994) or the corresponding video *Forest and Ranch Roads* (MCRCD 2003).

Treatment	Ideal Equipment	Sample Cost Rate[1]	Sample Application Rate and Assumptions	Sample Cost[2]
Outslope road and fill ditch	Grader with rippers	$85/hr	500ft/hr for 20' wide road	$170/1000 ft
Rolling dip	Dozer with rippers	$85/hr	1 hr each (30-40' long on flat roads) 2 hrs each (50-100' long on steep roads)	$85 - $170 each
Remove berm or clean ditch	Grader	$85/hr	1000'/hr (no trees on berm or in ditch)	$85/1000 ft
Rock road (1.5" minus crushed)	Dump truck spread	$17 – $40/ yd^3 - delivered	4" deep x 20' wide = 250 yds3/1000 ft road	$4,250 - $10,000/1000 ft
Install ditch relief culvert (assumes 40' of 18" culvert	Back hoe or Excavator[2] and Laborer	$65/hr $125/hr $30/hr	3 hours each + $8.50/ft + $18 coupler + $90 labor	$645 to $825 each
Stream crossing installation (36" x 40' culvert with 200 yd^3 fill)	Excavator Tractor Water truck and Laborer	$125/hr $85/hr $85/hr $30/hr	$1,520 culvert (w/coupler) + $875 excavator + $595 dozer + $170 water truck + $90 labor + $100 tamper	$3,270 each
Culvert downspout installation	Hand labor and Equipment (>24")	$30/hr $125/hr	20' x 24": 2 hrs labor 40' x 36": 3 hrs labor + 1 hr excavator	$60 + materials $375 + materials
Straw mulch bare soils areas	Labor	$30/hr $5/bale straw	1 bale/600 ft^2 - 700 ft^2 + spreading @ 4 bales/hr	$19-$22/1000 ft^2
Complete road upgrading	Excavator, Tractor and Dump trucks	$125/hr $85/hr $65/hr	Average mid-slope road requiring stream crossing upgrades	$15,000 - $40,000/mile

[1] Costs can vary considerably from these typical figures, depending on operator skill and experience, equipment types, local site conditions and regional location. Example costs are from 2004 data for north coastal California and are not based on prevailing wage rates. Production rate data from PWA (unpublished).

[2] Costs are variable depending on materials costs, equipment types and rental rates, and operator experience. Culvert cost assumptions (<= 24" - 16 gauge galvanized culvert, >=30" – 12 gauge galvanized culvert): 18" - $8.50/ft; 24" - $11.50/ft; 36" - $29/ft; 48" - $38/ft; 60" - $48/ft. Some treatments (e.g., outsloping road and filling the ditch) may be performed for different rates using tractor instead of grader. Dozer and dump trucks are often needed on culverted stream crossing installations larger than 200 cubic yards.

Table X-5. Example logistics and costs for a variety of upgrading task for forest and ranch roads.

Stream Crossing Upgrading

- Eliminate stream diversion potential by dipping the entire stream crossing fill or by installing a critical dip (Figure X-13). A critical dip is a rolling dip that is constructed on or close to the down-road hinge line of a stream crossing that displays a diversion potential.
- Upgrade stream crossings by installing culverts sized for the 100-year flood flow, including sufficient capacity for expected wood and sediment (Figure X-13 and Figure X-14). These requirements are determined by both field observation and calculations using a procedure such as the Rational Formula (PWA 1994; Dunne and Leopold 1978) for small watersheds (<100 acres), or regional regression equations developed for ungaged watersheds up to several hundred acres in size (Waananen and Crippen 1977; Cafferata et al. 2004).[2] Where necessary, install inlet protection (trash barriers) to prevent culvert plugging on non-fish bearing streams.
- Place culverts in line and on grade with the natural stream channel above and below the crossing site (Figure X-14). This minimizes the probability of culvert plugging. In streams with resident or anadromous fish, or where there is a requirement to provide for passage of non-fish aquatic species, culverts must be embedded in the natural stream channel according to specific guidelines (DFG Manual, Part IX). If non-fish stream crossing fills are exceptionally deep (beyond backhoe reach from the road surface) then a full round downspout can be installed to take the stream flow to the base of the fill and discharge it into the natural stream channel. At the point of return flow from the pipe to the natural stream channel, some form of energy dissipation and erosion protection may be required to control scour at the culvert outfall (Figure X-14).
- Replace large high-risk culverts with bridges. Consider replacing any culvert greater than 72 inches in diameter with a bridge, especially in Class 1 streams.
- Replace culverted fills with hardened fords or armored fills (Figure X-15 and Figure X-16) on non-fish bearing streams where regular winter inspections and culvert maintenance is not feasible, or on steep gradient stream crossings where the culvert plug potential will always be high.

<u>Stream Crossing Culvert Installation for Non-fish Bearing Streams</u>

- Align culverts with the natural stream channel orientation to ensure proper function, prevent bank erosion and minimize debris plugging problems.
- Place culverts at the base of the fill and at the grade of the original streambed or install a downspout past the base of the fill (Figure X-13 and Figure X-14). Down-drain (or downspout) assemblies should only be installed if there are no other options.

[2] Technical references for rainfall and runoff data include the California Data Exchange Center http://cdec.water.ca.gov, the Department of Water Resources http://wdl.water.ca.gov (under construction), the Department of Forestry http://cdf.ca.gov/projects/esu/esulooup.asp and the Western Regional Climate Center http://www.wrcc.dri.edu/summary/climsmnca. Software for performing peak flow calculations is also available (e.g., USGS Peak Frequency Software, http://water.usgs.gov/software/peakfq.html and USGS National Flood frequency Software, http://water.usgs.gov/software/nff.html

- Culverts should be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
- Culvert beds should be composed of rock-free soil or gravel, evenly distributed under the length of the pipe.
- Compact the base and sidewall material before placing the pipe in its bed.
- Lay the pipe on a well-compacted base. Poor basal compaction will cause settling or deflection in the pipe and can result in separation at a coupling or rupture in the pipe wall. If compaction is problematic, then the potential sagging after burial can be accounted for by maintaining an upward camber between 1.5 to 3 inches per 10 feet culvert pipe length.
- Backfill material should be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around the pipe.
- Cover one end of the culvert pipe, then the other end. Once the ends are secure, cover the center.
- Tamp and compact backfill material throughout the entire process, using water as necessary for compaction.
- Backfill compacting will be done in 0.5 – 1.0 foot lifts until 1/3 of the diameter of the culvert has been covered (Figure X-14). A gas powered tamper or sheep's foot roller should be used for this work.
- Armor inlets and outlets with rock, or mulch and seed with grass as needed (not all stream crossings need to be armored).
- Install a trash rack (only on non-fish bearing streams) upstream from the culvert inlet where there is a high hazard of floating debris plugging the culvert.
- Push layers of fill over the crossing to achieve the final design road grade, at a minimum of one-third to one-half the culvert diameter.

Trash Racks

All trash racks require on-going maintenance. Two efficient trash rack designs include:

- On streams with culverts 48 inches diameter or greater, build a grate or sieve across the entire channel to collect the large material that would otherwise plug the culvert inlet. Locate the trash rack anywhere from five to 25 feet upstream from the culvert inlet.
- On streams with culverts under 48 inches diameter, set a single post vertically in the steam bed, centered directly upstream from the culvert inlet, and located one culvert diameter distance upstream from the inlet. Size the post and set the post deep into the streambed to withstand the size of woody debris transported by the stream during extreme runoff events.

<u>Ten steps to building an effective armored fill stream crossing</u>

Install armored crossings (Figures X-15 and X-16) in areas where debris torrents are common, can be expected or where small steep gradient streams cross the road. Armored fill crossings are for sites where it will be very difficult to prevent frequent culvert plugging due to high amounts of transported sediment and debris. The treatment requires excavating a portion of the fill in the stream crossing and leaving a very broad dip in the axis of the natural channel, with long and

gently sloping ramps into and out of the stream crossing. This treatment may be most appropriate along roads built on a floodplain and terrace, or where roads cross steep gradient stream channels with relatively small depths of fill at the outboard edge of the road.

Before prescribing or building an armored fill, make sure the site is appropriate for the structure. Evaluate the suitability of the site for an armored fill, making sure the stream is not too big and the fill is not too deep. The stream should be a relatively small Class 2 or Class 3 stream (a fish-bearing Class 1 in not appropriate) and the fill depth at the outside edge of the road should not exceed about six (6) feet in depth. Once the site is determined to be potentially suitable, there are ten basic steps to converting the stream crossing to a stable armored fill.

1) Evaluate design and construction requirements - The four most important concepts to understand when constructing an armored fill are: a) constructing a broad and deep rolling dip through the road where the stream is to cross, b) excavating a keyway in the outer half of the roadbed, down the fillslope and across the toe of the fillslope to hold the rock armor, c) selecting rock armor that is suitably sized to resist transport by the stream during design flood flows, and d) placing the rock armor. Proper shaping of the excavated road fill, proper armor sizing, and good armor placement will reduce the likelihood of crossing failure.

The rock must be placed in a broad "U" shaped excavation across the channel and the roadbed so that the streamflow will always stay confined within the armored area; even during the 100-year design flood flow. If the flow gets around (outside) the rock armoring on the road surface or on the armored fillslope, it will quickly gully around and through the remaining road fill.

A range of interlocking rock armor sizes should be selected and sized so that peak flows will not pluck or transport the armor off the roadbed or the sloping fill face of the armored fill (e.g., see Racin et al., 2000). There are two key places where rock size and rock placement is critical: 1) at the base of the armored fill where the road fill meets the natural channel and 2) at the break-in-slope between the outer roadbed and the upper fill face. The largest rocks must be used at the toe to support or buttress the armor placed on the fillslope above it. This will provide toe support for the rest of the armor and reduce the likelihood of it washing downslope. Armor placed at the slope break at the top of the fillslope is also critical in that it will provide the stable "base level" for the creek as it crosses the road surface and accelerates down the fill face.

2) Remove drainage structures - Remove any existing drainage facilities in the fill, including culverts and Humboldt logs or large organic debris in the stream crossing fill (Figure X-16; cross sections A-B).

3) Dip the roadbed - Construct a broad rolling dip across the roadbed, centered at the crossing, which is large enough to contain the expected 100-yr flood discharge while preventing flood flow from diverting down the road or around the rock armor (Figure X-16; cross sections C-D; E-F). For many crossings, the broad dip typically averages two to three feet deep along the "thalweg" or axis of the dip.

4) Excavate the keyway and armored area - Excavate a two to three foot deep "bed" into the dipped road surface and adjacent fillslope (to place the rock in) that extends from approximately

the middle of the road, across the outer half of the road, and down the outboard road fill to where the base of the fill meets the natural channel. Peak flow calculations for the 100-year discharge (e.g., using the rational formula) should be performed to determine the proper width of the armored area through the roadbed and on the fillslope. Typically, for small Class 2 and Class 3 channels, the required armored width at the outside edge of the road has been found to be at least five times the estimated peak flow width of the natural channel upstream of the crossing. At the base of the fill, excavate a three (3) foot deep keyway trench extending across the channel bed (Figure X-16; cross sections G-H; I-J).

5) Install fabric lining - Install geo-fabric within the trenched keyway at the toe and extending up the excavated fillslope and across the excavated part of the roadbed; anywhere rock armor is to be placed (Figure X-16; cross sections G-H). Bury the top of the fabric in a trench across the roadbed to key in the fabric. The fabric will support the rock armor in wet areas and prevent winnowing of the fine sediments and road fill beneath the rock armor when the stream flows over the armored fill.

6) Armor the basal keyway - Put aside the largest rock armoring to create two buttresses. Use the largest rock armor to fill the basal trench and create a buttress at the base of the fill. This should have a “U” shape to it and it will define the outlet where flow leaves the armored fill and enters the natural channel (Figure X-16; cross sections K-L).

7) Armor the fill - Backfill the fill face with the remaining rock armor making sure the final armor is unsorted and well placed, the armor is two coarse-rock layers in thickness, and the armored area on the fill face also has a “U” shape that will accommodate the largest expected flow (Figure X-16; cross sections K-L).

8) Armor the top of the fill - Install a second trenched buttress for large rock at the break-in-slope between the outboard road edge and the top of the fill face. The level of the armor rock placed in this “buttress” at the top of the fill face will define the base level of the stream as it crosses the roadbed (Figure X-16; cross sections M-N).

9) Armor the roadbed - Backfill the rest of the roadbed keyway with the unsorted rock armor making sure the final armored area on the roadbed has a “U” shape (Figure X-16; cross sections O-P) that will accommodate the 100-year design flood flow.

10) Inspect and maintain the crossing - Monitor the armored fill for the first several winters and make maintenance repairs to any armor that may have moved during peak flow periods. Maintain the flood flow capacity of the armored fill on the roadbed (Figure X-16; cross sections O-P) by grading alluvial deposits and debris off the road as needed.

Erosion Control Measures for Culvert Installation

Use a combination of mechanical and vegetative measures to minimize accelerated erosion from stream crossing and ditch relief culvert installation. Erosion control measures may include:

- Minimizing soil exposure by limiting excavation areas and heavy equipment disturbance.

- Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to down slope areas and stream channels.
- Insloping the road prism at newly constructed or upgraded stream crossings to minimize fillslope erosion caused by road runoff.
- Protecting bare slopes created by construction operations until vegetation can stabilize the surface. Minimize surface erosion on exposed cuts and fills by mulching, seeding, planting, compacting, armoring, and/or benching prior to the first fall rains.
- Storing extra or unusable soil in long-term spoils disposal locations that are not subject to excessive moisture, steep slopes, archaeological sites, listed species, or proximate to a watercourse.
- If there is running or standing water, pumping or diverting water past the crossing and into the downstream channel during the construction process.
- Installing straw bales and/or silt fencing where necessary to control runoff and sediment movement within the construction zone.

Excavation of Unstable Fillslope

Remove unstable sidecast and fill materials from steep slopes (Figure X-17), steep headwater swales, and along road approaches to deeply incised stream channels, where there is potential for sediment delivery. Worker safety in potentially hazardous areas, where slopes are steep, wet and potentially unstable, must be in conformance with applicable worker safety regulations (e.g., see Caltrans 1990).[3]

- Excavate small volumes of unstable fill along the outside edge of the road, turnout or landing if it has the potential to fail and be delivered to a stream channel.
- Unstable fill that has little or no potential to fail or be delivered to a stream need not be excavated if fish habitat protection is the only goal.
- Excavate fill material in an arc-shaped downslope profile, so as to remove as much of the unstable mass as is possible.
- Store excavated spoil materials in a location where eroded sediment will not enter a watercourse.

[3] Wherever workers have to enter an area where the banks or cuts are greater than five feet in height (functionally a trench), the banks of such areas will need to be properly sloped, benched, or shored (trenching needs to be in compliance with all applicable worker health and safety regulations including but not limited to sections: 29, the Code of Federal Regulations (CFR) 1926.650, 601 (b)(6) of and Title 8, Sections: 1540, 1541, 1541.1 of the California Code of Regulations.

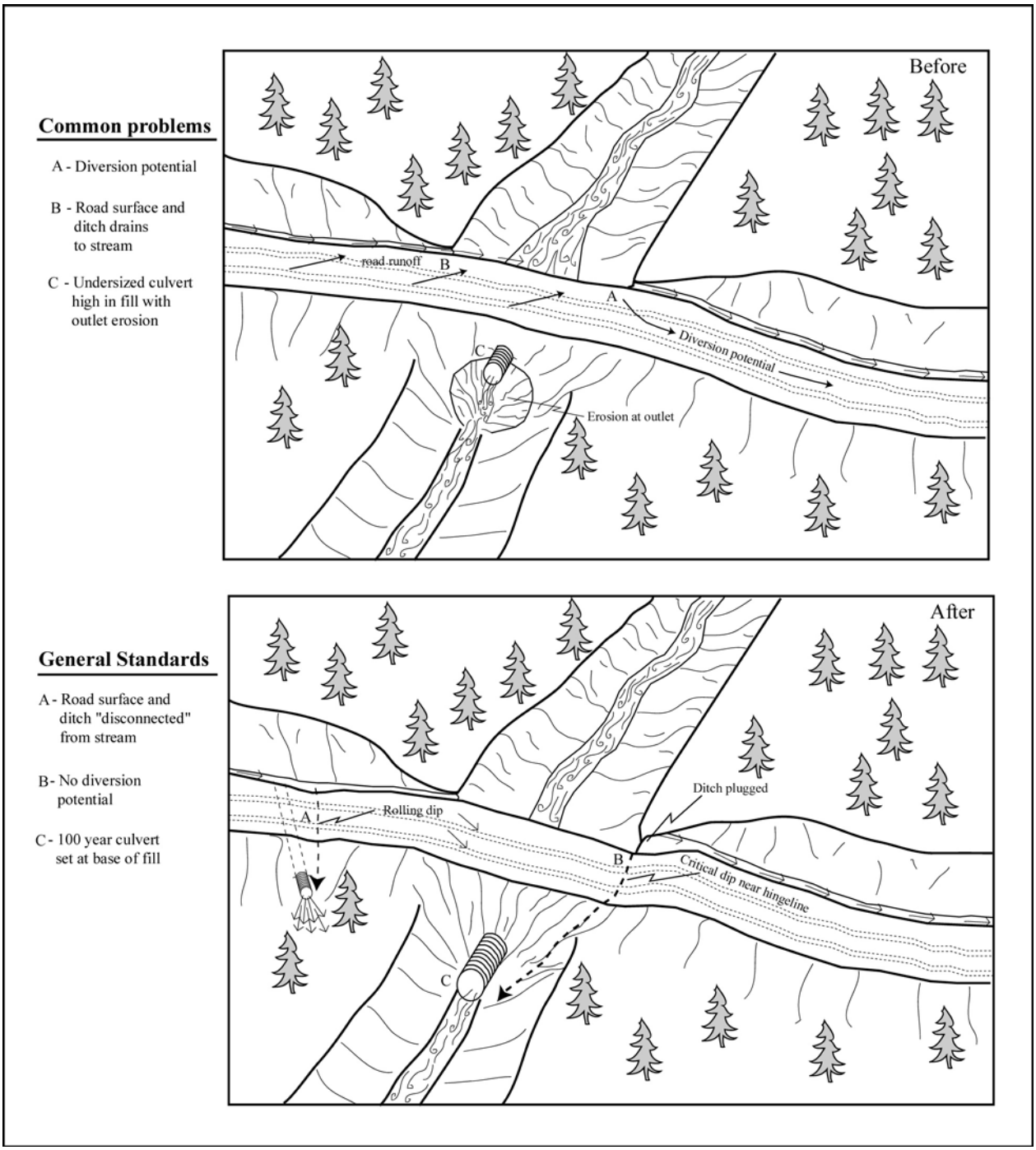


Figure X-13. Typical upgraded stream crossing.

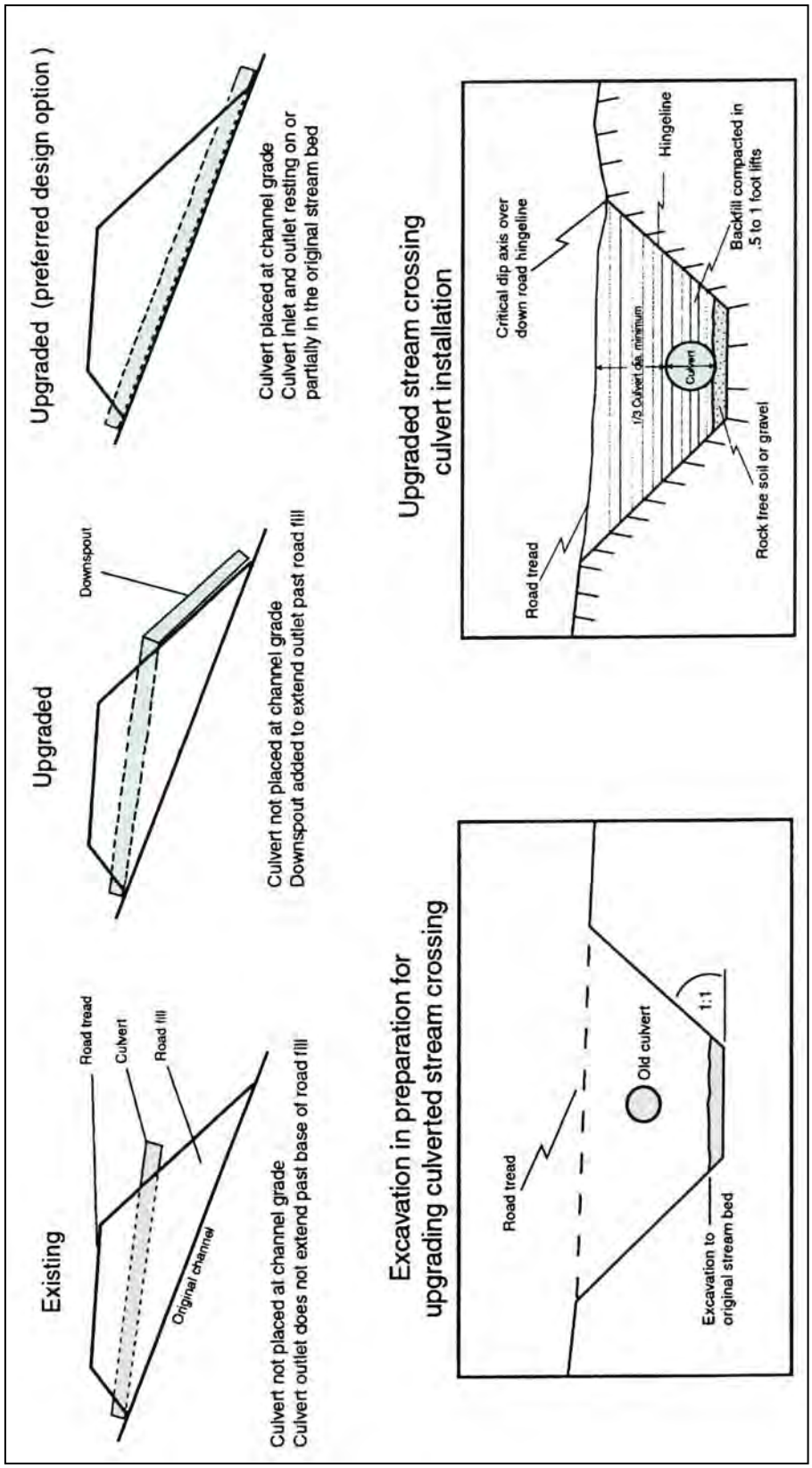


Figure X-14. Typical culvert installation on non fish-bearing streams.

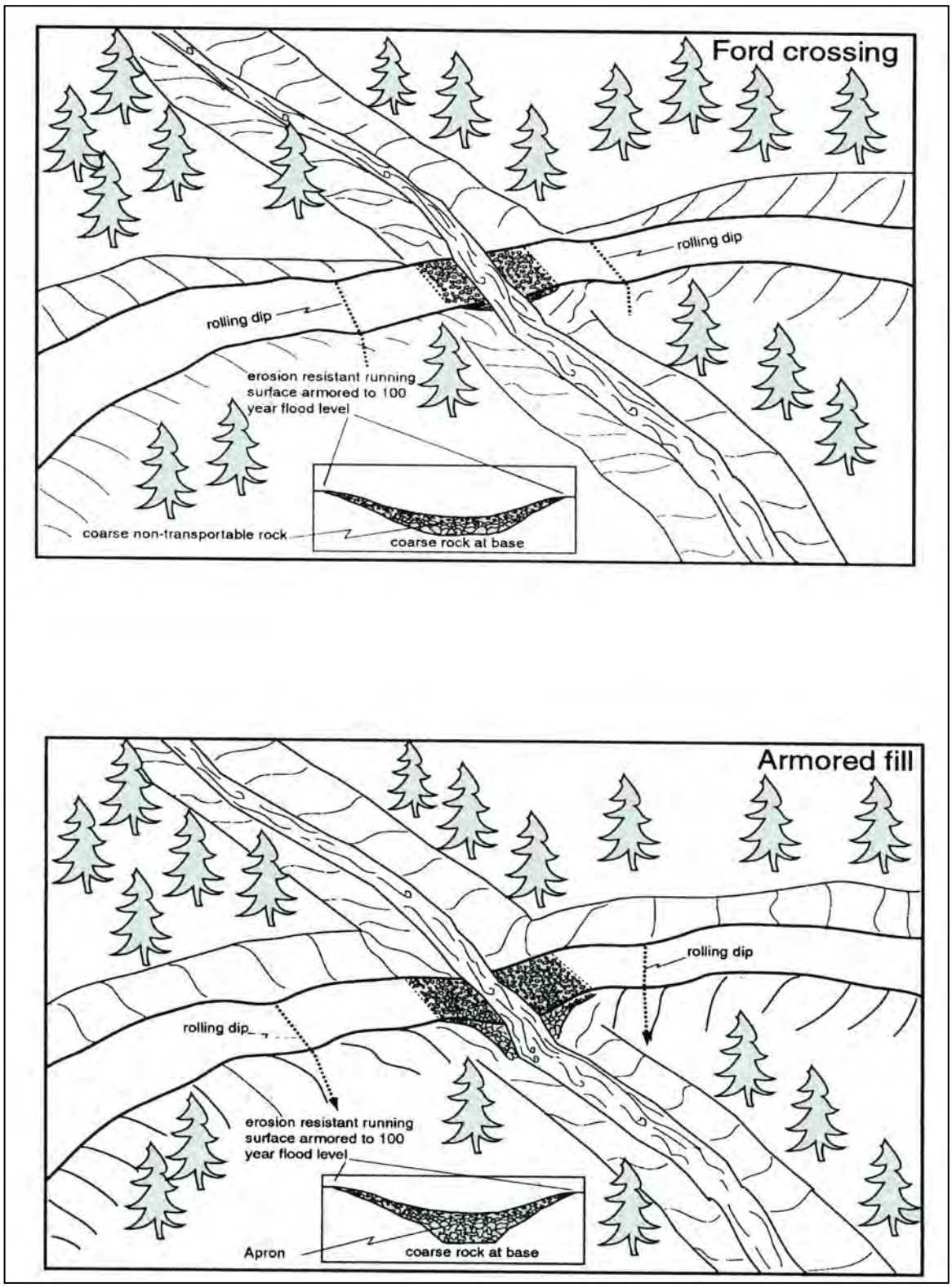


Figure X-15. Typical ford and armored fill stream crossings.

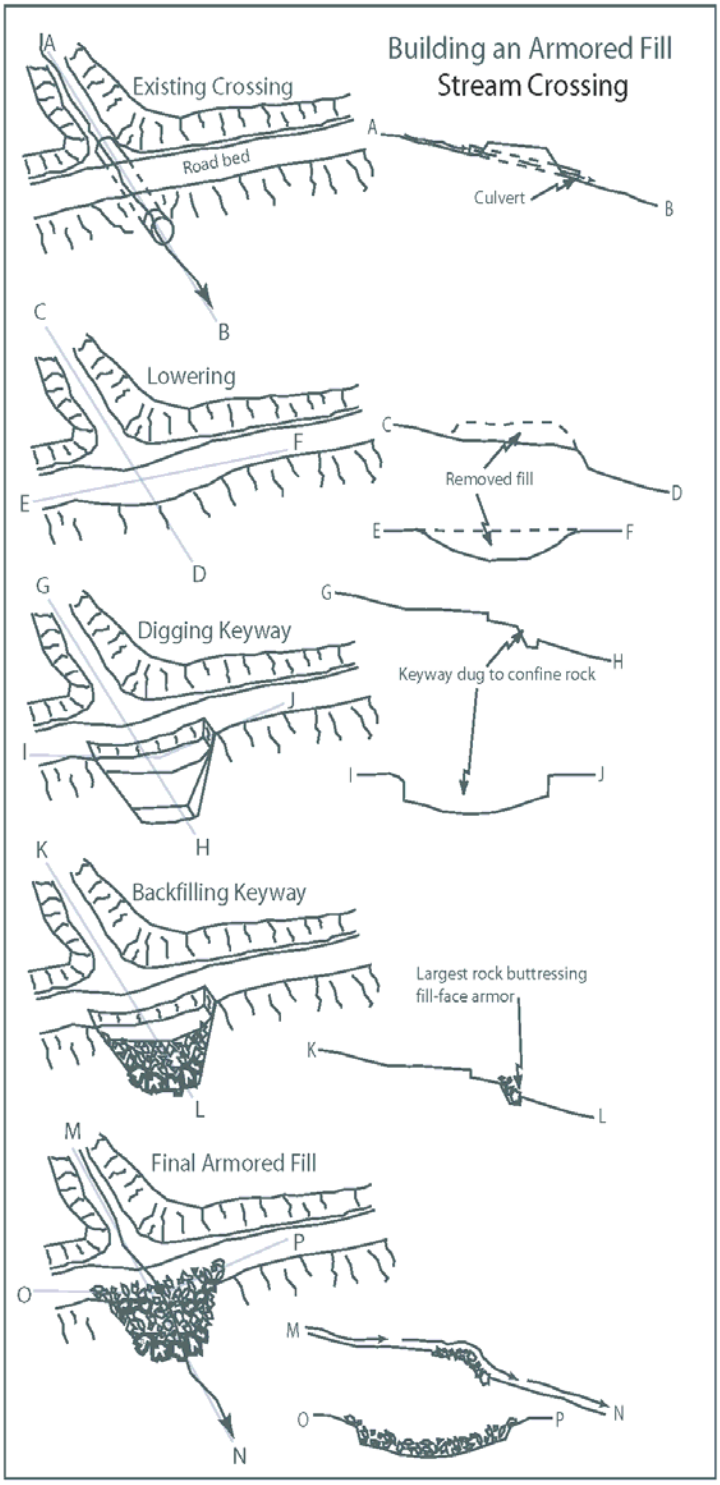


Figure X-16. Design elements of a typical armored fill crossing. Note: where geotextile fabric may interfere with passage of amphibians in any Class 2 or 3 crossing, bury geotextile fabric with at least 6 inches of rock. Do not expose geotextile fabric in the bed of fish-bearing stream channels.

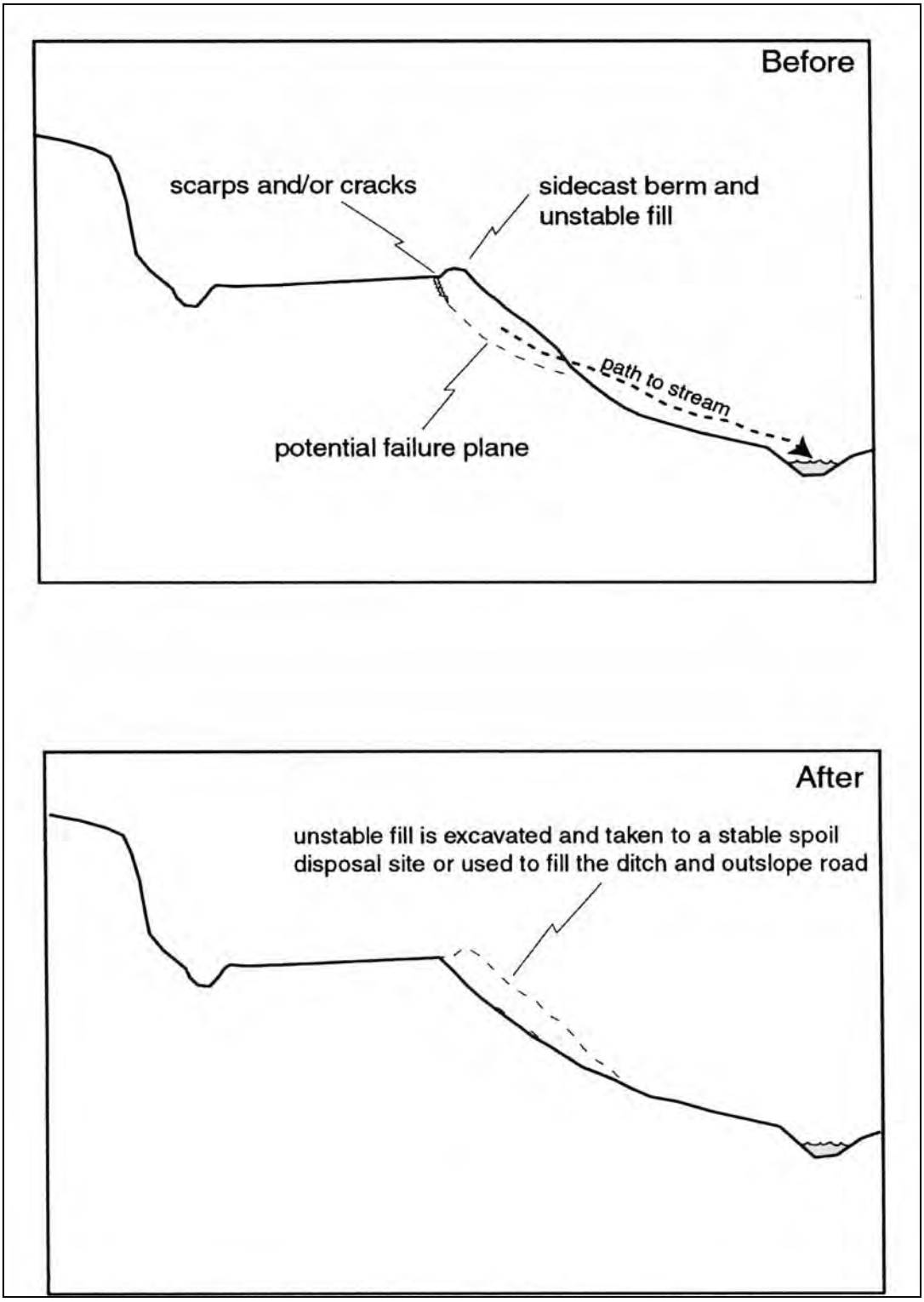


Figure X-17. Removal of unstable sidecast materials.

Dispersion of Road Runoff

Disperse and disconnect road surface runoff from streams. Road cutbanks and road ditches are known to deliver substantial volumes of fine sediment to streams in some watersheds (e.g., Reid 1981; Reid and Dunne 1984) and they have been found to significantly affect watershed hydrology (Wemple 1994). Relatively simple treatments can be performed to upgrade road drainage systems to significantly reduce or largely eliminate this source of fine sediment delivery to streams. Sediment may be minimized by utilizing seasonal closures or traffic restrictions, and dispersing road runoff. Choose from a variety or combination of surface drainage techniques including berm removal (Figure X-19), water bars (Figure X-10), road surface shaping (outsloping, insloping or crowning (Table X-6), ditch relief culverts (Figure X-19), rolling dips (Figure X-19), and other measures that effectively disperse road surface runoff and reduce or eliminate sediment delivery to the stream. To be effective, they must effectively disperse most road runoff and ditch flow before it reaches the stream. It is critical that all road surface drainage techniques effectively drain the road surface and be drivable for the expected traffic.

Spring and seeps along the road may occur in the roadbed or on the inside cutbank. Drain these sources of emergent groundwater to minimize damage to the road bed and to control sediment delivery to local stream channels. Drain roads with common or high volume springs with frequent ditch relief culverts. Culvert spacing must be close enough to prevent downslope gully erosion or hydrologic connectivity to nearby streams. Drain emergent water from the roadbed using such techniques as French drains and drainage blankets.

Road Shaping (outsloping, crowning and insloping)

- Where suitable and appropriate, road outsloping is the preferred method of road shaping for protecting water quality and minimizing fine sediment delivery to streams.
- Outsloped roads drain their surface runoff to the outside edge of the roadbed and onto the fillslope (provided there is no berm) (Figure X-19). The degree of outslope is typically at least 2% for low gradient roads (<4%) but increases as road grade increases (Table X-6), with consideration for driver safety.
- Outsloped roads may or may not have an inside ditch. If the cutbank is wet or has springs during part of the year, a ditch will be necessary to drain emergent water to a ditch relief culvert or rolling dip.
- Insloped roads can be converted to outsloped roads in several ways. If there is no spring flow in the ditch and the ditch can be filled, the insloped road can be ripped and regraded with the spoil material generated on the outside half of the road being used to fill the ditch and provide the outslope shape to the roadbed. Alternatively, fill can be imported to fill the ditch and outslope the roadbed. If an inside ditch needs to be maintained, because emergent groundwater and seeps are present along the cutbank, either of these construction techniques can be used to outslope the roadbed without filling the ditch.
- Crowned roads drain both to the outside of the road onto the fillslope, as well as to the inside of the road into a ditch (Figure X-19).
- The crown or high spot in the road cross section is often the center of the road, but it can be shifted towards the inside third of the road decrease the amount of road runoff that is delivered to the ditch.
- Steep roads (greater than about 14%) are difficult to drain, so crowned road shapes are sometimes employed to improve road drainage and to increase vehicle safety. However, it

is imperative that an appropriate number of ditch relief culverts and/or rolling dips be used to drain the ditch on steep roads.

- Insloped roads are used where water cannot be discharged over the outside fillslope because of soil erodibility, fillslope instability or potential water quality problems, or where cutbanks are very unstable (Figure X-19).
- Insloped road surfaces typically slope at 3% to 4% towards the ditch, but the degree of inslope will increase as the grade of the road increases in order to drain road runoff into the ditch (Table X-6).
- Insloped roads need a ditch to carry road runoff and spring flow from the cutbank and from upslope areas to the nearest ditch relief culvert or rolling dip where it can be discharged to the hillslope.
- Insloped roads with ditches are one of the most common ways in which roads are hydrologically connected to streams in a watershed. Thus, to the maximum extent possible, insloped roads should be frequently drained onto the hillslope, using ditch relief culverts or rolling dips, where runoff will not enter a stream channel.

Outsloping pitch for roads up to 12% grade		
Road Grade	**Outslope Pitch for Unsurfaced roads**	**Outslope Pitch for Surfaced Roads**
4% or less	3/8” per foot	1/2” per foot
5%	1/2” per foot	5/8” per foot
6%	5/8” per foot	3/4” per foot
7%	3/4” per foot	7/8” per foot
12% or more	1” per foot	1/4” per foot

Table X-6. Outsloping pitch for roads up to 12% grade.

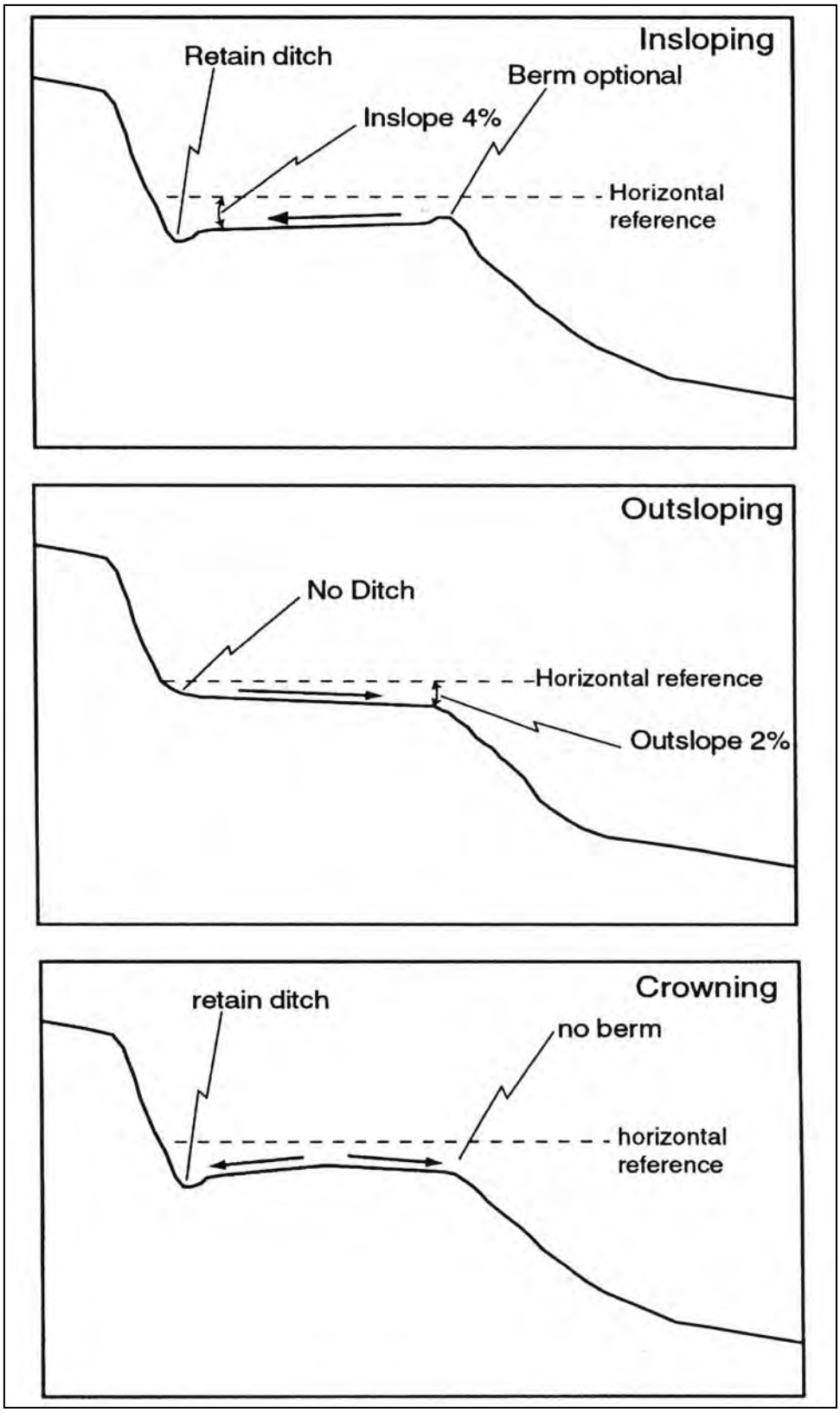


Figure X-18. Utilizing road shape to reduce surface runoff rates.

Berm Removal

- Road berms on insloped roads do not affect road drainage and can usually be left in place with little negative effect.
- Berms located along the outside edge of a crowned or outsloped road prevents road runoff from leaving the roadbed. This often results in roadbed erosion or gully erosion where the concentrated runoff is discharged off the road.
- On steep gradient roads, berms are sometimes used as a real or perceived safety measure to keep vehicles from sliding off the road. In other places, berms are sometimes intentionally used to keep road runoff from discharging onto an erodible, unstable or potentially unstable fillslope. Some berms are simply the end-product of years of grading that have left a continuous or discontinuous berm of road grader spoil material along the outside edge of the roadbed, so that the grader operator can use it to pull back onto the roadbed during future maintenance work.
- Berm breaks are locations where the berm is not intact and road runoff is allowed to discharge onto the slopes below the road. The runoff from berm breaks can be discharged directly onto the fillslope or directed into a culverted or sheet metal berm drain that is used to carry the runoff some distance downslope or to the base of the fillslope (Figure X-19).
- If they are not needed, or if they are causing road drainage and erosion problems, road berms on crowned and outsloped roads can be either partially or completely removed. On low gradient roads, berms can often be completely removed. On steeper roads, where safety is an issue, the berm can be frequently breached with short gaps spaced 30 to 100 feet apart. A semi-continuous berm is thereby left for safety reasons and the road is frequently drained (Figure X-19).
- Depending on the slope steepness and proximity of the road to a stream, berms can be removed by excavation or sidecasting. Sidecasting should not be used if there is a possibility that spoil or eroded sediment could enter a watercourse.

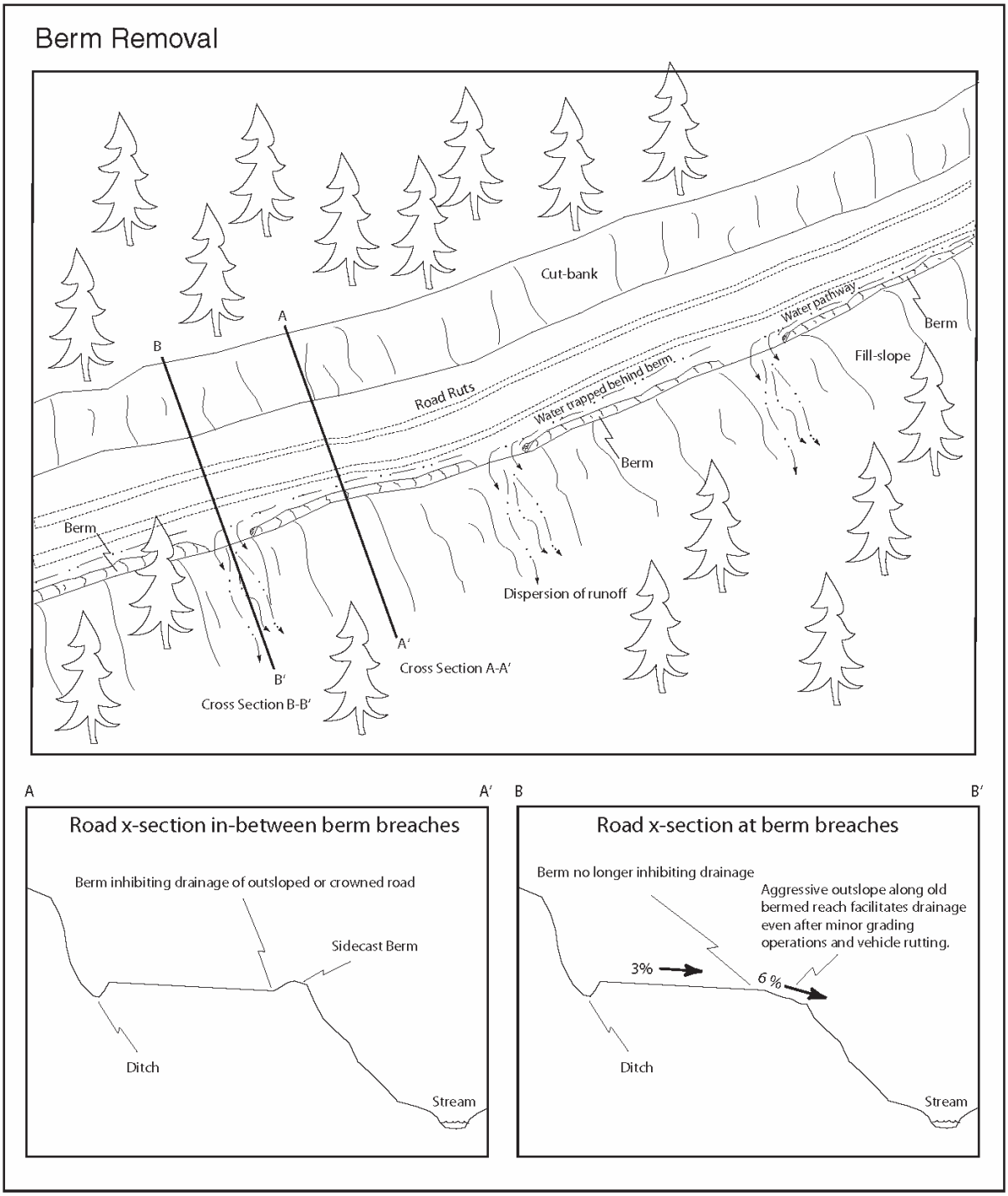


Figure X-19. Berm removal for improved drainage on outsloped and crowned roads.

Ditch Relief Culverts

- Install ditch relief culverts at an oblique (typically 30 degree) angle to the road so that ditch flow does not have to make a sharp angle turn to enter the pipe (Figure X-20). On low gradient roads (<5%), where ditch flow is slow, ditch relief culverts can be installed at right angles to the road.
- Install ditch relief culverts (DRC) to outlet at, and drain to, the base of the fill (preferred option) (Figure X-20).
- If it cannot be installed at the base of the fill, install the DRC with a grade steeper than the inboard ditch draining to the culvert inlet, and then install a downspout on the outlet to carry the culverted flow to the base of the fillslope (Figure X-20).
- Downspouts longer than 20 feet should be secured to the hillslope for stability. Full round downspouts are preferred over half-round downspouts.
- Ditch relief culverts should not carry excessive flow such that gullying occurs below the culvert outlet. Use field evidence and culvert spacing tables (e.g., PWA 1994) to provide guidance on proper culvert spacing along upgraded roads.
- Do not discharge flow from ditch relief culverts onto unstable or highly erodible hillslopes.
- If the ditch is on an insloped or crowned road that is very close to a stream, consider using outsloping to drain the road surface. The ditch and the ditch relief culvert would then convey only spring flow from the cutbank, and not turbid runoff from the road surface.

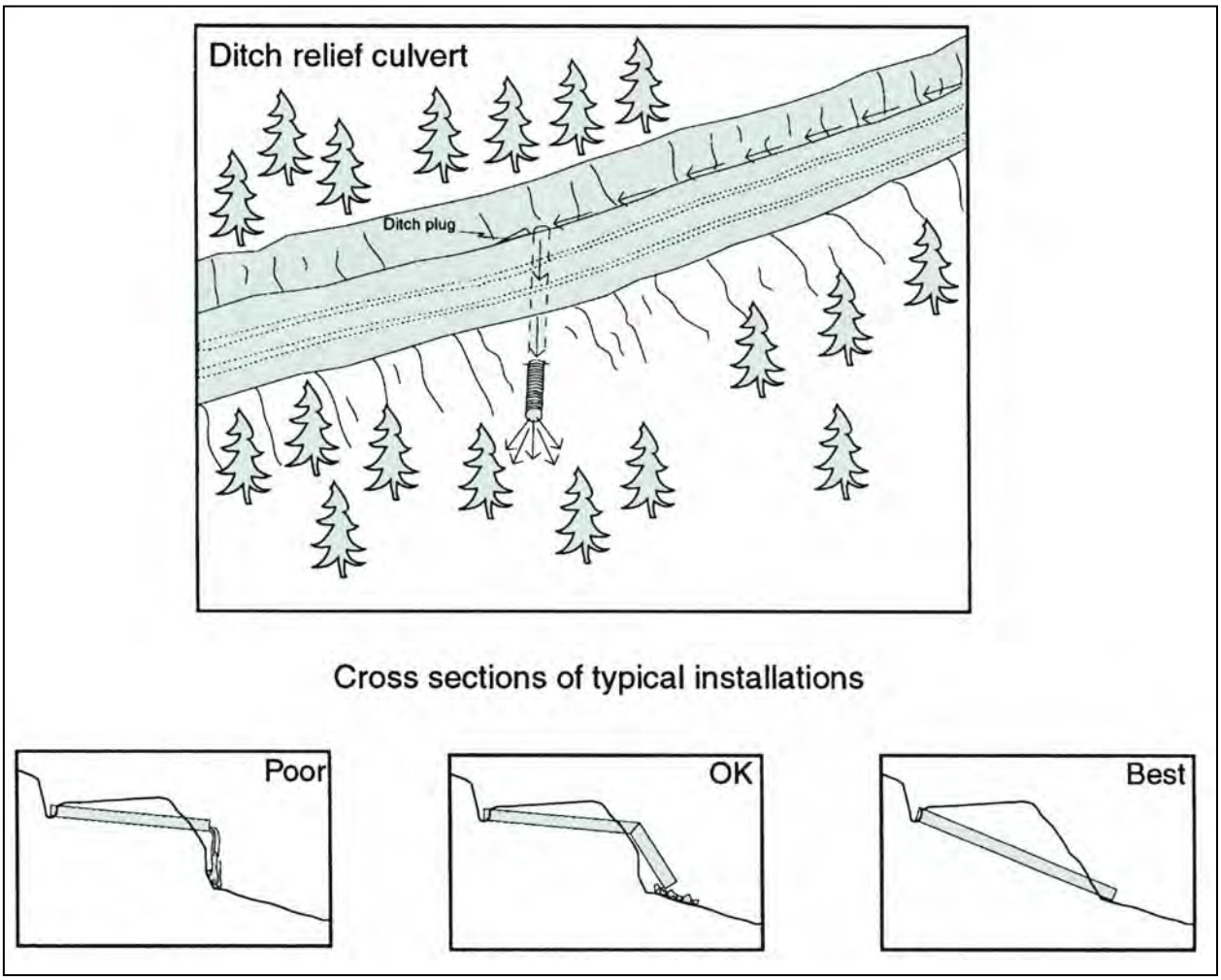


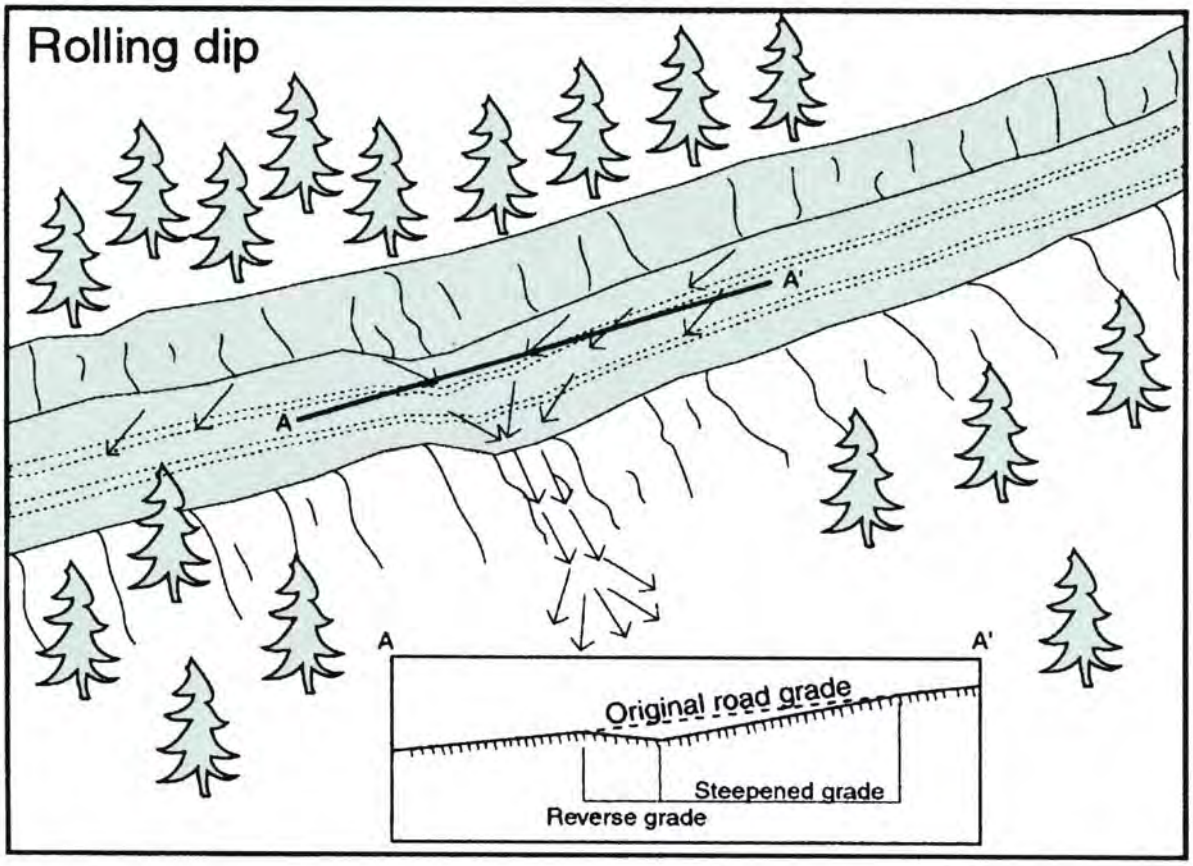
Figure X-20. Typical ditch relief culvert installation.

Rolling Dip Installation

- Install rolling dips in the roadbed as needed to drain the road surface. Rolling dips can be sloped either into the ditch (use sparingly) or to the outside of the road edge (preferred design) as required to properly drain the road and disperse surface runoff.
- Rolling dips should be located frequently enough to prevent erosion on the hillslope below the road and placed where they will not cause instability or gullying. To the extent that they can be, outboard sloping rolling dips should be coincident with natural drainage swales that are well-vegetated. They will likely need to be constructed at many other locations as well.
- Do not discharge rolling dips or ditch relief culverts into swales that show signs of instability or active landsliding.
- If the rolling dip is designed to divert both road surface and ditch runoff, block the down-road ditch with compacted fill. Ditches that carry a large volume of spring flow should probably be drained using ditch-relief culverts rather than rolling dips.
- Rolling dips are usually built directly across the road alignment with a cross grade at least one percent greater than the grade of the road (so that it will drain).
- Excavate the rolling dip with a medium size bulldozer (D-7 size) with rippers or with a grader.
- Begin excavation of the dip approximately 50 to 100 feet up-road from the proposed axis of the dip (Figure X-19). Progressively excavate material from the roadbed, with the grade becoming steeper, until reaching the axis (Figure X-21).
- Determine the depth of the dip, by the grade of the road (Figure X-19). In all cases, rolling dip dimensions must be consistent with the type of vehicles that will be using the road (Figure X-21).
- On the down-road side of the rolling dip axis, install a grade change to prevent runoff from continuing down the road. Carry the rise in grade for about 15 to 25 feet, or more, and then fall back to the original slope (Figure X-21). The axis of the dip must be a broad “u” shape to facilitate good driveability.
- In all cases, the rolling dip must be driveable and not significantly inhibit traffic and road use. It must also effectively drain the road surface.

Road grade %	Upslope approach (distance from up-road start of rolling dip to trough) (ft)	Reverse grade (distance from trough to crest) (ft)	Depth below average road grade at discharge end of trough (ft)	Depth below average road grade at upslope end of trough (ft)
<6	55	15-20	0.9	0.3
8	65	15-20	1.0	0.2
10	75	15-20	1.1	.01
12	85	20-25	1.2	.01
>12	100	20-25	1.3	.01

Table X-7. Table of rolling dip dimensions.



Note: Rolling dips must drain the road surface and be driveable for the expected traffic.

Figure X-21. Use of rolling dips to reduce ditch erosion and surface runoff.

Upslope Restoration Treatment Production Rates

Upslope restoration treatments consist of both heavy equipment and manual labor tasks. Heavy earth moving tasks, such as landslide excavations and road upgrading or decommissioning, often entail 80% to 95% of the total project costs. Upslope restoration project manual labor consists of such tasks as: culvert installation, installation of trash racks and culvert downspouts, flared inlet assembly and installation, gully control, stream bank protection, planting, seeding and mulching. On individual sites, there is generally a mix of heavy equipment and manual labor work.

Heavy Equipment Guidelines

Restoration involving heavy earth moving equipment can involve a wide range of equipment types. The key is to match the size of the equipment with the size of the job. If the job requires extensive excavation, large equipment can move greater amounts of material faster than smaller equipment for an overall cost saving, even though hourly cost rates are higher. If space or excavation volumes are limited, smaller equipment will be most cost-effective. The three most commonly used equipment types for road restoration are:

- Hydraulic excavator, with 1.5 to 3 yd^3 bucket and thumb;
- Crawler tractor (D5, D6, or D7 size, with hydraulic rippers and a U-blade, 3-way blade or 6-way blade);
- Dump truck (10 yd^3).

Other equipment frequently used on upslope restoration projects include backhoes, road graders, front-end loaders, compactors, water trucks, tractors with a winch, D-8 sized tractors and 20-30 yd^3 off-highway dump trucks.

Safety

A complete discussion of worker safety requirements, including those for laborers and equipment operators, is beyond the scope of this document. However, common sense practices and basic accident prevention techniques are required of all contractors, workers and supervisory personnel on a restoration project site. Safety should be the prime consideration on all jobs. Equipment operators know their personal limitations and strengths, and supervisory personnel should not request operators to perform tasks that are beyond their ability or comfort level. Department of Fish and Game grants contain specific provisions regarding required safety measures that must be followed during the conduct of State grants. Among others, these include:

- Pre-work safety sessions and grant requirements
- Development of a workers safety plan in case of accidents including appropriate first aid kits, ear plugs for work around heavy equipment, hard hats, high visibility clothing or safety vests, and appropriate field clothing and protective gear
- Fire safety plan; charged and appropriately sized fire extinguishers, emergency fire fighting hand tools (like a Pulaski fire axe), and spark arrestors on heavy equipment (or require turbo charged machinery)
- Equipment oil and fuel spill prevention plan and spill response kits
- Communication tools, including CB radios for travel on back roads to and from the work site and development of pre-determined hand signals during equipment operation

It is also recommended that erosion control practitioners have basic training and certifications in first aid and cardiopulmonary resuscitation (CPR). Specialized training in swift water rescue (for work on larger streams), wildland firefighting, emergency medical technician and confined space awareness (for trenches and culverts) can also be useful for some projects and personnel.

Equipment Production Rates

Most upslope restoration involves some type of excavation work. Excavation is involved in some types of landslide treatments, culvert installations and culvert replacements, and stream crossing installations for road upgrading, as well as decommissioning tasks such as stream crossing excavations, road outsloping, and excavations associated with road fill failures. Listed below are example production rates used to estimate job times and costs. Production rates include all work associated with excavations, not just digging dirt. Adjust time according to actual excavator production rates.

Stream Crossing Excavations

Excavator with 1.5 yd^3 bucket and thumb:

- Direct excavating of soil, 50 – 75 yd^3 per hour;
- Excavating extensive organics (such as Humboldt stream crossings) or excavating complicated long, deep and/or steep crossing fillslopes, 35 – 50 yd^3 per hour.

Sidecast Fill Excavations

Excavator with 1.5 yd^3 bucket and thumb:

- For clean sidecast dirt, 100 -120 yd^3 per hour;
- For sidecast with extensive organic debris or if many trees exist to work around, 50 - 100 yd^3 per hour.

Compaction

Proper compaction is very important in a variety of restoration project activities including: culvert installation, armored fills, rolling dips, and development of spoil disposal sites. Compaction during the dry summer months, when most restoration work is accomplished, will likely require the use of water trucks and artificial wetting of dry soil materials.

Pumping and Flow Diversion

Project work in live streams requires that the work site be dewatered and flow diverted around the site when equipment is working. Dewatering is performed to keep soils and excavated materials as dry as possible during work activities, and to reduce the potential for causing excessive erosion and downstream water quality impacts. If streams in the project area are live (flowing) delay instream work until the last possible moment, so that flows have dried up or are at a low point for the season. It is always best to work in dry streambeds.

Dewatering can be accomplished on small streams by diverting flow around the project site. Flows can be diverted with pumps or passive (gravity) systems such as side channels, constructed canals, or flexible pipe. Flow diversions require careful consideration of the backwater effects on diversions, pump capacities, diversion-channel capacities, and the need for temporary erosion

protection to prevent scour at the point where the water is returned to the natural channel downstream of the project site.

On larger streams, coffer dams can be used. Cofferdams are temporary watertight dams that may be used to impound the flowing water so that it can then be diverted around the project site. Coffer dams can be constructed by excavating into the alluvial stream bed (to capture both surface flow and intergravel flow) or by building a small dam to block flow in the channel. The diverted flow is then returned to the natural stream channel downstream of the work site.

Regardless of the technique employed, dewatering systems should be able to divert the one-year flows anticipated during the period of construction (i.e., the greatest flow with a 100-percent chance of occurring during the construction period). The possibility that the system will be overwhelmed by storm flows should also be planned for in the dewatering design.

In Class 1 streams, install screens upstream and downstream of the affected reach, then have a qualified fisheries biologist remove all fish and amphibians, prior to initiating flow diversions and dewatering. Similarly, a plan must be in place to recover any fish that might be left behind when the water is gone. Contact the Department of Fish and Game prior to initiating flow diversions in Class 1 streams. Dewater streams by gravitational diversion of stream flow in flexible pipes, or by using gas-powered pumps that can lift water out of and around the work site. Unless the stream reaches have been isolated and cleared of fish, pumps used in fish-bearing streams will require screens designed to DFG and NMFS specifications to prevent loss of fish. Whenever pumps are used, backup pumps and hoses should be available on-site in case of equipment breakdown. Pumps require on-site management; if pumps will be used only during the standard work week, then a plan for gravity diversions during nights and weekends will need to be in place until the site work is completed.

Specifically designate personnel to monitor and maintain each site diversion so as to minimize the potential for construction-related sediment releases. Limit diversions to the dry season operating period (before October 15) and only install diversions when weekly weather forecasts do not call for rain. Install silt fences, straw bales or other flow-filtering measures in the channel to reduce turbidity and suspended sediment when flow is reestablished through the work site. Strictly follow all requirements listed in the DFG 1600 Streambed Alteration Agreement for each site.

Mulching, Seeding, Planting

Cost-effective labor techniques include mulching, seeding and planting. Completely cover bare soil areas where surface erosion may deliver sediment to a stream with mulch, such as weed free straw. Rates of about 4,000 pounds per acre, or approximately 50 bales/acre of straw meet this standard. Use mulch to cover seed to improve microclimatic conditions for germination and seedling survival. Seeding and mulching rates are highly variable, depending on the seed mix used. Consult your local extension office, Natural Resource Conservation Service (NRCS), Resource Conservation District (RCD), or seed supplier for recommended rates of application and local site conditions. Mulching, seeding and planting are often good cost share jobs for landowners and volunteers.

Typical Road Upgrading and Road Decommissioning Costs

Costs for road upgrading and road decommissioning are highly variable and depend on a host of factors (Weaver and Hagans in press). General cost-estimating rules are not available, and extrapolating documented costs from an actual project to another is risky without close evaluation. See Tables X-3 and X-4 for generalized, estimated costs for a number of road upgrading and road decommissioning tasks. Table X-8 gives estimated cost ranges for road reaches developed from watershed inventories and actual forest and ranch road projects completed in northern coastal California between 1995 and 2000.

Road restoration activity	Typical unit costs[1]
Road upgrading (watershed-wide average, 100-year design)	$15,000 - $40,000/mile
Road upgrading (high priority road - moderate to high difficulty)	$45,000 - $75,000/mile
Road decommissioning (range of roads from ridge spurs to moderate complexity mid-slope roads)	$2,000 - $35,000/mile
Road decommissioning (moderately difficult roads)	$25,000 - $50,000/mile
Road decommissioning (difficult roads and/or full recontouring)	$50,000 - $100,000+/mile

[1] Example unit costs for road upgrading and road decommissioning are from 2000 to 2005 project data for a number of roads and road segments treated in north coastal California (PWA, unpublished).

Table X-8. Estimated road restoration cost ranges.

In general, overall road restoration costs closely correlate with the frequency of sites along the road and the volume of soil moved to perform the necessary erosion prevention and erosion control treatments. The higher the site frequency and the larger the sites, the more expensive it becomes. Widely spaced projects can significantly increase move-in/move-out costs. In addition, projects and sites requiring endhauling of excess spoil material are typically more expensive than similar projects where spoil is stored locally.

Implementation Methods

There are several ways to accomplish restoration work. These include direct contracting, equipment rental and in-house for landowners with equipment. Each method has advantages and disadvantages.

Contracting

Contracting is a common way to accomplish restoration projects. This starts by developing a written description of the job and the desired finished product, then soliciting bids to perform the work. Consider the following before deciding to contract out a project.

- Contracted restoration work requires extensive up-front planning, the development of enforceable specifications and project layout. Lay out the job as accurately (typically using surveys and grade staking) and as precisely as possible so that the contractor knows exactly what they are bidding on and what they will be responsible for in the end.

- Contractors usually bid vague projects high because they are not sure what will be required or what they may encounter.
- Any encountered changes (increases) in the job require a change-order in which the contractor may be charging a premium price.
- Preparing detailed project specifications, volume surveys and/or grade staking is a complicated and time-consuming job that represents a substantial investment in up-front time and money. This planning effort may not be possible due to personnel limitations or restricted timeframes.
- Awarding a contract to the lowest bidder is not always best. Depending on the contracting evaluation rules, this can encourage low-ball bids and may require acceptance or use of less qualified or less experienced contractors.

Equipment Rental

Under this method, hire contractors on an hourly basis (equipment with operators) and technically supervise the contractors to complete the restoration work on an hourly basis. This is termed a time-and-materials contract.

- Seek to hire equipment operators skilled and experienced in erosion prevention and control techniques.
- If equipment operators are less experienced, the on-site supervisor must be able to provide technical guidance. As described elsewhere, some types of projects will require supervision by professional geotechnical specialists. On-site supervision or oversight is important for all projects, but becomes even more critical when using inexperienced or unfamiliar operators. For reasons of safety and project cost-effectiveness, inexperienced contractors and operators should not be hired for restoration projects.
- This allows modification of work, without the need for change orders, when encountering unexpected conditions in the field. This added flexibility is often important.
- The equipment rental rate is set for all restoration work, regardless of the nature and magnitude of the project.
- Contractors are likely to provide favorable rates because they know they will be paid for all work they complete (there is little or no risk on their part).
- It is possible to replace contractors if their performance is not up to required standards.

In-house

Some landowners have in-house capability to conduct upslope restoration, especially road upgrading and decommissioning, using their own equipment. To be successful, equipment operators and supervisors must have experience with the types of restoration treatments being implemented. Because they are typically in business for other purposes (e.g., logging or ranching) restoration experience of available in-house operators may be lacking.

- Hourly rates for the use of in-house heavy equipment are frequently lower (more favorable) than for contracting or equipment rental.
- In-house capability is typically the indirect result of having heavy equipment purchased for other purposes such as logging. As such, available equipment may not be perfectly suited for the restoration work. If a special piece of equipment is required to complete the

work (e.g., a larger excavator, or a dozer with a 6-way blade and rippers, etc.), do not compromise the cost-effectiveness of the entire project by not requiring the landowner to lease or rent the proper equipment. This is often a disadvantage.

- Many landowners have old equipment that is subject to frequent breakdowns.
- In-house equipment operators and laborers who are hourly employees are more likely to work restricted hours (to avoid overtime) as compared to a contractor or owner/operator who will work full days. With a limited summer work schedule, long work hours are often a necessary component of successful restoration projects.
- Equipment shortages are likely to occur if the landowner or land manager prematurely moves the equipment off-site to conduct logging or other activities.

QUALITY CONTROL, DOCUMENTATION AND MONITORING

Quality Control Measures

Quality control measures implemented in the field before and during the on-the-ground work help ensure the most effective, efficient techniques are applied, and that projects meet the established design standards. There are a number of ways that incorrect implementation can result in ineffective projects, excessive costs and/or environmental damage. A quality control/assurance program can help prevent these occurrences. Various procedures can be instituted that will increase the probability that the proposed restoration work is effectively and cost-effectively implemented by heavy equipment contractors and labor crews.

Selecting Contractors and Operators

Trained and experienced contractors, equipment operators and technical specialists are one of the most important keys to completing effective and cost-effective upslope restoration work. High quality work is much more likely to occur by screening operators for experience, skill and the proper heavy equipment prior to selection.

Check certifications, past job experience and professional references to ensure that contractors, equipment operators, engineers and geologists that are to be selected for the job are appropriately licensed and skilled. Request and check references and job performance for similar projects. Specifications of heavy equipment required for the job should be stated and checked against those listed by the contractor or operator.

Adaptive Project Design

Prior to heavy equipment or laborers arriving to conduct restoration work, check final prescriptions and clearly flag each work site. Marking should be sufficiently explicit to provide complete guidance as to the boundaries and general prescriptions for the treatments. Review the entire project area in the field. If conditions have changed since the original prescriptions were developed, prepare revisions to the original site plans. The discovery of new sites due to changed conditions, or sites originally overlooked, require site plans and prescriptions be prepared for additional restoration treatments. Finally, identify and flag treatments for surface drainage improvements along the roadbed. These treatments include the exact location of rolling dips, crossroad drains, ditch relief culverts and other work items originally prescribed but not precisely

located. If skilled operators are used, they can often perform the road drainage tasks on their own.

Pre-treatment Orientation Tour

Take the lead contractor, lead equipment operator and on-site labor supervisor on a pre-work field tour of the restoration project area to review all proposed treatments. The project supervisor who has intimate knowledge of the proposed treatment plan should lead the field inspection. Give the operator a complete treatment-log that describes the proposed treatments to be completed along the road (by milepost) or at other work areas.

Treatment Summaries

During the orientation tour, provide equipment operators and labor leaders a clearly written site-by-site summary of the treatments that are in the project work plan.

Measurable Standards

Provide contractors, equipment operators and the labor crew leader a list of typical standards, specifications, and/or technical drawings to be met for each general restoration treatment included in the project (e.g., the typical standards for a decommissioned stream crossing excavation; mulching, rolling dips and ditch relief culvert installation, etc.). These standards should be included in the site-specific treatment summaries provided to the operators.

Technical Supervision and Oversight

An important quality control practice is to have technically trained and experienced project supervisors on-site regularly during operations. Their job is to interpret and answer questions about the treatment prescriptions, to provide general guidance to the operator or labor crew leader on specific design requirements for each site, and to verify and approve completed work. Inexperienced operators should have careful and ongoing supervision until their skills, judgment and performance consistently meet expectations. Road decommissioning requires frequent inspections because access is cut-off as work proceeds. Mistakes made during road decommissioning are difficult to correct or repair. Rarely can labor crew treatments prevent or correct erosion problems caused by poor or inadequate heavy equipment work.

Documentation

Documentation and Monitoring

Documentation of work performance and monitoring of restoration effectiveness are two techniques that allow for adaptive management at a relatively short and useful time scale. For example, use documented equipment operations and productivity to institute more efficient treatment procedures. Use qualitative and quantitative monitoring of project performance in the first few years following restoration work to alter procedures and prescriptions for current and future projects. Thus, effectiveness monitoring for adaptive restoration can consist of simply reviewing the erosion response of a variety of past restoration projects and identifying techniques that have worked well and others in need of modification.

Documenting Work Activities

Document work procedures and production rates for various restoration tasks to improve the efficiency and the cost-effectiveness of on-the-ground restoration projects. Document work effort by direct observation of operations, by measuring a sample of production rates (e.g., counting dump truck loads or excavator buckets) or by requiring contractors (operators or laborers) to keep accurate records of work production on a site-by-site basis.

At a minimum, have equipment operators keep a daily record of work accomplishments (hours spent, loads hauled, etc.) on a site-by-site basis. Table X-9 provides a sample form for operators and laborers to complete on a daily basis. Compare actual work with the treatment prescriptions of the restoration plan.

Project Site Implementation Reporting

The project leader should take before and after photos from selected photo-point locations (Hall 2002), assemble and analyze production records from the operators, and check production data by surveying selected sites to determine actual volumes or by counting/timing equipment activities (Table X-9) The project leader also must review each project to confirm the quality and quantity of work performed.

The implementation report should contain many similar elements to the summary report. Report the quantities as known rather than estimates (Appendix X-D). This information forms the basis of implementation monitoring and is very important for post-project effectiveness monitoring used in evaluating the success of the upslope restoration efforts.

The completed implementation report should contain the following information:

- Project identification #
- Project location (descriptive location)
- Map of watershed (location map, showing relationship of project area to region)
- Map of project area and roads treated, which shows:
    - Base information (streams, roads, sections, contours (optional), scale, north arrow, stream labels, road names, cultural features)
    - All roads within the treatment area (whether treated or not), including symbols for current maintenance status (maintained roads, and abandoned (unmaintained) roads) and treatment status (treated and untreated)
    - All treated and untreated sites, including:
        - All stream crossings, showing which ones were actually treated
        - Potential and active landslides which were treated
        - Ditch relief culverts and other ditch drains
        - Gullies and other fluvial erosion features
- Other pertinent maps of the project area, including but not limited to geologic maps, landslide hazard maps, and fault location maps.
- Project report should contain the following information:
    - Introduction (setting, problem, purpose of restoration project)

- Site characterization, areas of concern, landslide and fault location information or other hazards and/or limitations on activities.
- Methods, including:
  - What was done (planning, gear-up, implementation, documentation, monitoring)
  - Describe documentation data that was collected (production rates, volumes, etc.)
  - Describe monitoring efforts initiated (photo points, surveys, etc.)
- Results of implementation work, including work accomplished and costs, including:
  - Description of deviations from original plan or proposal
  - Layout work completed (flagging, prescription marking, etc.)
  - Move-in and move-out, and site preparation work (e.g. road opening)
  - Description of actual treatments (keyed to the site map), including:
    - Road upgrading (show and describe upgraded roads)
    - Road decommissioning (show and describe roads decommissioned)
  - Describe treatments and sites recommended for treatment (including stream crossings, fillslopes, and surface erosion treatments)
- Cost analysis, including:
  - Actual equipment rates (cost/hr) and hours for each site
  - Actual manual labor rates (cost/hr) and hours for each site
  - Total site costs (all site costs added together)
  - Equipment move-in and move-out costs (lowboy)
  - All other project costs not listed above (specify)
  - Total costs for entire project (equipment + labor + materials + other)
- Cost-effectiveness analysis, including:
  - Total measured or estimated sediment savings (yds^3)
  - Total project cost-effectiveness (cost/yd^3 of sediment delivery prevented)
  - Explain any differences between projected and actual costs and sediment savings
- Sources of funds used in project.

DAILY AND WEEKLY HEAVY EQUIPMENT LOG

Name of restoration project:	Date:	Road name:	Inspectors:

Date	Site #	Site type (St = stream LS =landslide RR = road reach DR=ditch relief OT = other)	Excavator (hrs)	Dozer (hrs)	Dump truck #1 hrs	Dump truck #1 loads	Dump truck #2 hrs	Dump truck #2 loads	Grader (hrs)	Water truck (hrs)	Labor (hrs)	Backhoe (hrs)	Oth er (hrs)	Comment/ activities

Table X-9. Daily heavy equipment log (for operators).

PHOTO POINT MONITORING LOG

Project #:	Road:	Date:	By:	Weather: Sun____ / Shade____

Site #	PP #	Time	Roll & frame # or digital #	Lens (mm)	Framing (horizontal or vertical)	Compass direction	PP location (site description)	PP description (scene description)

Table X-10. Photo point monitoring log.

Monitoring

Effectiveness Monitoring

Qualitative and quantitative site and project monitoring techniques can be undertaken with the specific objective of documenting the performance of various watershed restoration treatments or for documenting post-restoration erosion rates on treated areas. Detailed monitoring protocols for upslope erosion prevention and erosion control work is beyond the scope of this chapter.

Site Monitoring

It is not always practical to monitor all sites of a large restoration project. Prior to implementation, select a representative range of sites of varying complexity and type (e.g., stream crossings, fillslopes, road surface treatments, etc.) to monitor. Two types of monitoring can be useful:

- "Topographic" surveys - These surveys document the volume of spoil excavated, as well as erosion changes or slope movements that occur in the post-restoration period. Conduct simple surveys, using a tape and clinometer, or auto-level, before restoration activities begin. After the work is completed repeat the survey, and at irregular intervals thereafter. A tag line cross section survey (stretch a taught line across an excavated stream channel between monumented endpoints, and take measurements of the ground surface beneath the line) is an especially simple and useful way to document channel changes (erosion) following stream crossing decommissioning. Void measurement of erosional features is another way to monitor and document changes to a treated site.
- Photo points - Install monumented photo points (Hall 2002) at selected work sites to document before and after scenes of restoration work sites (Table X-10). This type of monitoring is especially useful to portray the nature of the restoration work that is undertaken. Carefully planned and executed photo documentation will graphically portray project effectiveness through time. Monitor revegetation of work sites though sample plot inventories, or more generically through photo point monitoring. Consistent photographs include site documentation, photo point number, date, time, lens, weather (sun/shade), compass direction, orientation (vertical or horizontal), landmarks and other identifying data. Re-take photo points using the original photo to duplicate the exact framing of the scene.

Process Monitoring

Although more difficult than site monitoring, geomorphic processes operating at restoration sites can also be monitored through time. Use site monitoring, such as tag line channel cross-section surveys, to monitor channel change through time. In addition, perform sediment sampling above and below work sites to document sediment delivery to stream channels from the restoration sites both before and after implementation work (Klein 2003). Process monitoring requires a relatively long term, continuing commitment of personnel and money beyond what is typically required for most intermittent site monitoring activities. In general, the closer the monitoring station is to the work site, the more likely you will be able to attribute monitoring trends to restoration actions.

Upland restoration is recognized as partly science-based and partly art. This makes the process of experimentation and extrapolation of monitoring findings difficult. In a sense, most projects contain elements that can be considered experimental. The challenge for effectiveness

monitoring projects is to be able to uniquely identify restoration projects or project components that have measurable parameters that will allow comparisons to a class of projects (Switalski et al. 2003). In this way hypotheses can be successfully tested, differences identified and results extrapolated. Results will provide a better basis for design and implementation and should eventually lead to better projects.

As with any monitoring project, the study objectives (the questions to be answered) will determine the methods that are used. A complete and thorough study design will be the foundation of any successful monitoring project. Both feature and process measurements may be included in a monitoring study (Kahklen 2001, Wemple and Jones 2003). Depending on the need for associating specific stressing events with resultant geomorphic responses, process measurements may best be performed using automated data collection devices rather than manual sampling.

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GLOSSARY

Note: The following terms and words are defined in the context of upslope restoration. Additional terms, concepts and words not included here are in Appendices X-A and X-B.

Abandoned road - A road no longer maintained. An abandoned road may be still driveable although overgrown with vegetation (see *road abandonment*).

Abutment (bridge) - A solid foundation on each stream bank, which to secure the ends of a bridge. Naturally occurring rock outcrops may serve as abutments. Engineered abutments are generally constructed of concrete, logs or concrete or steel piers.

Accelerated erosion - Erosion directly or indirectly influenced by human activities or land use. Accelerated erosion is erosion which is not natural or in excess of that occurring naturally.

Active road - A road that is part of an overall road network that needs to be inspected and maintained.

Anadromous fish - Fish that are born in freshwater, migrate to the ocean to grow, then return to freshwater to breed. This includes salmon and steelhead trout, as well as several other species of fish.

Angle of repose - The steepest slope or angle, sediment will freely stay without failing or sliding down slope. The angle of repose of material without cohesion, like loose sand, is about 33 degrees. For material with some cohesion, the comparable term is the angle of internal friction. Slopes steeper than the angle of repose or angle of internal friction are likely to be unstable.

Axis - The central line of a rolling dip, critical dip, or stream channel.

Berm - A curb or dike constructed to control water and prevent roadway runoff water from discharging onto roadside slopes. Many road berms are the unintentional result of years of grading.

Borrow site - Excavation locations for sand, gravel and/or rock that is used in road construction activities. Borrow pits and rock quarries in California may be subject to the new Surface Mining and Reclamation Act (SMARA). This act requires landowners to develop site reclamation plans for many such sites (see *rock pit*).

CEQA - The California Environmental Quality Act, requires public disclosure of the environmental impacts and alternatives associated with any project, including restoration projects.

Check dam - A grade control structure used to prevent gully down cutting or to contain eroded soil from leaving a construction site. It is common to use straw bale check dams in swales, ditches, and small channels and gullies to collect and store sediment eroded from a work site. Straw bale check dams quickly decompose. They usually provide sediment storage or protection for only a single season. Permanent check dams are difficult structures to correctly build and

require maintenance to function properly. Check dams treat the symptom rather than the problem.

Class I watercourse - For forestry purposes, those watercourses serving as domestic water supplies and/or those watercourses where fish are present or restorable.

Class II watercourse - For forestry purposes, watercourses where non-fish aquatic species are present.

Class III watercourse - For forestry purposes, watercourses that have no aquatic life present, but under normal high water flow conditions are capable of sediment transport downstream.

Class IV watercourse - For forestry purposes, watercourses that are human made and supply water for domestic, agricultural, hydroelectric or other beneficial uses.

Clinometer - A pocket field instrument which measures slope steepness in degrees and percent.

CMP - An abbreviation for corrugated metal pipe, often used synonymously with culvert. Typically, metal culverts are galvanized steel or aluminum. Many new culverts, especially in the 18" to 36" diameter classes, are plastic.

Cofferdam - A barrier constructed across a waterway to control the flow or raise the level of water.

Compaction - Soil where an increase in bulk density (weight per unit volume) and a decrease in soil porosity results from applied loads, vibration or pressure. Compaction is often achieved by using gas powered vibrators, rollers, or heavy equipment.

Cost-effectiveness - In upslope restoration, the amount of money spent to prevent the delivery of a cubic yard of sediment to a stream. Measure cost-effectiveness by the volume of sediment delivery prevented from entering a stream not the amount of material excavated by heavy equipment.

Crossroad drain - A deeply cut ditch, excavated across a road surface, which drains the roadbed and inboard ditch. Crossroad drains are more substantial and deeper than conventional water bars used to drain forest and ranch roads, and are steeper and more abrupt than rolling dips. Properly constructed crossroad drains will often be deep enough to prevent vehicular traffic, therefore use them to close roads. Crossroad drains are constructed (excavated) using a tractor, a hydraulic excavator, or a backhoe.

Crowned - A crowned road surface is one which slopes gently away from the centerline (or near centerline) of the road and drains to both sides of the crown. Crowning a road surface is one method of providing for surface drainage on roads built on flat terrain. The inside half of the road drains inward to the cutbank and ditch, while the outside half drains out across the fillslope.

Crown scarp - A crown scarp is a visible fracture across the top of a landslide. Lateral scarps run down the hillslope from the crown scarp. For fill failures along the outside edge of a road, crown scarps, or cracks, mark the boundary between stable materials on the inside of the road and unstable fill on the outside edge of the road.

Culvert - A transverse drain, usually a metal or plastic pipe, set beneath the road surface to drain water from the inside of the road to the outside of the road. Use culverts to drain ditches, springs and streams beneath the road alignment.

Cutbank - The artificial face or slope cut into soils or rock along the inside of a road.

Debris flow – When a rapidly moving mass of rock fragments, soil and mud, saturated with water, flows down a hillside, with more than half of the particles being larger than sand size.

Debris slide – The slow to rapid slide, of relatively dry and predominantly unconsolidated materials, moving down a hillside, involving down slope translation, with more than half of the particles being larger than sand size.

Debris torrent – The rapid movement of a large quantity of materials (wood and sediment) down a stream channel during storms or floods. This generally occurs in smaller, steep stream channels and results in scouring of the streambed.

Decommission - To remove those elements of a road that unnaturally reroute hillslope drainage or present slope stability hazards. The process of proactively abandoning a road by eliminating all significant risks of delivery until the road is needed in future years. Decommissioning may be permanent or temporary (the road will be used again), but the treatments do not markedly differ. Decommissioning involves completely removing stream crossing fills and associated drainage structures and eliminating the risk of sediment delivery from unstable road and landing fills, and providing for permanent surface drainage (see *road abandonment*, *road closure*, and *put-to-bed)*.

Decompaction - See *ripping*.

Ditch - A human-made channel constructed to drain water from one location to another. Ditches are often located on the inside of the road (at the base of the cutbank - see *inboard ditch*), but they may also be located on the outside of a road, along a berm, on both sides of a crowned road or elsewhere on a slope.

Ditch relief culvert - A culvert installed to drain water from an inside road ditch to an outside area, beyond the outer edge of the road fill. Ditch relief culverts take the flow through or beneath the road surface. Rolling dips or cross road drains can perform the same function taking water across the road in a trough.

Diversion potential - A stream crossing has diversion potential if, when the culvert plugs, the stream would back up and flow down the road or ditch rather than directly over the fill crossing and back into the natural drainage channel. If flow would divert beyond the hinge line of the stream crossing fill, the site has a diversion potential.

Downspout - A flume or trough attached (bolted) to a culvert outlet and used to convey water from the culvert outlet down over and beyond the road fill to prevent erosion. Culverts placed at the base of the road fill discharge directly into the natural channel or hillslope and usually do not require a downspout. Downspouts may be half round or full round. Use full round downspouts (rather than half round) for a downspout on a stream crossing culvert.

Drainage basin - See *watershed*.

Drainage structure - A structure installed to control, divert or to cross over water, including but not limited to culverts, bridges, ditch drains, fords, water bars, road shape (e.g., outsloping or crowning) and rolling dips.

Earthflow - A mass-movement landform and slow-to-rapid mass movement process characterized by down slope translation of soil and weathered rock over a discrete shear zone at the base, with most of the particles being smaller than sand. Referred to as a soil glacier because of similarities in movement patterns.

Endhauling - The loading and transportation of excavated material from a site, and the storage of the hauled material in a stable location where it cannot enter stream channels. Dump trucks are most commonly used. Mobile scrapers are used on large jobs.

Ephemeral stream - A stream or portion of a stream that flows briefly in direct response to precipitation in the immediate vicinity and whose channel is at all times above the water table.

Erodible soils - Soils that are prone to erosion by raindrop impact and surface runoff. Granular, non-cohesive soils (such as soils derived from sand dunes or decomposed granite) are especially erodible.

Erosion - The dislodgement of soil particles caused by wind, raindrop impact or by water flowing across the land surface. Erosion usually refers to processes of surface erosion (raindrop erosion, rilling, gulling and raveling) and not to mass soil movement (landsliding). Erosion is not synonymous with sediment delivery if eroded sediment re-deposits before reaching a watercourse.

Erosion control - Treatments designed to control on-going erosion caused by raindrop impact, rilling, gulling, raveling and other surface processes.

Erosion prevention - Preventing erosion before it has occurred. Erosion prevention is typically less expensive and more effective than erosion control.

Erosion-proof - See *storm-proof.*

Fill - Consists of loose soil material that is placed or pushed (often by bulldozer) into low areas or onto a natural slope, and which is then compacted and built up to form a roadbed or landing surface.

Fillslope - That part of a road fill between the outside edge of the road and the base of the fill, where it meets the natural ground surface. On a half-bench road built by sidecast construction, the fill typically extends from near the centerline of the road to the outside edge of the road and down slope to where the sidecast meets the natural hillslope.

Filter fabric (geotextile) - A synthetic fabric manufactured and designed for use in subsurface and surface drainage applications. Filter fabric is especially useful in maintaining a separation between coarse aggregate and finer native soil particles. It comes in a number of different types, with different specifications and uses. It is common to use filter fabric in a number of different road building settings. Consult manufacturer's specifications before using a fabric for drainage or other engineering applications.

Fish bearing - A stream known to support fish during some part of the year.

Flared inlet - A flared or widened culvert inlet to increase its capacity and reduce the chance of inlet plugging and damage. Attach flared inlets to the normal culvert inlet using a band or bolts. Mitered inlets, made by cutting a normal culvert at an angle, improve culvert efficiency and increase capacity.

Fluvial - Pertaining to the processes of, or related to streams or flowing water.

Ford (dry) - A rock, concrete or other hardened structure built on the bed of a swale, gully or usually dry stream, allowing vehicle passage during periods of low or no flow.

Ford (wet) - A rock, concrete or other hardened structure built on the bed of a live stream, allowing vehicle passage during low flow periods. A ford can also be a naturally stable section of stream that vehicles use in low flow periods.

Geomorphic - Pertaining to the form or shape of the earth's surface, and to those processes that affect and shape the land's surface. Geomorphic processes include all forms of soil erosion and mass soil movement, as well as other surface processes.

Grading - Involves the excavation and movement of soil along a road alignment to an established grade-line during road construction or reconstruction. Grading is one of the tasks of road construction, and is preceded by ripping and followed by surfacing. Grading also refers to the mechanical smoothing of the roadbed to maintain a free-draining, smooth traveling surface.

Gully (gullied) - An erosion channel formed by concentrated surface runoff, larger than one square foot in cross sectional area (1' deep by 1' wide). Gullies often form from road surface or ditch runoff directed onto unprotected slopes. Gullies are a symptom of a problem: too much water collected and discharged onto a hillslope.

Headwater swale - A swale or dip in the natural topography that is upslope from a stream, at its headwaters. There may or may not be any evidence of overland or surface flow of water in the headwater swale.

Humboldt log crossing - See *log crossing*.

Inboard ditch - A ditch located on the inside of the road, usually at the foot of the cutbank (see *ditch*).

Inner gorge - A geomorphic feature formed by coalescing scars originating from landsliding and erosional processes caused by active stream erosion. The feature is identified as that area of stream bank situated immediately adjacent to the stream channel, having a side slope of generally over 65%, and being situated below the first break in slope above the stream channel.

Insloped road - A road surface sloped in toward the cutbank. Insloped roads usually have an inboard ditch that collects runoff from the road surface and cutbank.

Intermittent stream - A stream that flows only at certain times of the year, as when it receives water from springs or from a surface source; a stream that does not flow continuously, as when water losses from evaporation or seepage exceed the available stream flow.

Landing - Any place on or adjacent to a logging site (usually on a road) where logs are collected and assembled for further transport.

Landslide - The down slope movement of a mass of earth caused by gravity is termed a landslide. This includes, but is not limited to debris slides, torrents, rock falls, debris avalanches, and soil creep. It does not include; dry ravel, raindrop erosion or surface erosion caused by running water. Landslides may be the result of a natural erosion processes, such as earthquakes or fire events; or human disturbances such as, mining or road construction.

Log crossing (Humboldt log crossing) - A drainage structure made out of logs or woody debris, sometimes laid in parallel to a stream channel, covered with soil. Before the mid-1980's, log crossings were frequently used as permanent stream crossings instead of culverts or bridges. Log crossings are highly susceptible to plugging and washout during storm flows. Log crossings are used today only for temporary stream crossings that are to be removed prior to the winter period.

Lowboy transportation - Long, low trailers used to haul heavy equipment (tractors and excavators) to a work site.

Maintained road - A road whose cutslopes, road surface, drainage structures, and fillslopes are regularly inspected and repaired to prevent erosion and deterioration.

Mass soil movement - Down slope movement of a soil mass under the force of gravity. Often used synonymously with "landslide" common types of mass soil movement include rock falls, soil creep, slumps, earthflows, debris avalanches, debris slides and debris torrents (see *landslide*).

Mulch - Material placed or spread on the surface of the ground to protect it from raindrop, rill and gully erosion. Mulching is an erosion prevention treatment. Mulches include wood chips, rock, straw, wood fiber and a variety of other natural and synthetic materials.

Outsloped road - A road surface sloped away from the cutbank toward the road's fillslope. Outsloped roads may or may not have an inboard ditch.

Outsloping - To improve road drainage, by converting an insloped road to an outsloped road. Outsloped roads may or may not have an inside ditch to drain spring flow. Outsloping can also refer to the act of excavating the fill along the outside of the road and placing and grading it against the cutbank, thereby creating an outsloped road surface.

Peak flow (flood flow) - The highest amount of stream or river flow occurring in a year or from a single storm event. Design stream crossing culverts to pass the 100-year peak flood flow.

Permanent road - A road planned and constructed to be part of a permanent all-season transportation system. These roads have a surface suitable for travel and, where applicable, for hauling of forest and ranch products throughout the entire winter period. Permanent roads have drainage structures, at watercourse crossings designed to accommodate the 100-year flood flow. Permanent roads receive regular and storm-period inspection and maintenance.

Put-to-bed - See *decommission.*

Range finder - A hand-held field instrument used to measures distances less than 1,000 feet.

Rill - An erosion channel varying in size from a rivulet, to one-foot square in cross section, that typically forms where rainfall and surface runoff is concentrated on bare fillslopes, cutbanks and ditches. If the channel is larger than one square foot in size, it is a gully.

Riparian - The banks and other adjacent terrestrial environs of lakes, watercourses, estuaries and wet areas where transported surface and subsurface freshwater provides soil moisture to support mesic vegetation.

Ripping (of a road) - The process of breaking up or loosening compacted soil (e.g., skid trails, spur roads or landings) to better assure penetration of roots of young tree seedlings and to increase infiltration. Use a tractor with rear-mounted, hydraulically operated ripping chisels to rip roads. Also used are excavators, graders or other earth moving equipment. Three or four passes is usually sufficient to decompact a normal road surface.

Riprap - The rock placed on the ground, stream bank or gully to prevent or reduce erosion.

Road abandonment - Road abandonment involves a series of proactive activities which erosion-proof a road so that further maintenance will not be needed and significant erosion will not occur. In the past, road abandonment was synonymous with blocking the road and letting it grow over with vegetation, which led to significant erosion (see *road closure and decommission*).

Road closure (proactive road abandonment) - A method of closing a road so that regular maintenance is no longer needed and future erosion is largely prevented. The goal of road closure is to leave the road so that little or no maintenance is required for stability while the road is unused. Road closure usually involves storm-proofing techniques including removing stream

crossing fills, removing unstable road and landing fills, installing cross road drains for permanent road surface drainage and other erosion prevention and erosion control measurers as needed. Proper road closure is not accomplished by blocking a road and walking away from it to let nature reclaim the road (decommission, road abandonment).

Road failure - Damage to the roadbed, usually caused by a roadbed slump, fill failure, stream crossing washout or major gully, which prevents vehicular passage; not minor cutbank or fill sloughing incidental to road settling.

Road grade - The slope of a road along its alignment is the road grade. Road grades typically run up to a maximum of 20%, but may exceed this slope for short pitches.

Road maintenance - Upkeep of a roads cutbanks, road surface, fillslopes, and all drainage structures, intending to prevent erosion and deterioration. Road maintenance activities include; grading, ditch cleaning, brushing and culvert cleaning.

Road runoff - Surface runoff drained from the road surface, usually as a direct response to rainfall.

Rock armor - Course rock placed to protect a soil surface, usually from erosion caused by flowing or falling water. Rock armor is one type of material used for energy dissipation at culvert outfalls.

Rock pit - A large outcrop of bedrock developed for aggregate uses, such as road surfacing material and/or larger rock armor. A borrow pit is an excavation from which material is removed for use in another location (see *borrow site*).

Rolling dip - Shallow, rounded dip in the road that reverses road grade for a short distance, and directs road surface runoff in the dip or trough to the outside or inside of the road. Construct rolling dips to allow vehicles to travel at normal or slightly reduced speeds.

Rotational slide - A failure plain landslide that is arcuate and concave-up. Its movement is predominantly rotational verses translational.

Runoff - Water from rainfall or snowmelt that drains from hillslopes, or bare areas along roads and trails becomes runoff.

Seasonal road - A road planned and constructed as part of a permanent transportation system whose use is restricted to periods when the surface is dry. Most seasonal roads are not surfaced for winter use, but have a surface adequate for hauling of forest and ranch products in the non-winter periods, and in the extended dry periods or hard frozen conditions occurring during the winter period. Seasonal roads have drainage structures at watercourse crossings designed to accommodate the 100-year flood flow.

Sediment delivery - The eroded material that is delivered to a stream channel. Sediment delivery refers to the percent of material eroded from a site and delivered to a stream channel, as opposed

to that which is eroded but then stabilized on the hillslope and does not enter a stream. Sediment delivery is not the same as erosion.

Sediment yield - The quantity of soil, rock particles, organic matter, or other dissolved or suspended debris transported through a cross-section of stream in a given period. Technically, sediment yield consists of dissolved load, suspended load, and bed load.

Sidecast - Excess earthen material pushed or dumped over the side of roads or landings.

Skid trail or **tractor trail** - A tractor-constructed trail usually built while logging or in response to fire control or prevention activities.

Slope angle - The gradient of a slope, usually expressed as percent or degrees, but sometimes as a unit-less ratio (100% = 45E = 1:1; 50% = 26E = 2:1).

Slope stability - The resistance to failure, of a natural or artificial slope, or other inclined surface by landsliding (see *mass movement*).

Slump - An episodic, fast to very slow, mass movement process involving rotation of a block of hillslope or road along a broadly concave slip surface (see *rotational slide*).

Soil texture - The relative proportion of sand, silt and clay in a soil; grouped into standard classes and subclasses in the Soil Survey Manual of the U.S. Department of Agriculture.

Spoil (spoil materials) - Material (soil and organic debris) that is not used or needed as a functional part of the road or a landing. Spoil material is generated during road construction and maintenance activities and during restoration work when stream crossings are upgraded or removed and unstable material is excavated. Spoil may be stored locally (pushed) or it may be endhauled with dump trucks.

Spoil disposal site - The location to place spoil material (woody debris and excavated soils) without the threat of accelerated erosion and sediment delivery, or initiating slope instability. Stable spoil disposal sites may include the cut portion of closed roads, the inside portion of landings and turnouts, and flat or low gradient natural benches. Evaluate each spoil disposal site for its suitability before material is stored at the site.

Spur road - A side road off a main trunk road or a secondary road. Most spur roads are dead-end.

Storm-proof - Erosion control and erosion prevention activities which will protect a road, including its drainage structures and fills, from serious erosion and sediment delivery during a large storm and flood, as well as from chronic surface erosion and sediment delivery during normal runoff events.

Stream class (1, 2, 3): California stream classification methods are based on biological parameters, and not on flow conditions or the magnitude or frequency of stream flow. Class 1

streams are fish bearing, or provide a domestic water supply. Class 2 streams provide habitat to macroinvertebrates and/or amphibians at some time of the year, but are not fish bearing. Class 3 streams move sediment but do not provide habitat to macroinvertebrates or amphibians. Biological classification allows restorationists to prioritize problems and proposed treatments based on their potential to affect aquatic resources. Similarly, many in-channel treatments (e.g., the type of allowable culvert installation) are closely tied to the biological classifications. California stream classes do not correspond to generally accepted USGS classifications of perennial, intermittent and ephemeral streams. Thus, the biological classification has little relevance to the frequency of flow or the size of the stream channel. These factors are often necessary in designing effective in-channel and bank stabilization treatments.

Stream crossing - The location where a road crosses a stream channel is a stream crossing. Drainage structures used in stream crossings include bridges, fords, culverts and a variety of temporary crossings. If a stream diverts down a road to a ditch, it is a stream crossing.

Stream crossing excavation - The excavation of the fill material used to build (fill) a stream channel crossing during road construction. Specifically, this includes the removal of fill from culverted crossings, log crossings and fill (unculverted) crossings. A stable stream crossing excavation must be dug down to the level of the original stream bed, with side slopes graded (excavated) back to a stable angle (usually 50% or less, depending on soil and site characteristics).

Surface erosion - Soil particles detached and transported by wind, water or gravity. Surface erosion can occur as the loss of soil in a uniform layer (sheet erosion), in many rills, gullies, or by dry ravel. Surface erosion may deliver sediment to a stream channel.

Surfacing (surface course) - The top layer of the road surface, also called the wear course. Rock aggregate and paving are two types of surfacing used to weatherproof a road for year-round use.

Swale - A channel-like linear depression or low spot on a hillslope that rarely carries runoff except during extreme rainfall events. Some swales may no longer carry surface runoff under the present climatic conditions.

Tag line cross section survey - A surveying technique for monitoring channel and gully erosion, taking vertical measurements from a taught level line stretched between fixed endpoints on either side of the channel to the ground surface. Use tag line cross sections to monitor erosion of excavated stream crossings.

Temporary road - A road used temporarily. These roads have a surface adequate for seasonal hauling use and have drainage structures, adequate to carry the anticipated flow of water during the period of use. Remove all drainage structures prior to the beginning of the winter period (see *temporary stream crossing*).

Tension cracks - Cracks in the ground (usually in a road fill) that may indicate slope instability. Cracks that form as un-compacted fill material naturally settles, and may indicate the beginning of a potential fillslope failure.

Through-cut - A road cut through a hillslope or, more commonly, down a ridge, in which there is a cutbank on both sides of the road. Through-cuts more than two feet deep are very difficult to drain and prone to forming gullies.

Trash rack (debris barrier) - A barrier built just upstream from a culvert inlet to trap floating organic debris before it can plug the culvert. Design trash racks or barriers to filter organic debris from flood flows. All trash racks require periodic cleaning.

Treatment prescription - A suggested treatment for erosion prevention or erosion control is a treatment prescription.

Trough - A long depression between two ridges.

Upgrade - Road upgrading consists of storm-proofing treatments designed to reduce the risk of road failure and the volume of sediment delivery from roads. Treatments generally consist of upgrading stream crossings (to increase flow capacity and to prevent stream diversion), excavating unstable fillslopes (which would otherwise fail and deliver sediment to a stream channel), and disconnect road surface drainage from the natural stream network (thereby dispersing road surface runoff and preventing delivery of fine sediment to streams).

Unstable areas - Areas characterized by mass movement features or unstable soils. An example of an unstable area is hummocky topography consisting of rolling bumpy ground, with frequent benches, and depressions. Short irregular surface drainages which begin and end on the slope, visible tension cracks, and head wall scarps and irregular slopes which may be slightly concave in upper half and convex in lower half as a result of previous slope failure also indicate unstable areas. Evidence of impaired ground water movement resulting in local zones of saturation including sag ponds with standing water, springs, or patches of wet ground; hydrophilic (wet site) vegetation; leaning, jack-strawed or split trees; and pistol-butted trees with excessive sweep in areas of hummocky topography are generally unstable.

Unstable soils - Characteristics of unstable soils include unconsolidated, non-cohesive soils (coarser textured than loam) and colluvial debris including sands and gravels, rock fragments, or weathered granitics. Such soils are usually associated with a risk of shallow-seated landslides on slopes of 65% or more, having non-cohesive soils less than 5 feet deep in an area where precipitation exceeds 4 inches in 24 hours in a 5-year recurrence interval. Soils that increase and decrease in volume as moisture content changes are unstable. During dry weather, these materials become hard and rock-like exhibiting a network of polygonal shrinkage cracks and a blocky structure resulting from desiccation. Some cracks may be greater than 5 feet in depth. When wet, these materials are very sticky, dingy, shiny, and easily molded.

Washed-out stream crossing - A partially or completely eroded stream crossing fill washed downstream. When a culvert plugs and stream flow backs up and flows over the roadbed during flood events washouts occur. They are most common on abandoned roads, but may also occur on maintained roads in response to severe storm events.

Water bar (water break) - Shallow ditch excavated at an angle across a road or trail to drain surface runoff. Water bars are typically built on seasonal or temporary roads receiving little or no traffic during the winter period.

Watercourse - Any well defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand or gravel. Watercourse also includes human-made watercourses (see *Class I, II, III and IV watercourse*).

Water quality - The chemical and biological characteristics of a stream and lake water defines water quality.

Watershed - The area or drainage basin contributing water, organic matter, dissolved nutrients and sediments to a stream or lake. An area bounded mostly by ridges and drained, at its outlet, by a single trunk stream.

APPENDIX X-A. INSTRUCTIONS FOR COMPLETING UPSLOPE INVENTORY DATA FORM

ASAP (Y, N): Enter "Y" if a site urgently needs treatment to prevent imminent damage to a stream, otherwise enter "N".

GENERAL INFORMATION

Site No: A unique systematic identification number assigned to a specific site. Also, record the site number on the aerial photo Mylar overlay. Use only numbers, not letters, for effective database searches.

Treat (Y, N): Enter "Y" if the final assessment recommendation is for site treatment; and "N" if not recommended for treatment.

Watershed: Write in the name of the watershed from the USGS 7.5 minute topographic map, (i.e. Bull Creek).

Quad: Write in the name of the USGS 7.5 minute quad.

GPS: Record the GPS coordinates for the specific site.

CALWAA: The California Watershed Analysis Area number assigned to the inventoried sub-watershed or land unit.

Photo: The flight line and frame number of the air photo used for mapping the location of this particular site. Original field mapping information is contained on acetate or Mylar overlay for each of the aerial photos covering the assessment area.

T/R/S: From the USGS quadrangle, enter the township, range, and section for the site.

Road Name/#: Enter the road name or number where the site is located. Many roads have posted names, such as the 500 Road. For unnamed road systems, adopt a logical road numbering system for the survey and include the names on the final site map.

Drivable (Y/N): If the road is drivable, even if abandoned, enter "Y"; if there are obstructions, washouts or vegetation that make it impassible, enter "N".

Mileage: For each drivable site, log a distance from start on the data sheet and a photo overlay map. Typically, start recording mileage at the beginning of the road to the site. Use an odometer or vehicle mileage computer to record mileage to the nearest 0.01 mile. If the road is not drivable, enter the word "WALK" instead of a mileage. The length of roads walked is determined later from digitizing maps or aerial photographs.

Inspector(s): Record the names or initials of the inventory crew. List the data recorder first.

Date: Record the date of the survey.

Year Built: Record the first year the road is visible on aerial photographs. This is likely not the year it was constructed, but provides a frame of reference for its construction.

Surface: Check one. Check "rock" for surfaced roads with pit-run or river-run rock, crushed or not crushed. Unsurfaced roads are "native" roads or dirt roads, even though they may contain some natural rock. Use "paved" for all roads surfaced with asphalt, concrete, or chip-seal.

Status: Check "maintained" for a maintained road or if there is evidence of maintenance activities having been performed recently. Check "abandoned" for an abandoned, blocked, or not maintained road. The road may still be drivable, but classify it as abandoned if there is no obvious maintenance at culvert sites, the ditches need cleaning, and vegetation has overgrown the roadbed. Spur roads are also considered abandoned if their access is completely and permanently blocked. A road is either "abandoned" or "maintained". Check "decommissioned" for a decommissioned road. Check "decommissioned" if the stream crossings have been excavated and permanent surface drainage has been installed. A gated road, an overgrown road or a road with a tank trap at the beginning does not qualify as decommissioned.

Proposed: Check "upgrade" if recommending upgrading the road. Check "decommission" if recommending decommissioning the road. The site must be identified as either upgrade or decommission, but not both.

Sketch: Enter "Y" if a site sketch is included on the back of the data form (Figure X-3). Enter "N" if a site sketch is not included.

PROBLEM

Occasionally, more than one problem may occur at a single site.

Stream Crossing: Enter "Y" if the site is a stream crossing. Enter "N" if the site is not a stream crossing.

Landslide: Check "fill" if the site is a fillslope landslide involving the failure of sidecast materials along the outside edges of a road, especially those built on steep slopes, and around the outside edges of landings. Fillslope landslides usually cut into the roadbed and the slide material is deposited down slope from the road. Check "hill" if the site is a hillslope landslide above, across, and/or below the road, and involves more than just sidecast or cutbank material.
Check "cut" if the site is a cutbank landslide occurring on the inside, or cut side, of the road. Cutbank slides deposit material on the roadbed.

Roadbed: Check "bed" if the site involves erosion, rilling, or runoff from the roadbed. Check "ditch" if the site involves erosion from or runoff in the inboard ditch. Check "cut" if the site involves erosion from a cutbank.

Ditch Relief Culvert: Check if a ditch relief culvert (DRC) is delivering sediment to a stream channel. Erosion at the outlet of a ditch relief culvert does not warrant classification unless the eroded sediment reaches, or could reach, a stream. However, even a small gully or channel that extends from the outlet of a DRC down to a stream effectively connects the road and ditch to the stream, and merits classifying such a culvert as a site.

Gully: Check for a newly formed or actively eroding gully.

Bank Erosion: Check if the site involves eroding banks of a natural stream channel.

Road Related: Enter "Y" if the potential or existing erosion problem is directly related to the road. Enter "N" if the potential or existing erosion problem in not directly related to the road.

Other Non-road Related Site: If it is not road-related, check the location and land use associated with the on-going or potential erosion problem:

- ☐ home
- ☐ agricultural
- ☐ construction
- ☐ mining
- ☐ other site.

If "other site" included description.

LANDSLIDE

Road or Landing Fill: Check if the site involves failure of fill material on the outside edge of a road, landing, or pullout from loose material pushed over the road's edge during construction or maintenance.

Hillslope Debris Slide: Debris slides move fast and are typically relatively shallow compared to deep-seated, slow moving landslides. Debris slides may or may not turn into debris flows, depending on confinement, slope gradient and water content.

Cutbank Slide: Check for landslides confined to the cutbank on the inside of the road. Unless connected to an inboard ditch, these landslides just dump material on the roadbed and little or none of it gets into a stream channel. Some of the bigger cutbank slides cross over the road and continue down slope into a channel. Cutbank slides are usually just maintenance problems and do not often become sediment delivery problems.

Hillslope Landslide of Unknown Type and Depth: Check if the site is large with areas of multiple scarp systems running through natural slopes and/or across roads and skid trails. Large hillslope landslides often have the following characteristics: emerging groundwater; leaning trees; active and inactive scarp systems; and episodic, seasonal movement from several feet to several hundred feet annually. Some may not move

annually. Most deep-seated hillslope landslides involve far more than just a road and are difficult and expensive to control.

Potential Failure: Check if the site has the potential to fail. The site may be currently inactive and show no signs of movement in the last several years, but the scarps and other indicators suggest that during an especially large storm the instability could become active and fail or move down slope. Potential failures may also be earth block remainders from a slide that previously failed. If an unstable mass is on-site, even if it shows developed scarps and has moved or dropped several feet, classify the site as a potential failure.

Past Failure: Check if the landslide has already failed and appears to be inactive and partially or largely revegetated. Gullies will often have armor lag deposits in the channel bed. Landslides may be inactive even though vegetation is still sparse and it still looks bad.

Slope (%): Enter the percent slope of the hillside below the site. This is the slope of the natural ground below the base of the fillslope, not the slope of the road fill looking from the outside edge of the road. Take the measurement from the foot of the fillslope with a clinometer. This is the steepness of the slope the slide mass would first have to travel over to reach a stream channel.

Distance to Stream (ft): Enter the distance in feet from a landslide site to the nearest stream. Measure the distance from the foot or base of the potential slide down to the channel. It is the minimum distance soil would have to travel to deliver sediment to a stream.

STREAM

Check the most appropriate type of stream crossing. It is possible to have more than one crossing type at a single location (e.g., Humboldt and culvert).

- culvert
- bridge
- Humboldt
- fill
- ford
- armored fill.

Excavated Crossing: Check for an excavated stream crossing on an abandoned or decommissioned road.

% Excavated: Estimate the percent of the fill excavated.

Ditch Road Length(ft): Left: and **Right:** Record in feet, the longest distance of the road and/or ditch which drains water to the stream crossing from each side. This is the length of ditch and/or road contributing surface runoff and fine road sediment to the

stream crossing. Measure the distance along the ditch/road on both the left and right approaches. Right and left are determined when looking in the downstream direction.

Culvert Diameter (in): Enter the diameter of the culvert. Typical choices include 12, 18, 24, 30, 36, 42, 48, 52, 60, or 72 inches. Measure each culvert with a measuring tape or pocket-rod because it is easy to estimate incorrectly.

Pipe Condition (O, C, R , P) Inlet:, Bottom:, and **Outlet:** Record the condition of the three components of a culvert pipe crossing: the inlet, the bottom, and the outlet. Use the following codes: "O" for OK; "C" for Crushed (if any dents block 20% or more of the culvert, consider it crushed); "R" for Rusted (severe, to the point of having holes in the bottom); "P" for Plugged (any blockage of the culvert exceeding 20%, consider it plugged).

Separated: Check separated if a culvert joint has separated. Use a flashlight to determine if a separation exists. In a separated culvert, flow may enter the culvert but not come out the other end. Look for water flowing out from beneath the culvert outlet.

Headwall (in): Enter the headwall height on stream crossings with culverts. Measure the vertical height from the bottom of the culvert inlet to the lowest point in the stream crossing fill where the water would begin to flow out of the crossing and down an inboard ditch, or over the road and down its outboard fillslope. As long as water is ponding and backing up and not flowing down the road or over the crossing, the headwall height is not reached. Note: Make some headwall height measurements to the inboard edge of the road and make others to the ditch. The low point is merely the point where water would flow from the crossing inlet area if the culvert were to plug.

Culvert Slope (%): Enter the average slope of a culvert. Take this measurement by looking up the culvert from the outlet, or down the culvert from the inlet. Use a clinometer. If the culvert is straight, place the clipboard in the culvert inlet, put the clinometer on the clipboard and read out the slope gradient. If the crossing is on a fish bearing stream, see *Part IX*.

Stream Class (1, 2, 3): Enter the stream classification number. Class 1 streams are fish bearing, or provide a domestic water supply. Class 2 streams provide habitat to macroinvertebrates and/or amphibians at some time of the year, but are not fish bearing. Class 3 streams move sediment but do not provide habitat to macroinvertebrates or amphibians. California stream classification methods are based on biological parameters, and not on flow conditions or the magnitude or frequency of stream flow. Biological classification allows restorationists to prioritize problems and proposed treatments based on their potential affect aquatic resources. California stream classes do not correspond to generally accepted USGS classifications of perennial, intermittent and ephemeral streams.

Culvert Rust-line (in): Inlet: and **Outlet:** Enter the height of the rust-line at the inlet and outlet of the culvert. This is the vertical distance between the bottom of the culvert

and the top of the rusted area in the pipe. The inlet rust-line is generally the best indicator of pipe capacity for accommodating the stream's flow and will have a higher rust-line than the outlet. Plastic, aluminum, and concrete pipes will not have rust-lines, but may show scour or moss lines.

Culvert Undersized (Y, M, N): Enter "Y" for yes if there is field evidence a culvert is undersized. Enter "N" for no if the field evidence indicates it will pass the design flow. Enter "M" for maybe if uncertain. Describe the evidence in the comment section.

Washed Out (%): Enter the percentage of the fill material at the crossing that has eroded and is already gone. If the entire fill washed out, enter 100. Culverted stream crossings can wash out by having stream flow over the fill, by having extreme culvert outlet erosion, or by having a Humboldt log crossing develop sinkholes and subsurface gully erosion.

Diversion Potential (Y/N): Enter "Y" for yes if diversion potential exists. If the culvert plugged and the water would flow down the road or inboard ditch there is diversion potential. A stream has a diversion potential if the flow would leave the fill crossing and divert down the road past the fill's hinge line, even if it would re-enter the natural stream channel at some distance down slope. Enter "N" for no if there is no diversion potential. If the culvert plugs and floodwaters would flow straight across the road and spill back into their stream channel downstream of the road, there is no diversion potential. If the crossing has no diversion potential, overflow might cause a washout of the road fill, but the stream flow would not divert out of its natural channel. All stream crossings have either diversion potential or no diversion potential. There are no other choices.

Currently Diverted: Check for a stream currently diverted down the road or ditch, or if there is evidence that even part of the peak stream flow currently diverts down the road or ditch.

Road Grade (%): Enter the road grade in percent. Measure the downhill slope of the road leading away from the crossing or the direction a diversion would flow.

Plug Potential (H, M, L): Estimate the potential for the crossing to plug with sediment or woody debris (High, Moderate or Low). The plugging potential is an estimate of how likely the culvert is to plug in the next big storm. Plugging potential typically is higher for streams that transport significant organic debris and sediment. Write "H" if the evidence for high plugging potential includes:

- Culvert is currently plugged or partially plugged
- Culvert is too small for the drainage
- Culvert has plugged in the past (note terraces, ponding evidence, etc.)
- Culvert has been cleaned once or more in the past as evidenced by scattered debris
- Culvert inlet is damaged
- Cutbank or slope failure threatens the inlet.

If the culvert is undersized, it still might not have a high plugging potential. An effective trash barrier may reduce plugging potential. Make note of a trash rack in the comments.

Plugged (%): Enter the percent of the culvert inlet or outlet that is currently plugged with sediment or organic debris.

Channel Gradient (%): Enter the slope of the natural channel upstream from the stream crossing. Do not measure channel gradient in the flat reach influenced by the stream crossing and culvert inlet.

Channel Width (ft): The estimated width of the 100-year flood event channel. Record the width of the expected flow dimensions in feet. Measure channel dimensions in the undisturbed, natural channel above the influence of the road crossing.

Channel Depth (ft): The estimated depth of the 100-year flood event channel. Record the depth of the expected flow dimensions in feet. Measure channel dimensions in the undisturbed, natural channel above the influence of the road crossing.

Sediment Transport (H, M, L): Estimate the relative capability of the stream to transport sediment and thereby move sediment and debris down to the culvert inlet. Enter "H" for high, ""M" for moderate, or "L" for low. This is a subjective evaluation of stream competence and capacity that is used to provide qualitative information on culvert plugging potential. If a lot of sediment is moving during annual high flow events, then sediment transport is high. If the streambed has moss-covered cobbles that are stable, then transport might be considered low. In performing an inventory, it is important to be consistent in classifying sediment transport so that sites can be ranked or compared against each other at the end of the assessment.

Drainage Area (acres): Enter drainage area of the sub-watershed draining to the stream crossing. The drainage area is calculated later from a scaled topographic map or GIS map using a planimeter or dot grid, or employing a digitizer and GIS software. Drainage area is necessary for calculating peak stream flow estimates and culvert sizes.

FISH PASSAGE

Fish passage data provides information to determine possible barriers to adult and juvenile fish migration on Class 1 streams (*Part IX*).

Culvert Outlet Drop (in): Measure the vertical height in inches from the bottom of the culvert to the water surface at the time of the survey.

Bankfull Drop (in): Estimate, based on channel bank scour lines, the bankfull outlet drop.

Pool Size Bankfull Width (ft): Measure the maximum width of the pool, in feet, below the culvert outfall, from the bank scour lines, at bankfull stage.

Pool Size Bankfull Depth (ft): Measure the maximum depth of the pool, in feet, below the culvert outfall, from the bank scour lines, at bankfull stage.

EROSION

Collect information about past erosion, future erosion, and erosion potential for each site. Give estimates of how much past erosion occurred at the site, how much was delivered to a stream channel, how much future erosion is to be expected, how much will be delivered to a stream channel and the likelihood of future erosion.

Erosion Potential (H, M, L): Estimate the potential for future erosion, based on observation. This is a qualitative evaluation of the likelihood of erosion, not a quantitative volume estimate. Enter "H" for High if erosion is very likely to occur. This does not quantify volume, or if the erosion will reach a stream channel. For potential landslides, base erosion potential on the likelihood that the slide will move or continue to move in response to a large magnitude rainfall and runoff event. For fluvial erosion, it is an evaluation of the likelihood of continued or future gullying in the event of a large magnitude rainfall and runoff event.

Potential for Extreme Erosion: Check if potential for extreme erosion and sediment delivery exists or if there is a potential for erosion of more than just the obvious road fill or stream crossing fill material. This usually implies erosion or landsliding of original ground and may be associated with deep fill failures, torrenting of road fills in steep swales and the diversion of large streams onto steep, erodible or unstable hillslopes.

Volume of Extreme Erosion (<500, 500-1,000, 1-2K, 2-5K, >5K): Estimate the expected volume of erosion or slope failure from an extreme erosion event. Enter one of the volume ranges of the potential extreme erosion.

Past Erosion (yd^3) (optional): Enter the volume of past erosion for the site, derived from field measurements. Enter width, depth and length measurements. If the feature is complex, take several different measurements to account for the entire feature. Show these measurements on the sketch. Often small gullies form below outlets to ditch relief culverts where there is diverted road and ditch runoff to a slope that previously did not carry such concentrated flow. These gully volumes are easily estimated using width, depth and length measurements. The largest road-related gullies form when a stream diverts out of its natural channel and then discharges into another channel or onto a hillslope area. These diversions can cause large gullies or even landslides and such erosion features are often down slope, out-of-sight of the road where the diversion originated.

Past Delivery (%) (optional): Estimate the percent of the past eroded material that was actually delivered to the stream channel system. The rest should still be in storage on the hillside.

Total Past Delivery (yds^3): Past erosion (yd^3) times past delivery (%). This is the estimated volume of erosion that has been delivered to a stream channel.

FUTURE EROSION

Future Erosion (ft):, **Width:**, **Depth:**, and **Length:** Measure the potential erosion feature, recorded as average width, depth, and length in feet. If the feature is complex, take several different measurements to account for the entire feature. These measurements describe the planimetric assumption used by field personnel to determine future erosion volumes and should be shown on the sketch map of the site. For existing gullies, potential and existing landslides and potential stream crossing washouts, it is possible to estimate the volume of future erosion that is likely to occur. Detailed descriptions on measuring and estimating future erosion volumes begin on page X-34.

Future Erosion (yd^3): Calculate the volume of future erosion from the Future erosion measurements by using the formula width x depth x length, or by geometric calculations (Figure X-5, Figure X-6, Figure X-7, and Figure X-8.

Future Delivery (%): Estimate the future eroded sediment that will enter a stream channel. If all the eroded sediment will be stored on the slope and never move into the stream system then there will be no delivery. Estimate how much sediment, as a percent of the volume of expected erosion, is likely to be delivered to the stream channel. For erosion at stream crossings, assume 100% delivery to the stream. Delivery from landslides is usually less, and often considerably less, than 100%, depending on distance to the stream, steepness of the slope and other factors. Delivery can be to any size stream. Once it is in the stream system it will eventually work its way downstream.

Total Future Delivery (yds^3): Future erosion (yd^3) times future delivery (%). This is the estimated volume of erosion delivered to a stream channel if the site is untreated and the erosion event triggers.

COMMENT(S) ON PROBLEM

The summary comments for each site generally describe the nature of the erosion problem as well as important site characteristics. It should also contain enough information to clearly depict this site and differentiate it from other nearby sites. It should describe the features contained in the sketch map on the back of the data form. Someone who has never been to the site should gain an immediate understanding of the nature and scope of the problem from reading the comment.

TREATMENT

Identify those sites that will require consultation with a licensed geotechnical specialist to develop treatment options, and prescribe treatments for all other inventoried sites of future erosion and sediment delivery for which there is an identifiable erosion control or prevention treatment that would reduce or prevent sediment delivery. In prescribing treatments, assume access for equipment to the site unless it is completely and obviously impossible to do so. In general, if there was ever a road or equipment trail to the site, there is a good chance access can be developed. After developing treatments, and

evaluating costs for access and treatment, employ cost-effectiveness and other considerations to prioritize all the treatment sites.

There is a very real difference between the cause and the symptom of many erosion problems. For example, the gully below a ditch relief culvert is a symptom of the true cause; too much water flowing along the road and ditch to the culvert (i.e., too large a drainage area for the culvert). The treatment is not to stabilize the developing gully with grade control structures, or to release the water at another single location; rather, it is to disperse the water in the ditch (e.g., by using multiple ditch relief culverts) so gullying cannot continue here or elsewhere. Wherever feasible, it is important to treat the cause of the problem rather than the symptom.

Immediacy (H, M, L): Decide if the work needs to get done immediately. If the evidence suggests the feature is likely to change dramatically in the next storm event or winter season and the erosion at this site seriously threatens important downstream resources like salmonid spawning or rearing areas, enter “H” for High. Base this answer on the severity of the potential erosion, its volume, its predicted activity level and the sensitivity of the resources at risk. If mass movement, culvert failure or sediment delivery is imminent, even in an average winter, then treatment immediacy is high. Treatment immediacy is a summary assessment of a site's need for immediate treatment. Generally, rate sites likely to erode or fail in a normal winter that may deliver significant quantities of sediment to a stream channel, as having high treatment immediacy. The answers can also include combinations, such as “HM” or “ML” to cover sites where the answer is not clear-cut.

Complexity (H, M, L): Estimate the difficulty of performing the recommended treatment. For example, classify a 1,000 yd^3 excavation of a Humboldt log crossing that will require construction of a lower access road and dump truck endhauling as “H” for High complexity. Classify a simple stream crossing excavation or the excavation of a small unstable fill along the outboard edge of the road as “L” for Low complexity. Use the Comment(s) on Treatment for explanation.

Check Culvert Size (Y/N): Enter “Y” if the culvert may be undersized. This is not a treatment as such, but it requires a future action to determine proper culvert size for the drainage. It will alert staff to conduct further analysis to check for the correct culvert size. Make sure the site is accurately located on the photo (or map) so drainage areas can be correctly measured. Enter “N” if the culvert size does not need to be checked.

Bridge: Install a bridge. Check this recommendation for crossings of Class 1 streams, especially if culvert flow analysis calls for 72" or larger pipe.

No Treatment: Check if no treatment is required.

Mulch: Estimate the exposed area in ft^2 needing mulching, after heavy equipment operations, to prevent delivery of fine sediment to a stream. This is the area needing mulching and seeding to control erosion after operations are complete. Sites located

away from stream channels may not need mulching if there is no sediment delivery potential to a stream.

TREATMENT OPTIONS

Excavate Soil: Check for permanent excavations of soil from the site. Replacing or installing a culvert is not marked excavate soil if all the dirt is returned to the site after the culvert is installed. However, check if removing any portion of the soil from the work site.

Critical Dip: Check for installation of a critical dip. A critical dip is a rolling dip constructed on or close to the down-road hinge-line of a stream crossing, displaying a diversion potential. Build a critical dip at all stream crossings in order to prevent stream diversions when a culvert plugs and water flows out onto the road (Figure X-13).

Ford: Check for installation of a ford. Install fords at sites prone to frequent culvert plugging due to high amounts of sediment and debris in transport. The treatment requires excavating the entire volume of fill placed in the stream crossing and leaving a very broad dip in the axis of the natural channel, with long and gently sloping ramps into and out of the stream crossing. Build fords along roads built on floodplains and terraces and where the natural streambed is not prone to downcutting. Also, install fords where roads cross steep gradient stream channels with relatively small depths of fill at the outboard edge of the road (Figure X-14).

Armored Fill: Check for installation of an armored fill. Install armored fills at small stream crossings where culverts are prone to plugging or where maintenance during the winter is unlikely. Use armored fills on crossings with fill depths of six feet or less, instead of a ford. Protect the outer fillslope from erosion with rock armor, with a rock sill set in a key way, and with rock surfacing on the fill face. Shape the rock in a broad swale across the road to contain flood flows and direct flow over the armored fillslope (Figure X-15).

> ***Armor Size:*** The rock used for armor protection must be larger than that which can be transported by the stream during the design flood flow. This is determined by calculating minimum stable rock or stone size (Racin, et al. 2000) for the site. A seven step process is used to quantitatively determine the most appropriate minimum rock size for channel armor (Racin, et al. 2000). This includes an analysis of the local site conditions and calculations that determine the minimum rock weight (W) that will resist the flowing water. The outside layer of rock must interlock and be stable in design flows. In a typical armored fill, the rock armor covers the outer half of the road, with rock sizes increasing in the downstream and downslope direction. The largest boulders are keyed into the base of the armored fill structure, at the base of the fillslope and where flow will re-enter the natural stream channel.

Sill Height (ft): If all the fill cannot be removed from the stream crossing while still providing for easy vehicular passage, then a sill wall and energy dissipation apron will need to be constructed down the outside edge of the road to prevent erosion of the underlying erodible fill in the crossing (Figure X-15). The sill is the armored outside slope of the stream crossing fill that must be protected with armor. Enter the sill height in feet at the centerline of the stream channel, adding two feet for embedding the lowest boulders below the level of the natural stream channel at the base of the structure (e.g., if three vertical feet of fill remain at the outboard edge of the road, enter 5 feet for the sill height). This will allow for a standard two-foot deep keyway into the natural streambed for the sill wall. The armored fill treatment is typically designed for small steam crossing fills, with outboard fill depths no more than about six vertical feet. Do not recommend using this treatment if a sill wall is greater than 6 feet high, excluding the keyway or footing.

Sill Width (ft): Enter the sill width, needed to span the 100-year return interval storm. Construct sills of concrete poured into plywood forms or, more commonly, they may be made of coarse riprap or quarry rock.

Trash Rack: Check to add a trash rack just upstream from the culvert inlet to catch organic debris and to prevent culvert plugging.

Add Downspout: Length (ft): and **Diameter (in):** Check if a downspout is needed, and enter length and width of downspout required. Add a downspout to the culvert outlet to carry stream flow beyond the fill and to prevent discharge of flow onto erodible road fill or sidecast. Record the length (in feet) and diameter (in inches) of the downspout. Downspouts longer than 20 feet require anchor posts. Downspouts on stream crossings should be full, round culverts. In some instances, rock armor can provide energy dissipation, and substitute for a short downspout.

Repair Culvert: Check for repairing a culvert damaged or significantly dented by a backhoe, grader or other equipment.

Clean Culvert: Check for cleaning a plugged or partially plugged culvert inlet, and for cutting vegetation, including trees, away from the inlet or outlet.

Install/Replace Culvert: Check to install or replace a culvert.

Culvert: Diameter (in): and **Length (ft):** Specify the recommended culvert diameter, in inches, and length, in feet. Base culvert diameter on 100-year storm discharge and determine diameter from one or more empirical equations or formulas. Guessing is not a very good way to determine the appropriate culvert size. Estimate culvert length by measurements taken in the field.

Install Flared Inlet: Check if prescribing a flared inlet to prevent culvert plugging. Specify the diameter of the flared inlet, in inches.

Reconstruct Fill: Check for a completely or partially failed road due to a landslide. This will probably involve a newly engineered fill that will likely require design by a qualified engineer. Do not use this space for reconstructing or filling in a washed-out stream crossing.

Armor Fill Face (U, D, B): Check for armoring fill face(s) of a stream crossing fill with coarse boulders that will protect the fill from stream erosion caused by stream flow and scouring at the culvert inlet or unavoidable culvert plugging or overtopping at the culvert outlet. Enter "U" for armoring the upstream crossing fill, "D" for downstream, or "B" for both.

Armor Area (ft^2): Specify the surface area of rock needed to armor the upstream (U) and/or downstream fill faces.

Clean or Cut Ditch (ft): Check if a plugged ditch needs cleaning or a new ditch built. Specify the length in feet.

Remove Ditch (ft): Check to remove (fill) a section of inboard ditch. Specify the length in feet.

Outslope Road (ft): Check for the conversion of a flat, crowned or insloped road to an outsloped road. Generally, this treatment is for road upgrading or decommissioning where road surface drainage needs to be improved. "Outslope Road" is the correct prescription to use to change the surface drainage pattern on the roadbed. Specify the length of outsloping required, in feet. Use "Excavate Soil" (instead of "Outslope Road") when decommissioning a road and there is need to excavate substantial material from the outside edge of the road in order to prevent fillslope landslides.

Outslope and Remove Ditch (ft): Check if the road is to be outsloped and the inboard ditch removed. Specify the length of road to be outsloped with the ditch removed.

Outslope and Retain Ditch (ft): Check for road reaches to be outsloped but the inboard ditch retained. Specify the length of road to be outsloped with the ditch retained.

Inslope Road (ft): Check for the conversion of a flat, crowned or outsloped road to an insloped road. Generally, this treatment is for areas where it is important to keep water off the outside fillslope. "Inslope road" is the correct prescription to use to change the surface drainage pattern on the roadbed. Typically, but not always, an inboard ditch is needed when the road is insloped. For a retained ditch, prescribe clean or cut ditch as well (see above). Specify the length of insloping required, in feet.

Rolling Dips (#): Check for installing rolling dips on the road surface. Typically, install rolling dips in road upgrade projects. Usually, but not always, the rolling dip connects to

an inboard ditch if present. Also, use rolling dips on outsloped roads to drain the road surface (Figure X-21). Specify the number of rolling dips needed along the road reach. This is not the correct prescription to use for critical dips at stream crossings to prevent stream diversions.

Remove Berm (ft): Check to remove or grade a berm along the outside edge of the road. Specify the length of berm in feet.

Ditch Relief Culvert: Check for the installation of ditch relief culverts to drain the inside ditch. Specify the number and total length of the culvert needed. Unless otherwise specified, a ditch relief culvert will be 18 inches diameter (Figure X-20)

Rock Road Surface (ft^2): Check to rock the surface of a section of road. Use this treatment only for prescribing new rocking. Specify the total area needing rock in ft^2. To re-rock a site after installing a rolling dip or replacing a culvert on a rocked road, do not check this treatment.

Cross Road Drain (#): Check for installing cross road drains, or exaggerated waterbars, on decommissioned roads. Specify the number of cross road drains.

Other: Check if recommending another treatment. Fully describe in the Comment(s) on Treatment section.

HEAVY EQUIPMENT EXCAVATION DATA

Track and manage spoil according to the following equations:

- Total Volume Excavated = Volume Returned + Volume Removed
- Volume Removed = Volume Stockpiled + Volume Endhauled

Total Volume Excavated (yd^3): The total volume of material excavated from the unstable fillslope or stream crossing. Use this volume to help predict costs and equipment times needed to perform the excavation work. In addition, it is used to help determine whether endhauling will be necessary to dispose of spoil from the site.

Volume Put Back in (yd^3): This is the volume of material that is to be put back into the excavation hole, as in a culvert replacement.

Volume Removed (yd^3): This is the volume of excavated material removed from the excavation hole. For example in the excavation of unstable sidecast material, zero would be returned and all of it would be removed.

Volume Stockpiled (yd^3): Excavated spoil that can be locally stored without using dump trucks.

Volume Endhauled (yd^3): From measurements in the field, the available storage volume is calculated and compared to the total excavated volume to determine the need

for endhauling equipment. If local storage is insufficient, identify additional storage sites in nearby areas along the road.

Distance Endhauled (ft): Record the distance materials will need to be endhauled for storage.

Excavation Production Rate (yd^3/hr): Estimate the excavation production rate for the site to determine the required equipment hours. Use the Comment(s) on Treatment section to itemize the hours needed for each piece of equipment, for every assigned task and sub-task. See Table X-5 for guidelines in estimating equipment production rates for various tasks. For equipment and labor time estimates do not include time for traveling or other miscellaneous tasks.

EQUIPMENT HOURS DATA

If a piece of equipment is to perform several different tasks or sub-tasks, then list the individual times that go together to add up to total equipment time for each piece of equipment.

Excavator: Estimate the hours of excavator time needed at the site.

Dozer (Crawler Tractor): Estimate the hours of tractor time needed for excavation and spoil management at the site.

Backhoe: Estimate the hours of backhoe time needed at the site.

Grader: Estimate the hours of grader time needed at the site.

Loader: Estimate the hours of loader time needed at the site.

Dump Truck: Estimate the hours of dump truck time needed for endhauling excess spoil to stable storage locations.

Labor: Estimate the hours of laborers needed to perform such tasks as culvert installation, culvert cleaning, etc.

Other: Any other tasks or equipment not listed above.

COMMENT(S) ON TREATMENT

Add details for equipment or labor treatments and logistics or any information useful for the project. Fill this comment section with descriptive information that will be useful for the equipment operators, and will make it clear what work has been prescribed for the site.

UPSLOPE INVENTORY DATA FORM

ASAP (Y, N)_____

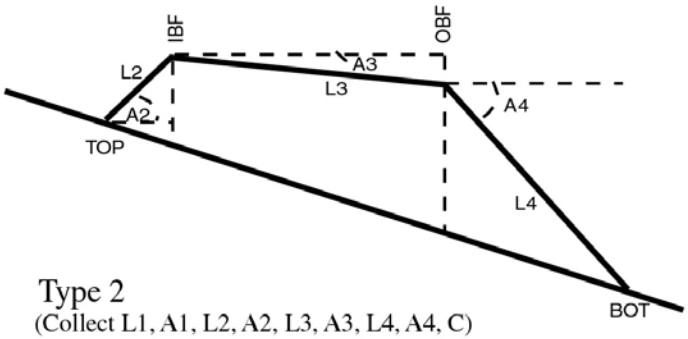
GENERAL	Site no:	Treat (Y/N):	Watershed:	Quad:	
	GPS:		CALWAA:	Photo:	
	T/R/S:		Road name/#:	Drivable (Y/N):	
	Mileage:		Inspector(s):	Date:	Year built:
	Surface: □ rock □ native □ paved		Status: □ maintained □ abandoned □ decommissioned		
	Proposed: □ upgrade □ decommission			Sketch (Y/N):	
PROBLEM	Stream crossing (Y/N):		Landslide: □ fill □ hill □ cut	Roadbed: □ bed, □ ditch, □ cut	
	□ ditch relief culvert		□ gully □ bank erosion	Road related (Y/N):	
	Other non-road related site: □ home □ agricultural □construction □ mining □ other site				
LANDSLIDE	□ road or landing fill		□ hillslope debris slide[1]	□ other hillslope landslide (depth unknown)[1]	
	□ cutbank slide		□ potential failure	□ past failure	Slope (%):
	Distance to stream (ft):				
STREAM	□ culvert □ bridge		□ Humboldt □ fill	□ ford	□ armored fill
	□ excavated crossing		% excavated:		
	Ditch road length (ft): Left:		Right:	Culvert diameter (in):	
	Pipe condition (O, C, R, P): Inlet:		Bottom: Outlet:	□ separated	
	Headwall (in):		Culvert slope (%):	Stream class (1,2,3):	
	Culvert rust-line (in): Inlet:		Outlet:	Culvert undersized (Y, M, N):	
	Washed out (%):		Diversion potential (Y/N):	□ currently diverted	
	Road grade (%):		Plug potential (H, M, L):	Plugged (%):	
	Channel gradient (%):		Channel width (ft):	Channel depth (ft):	
	Sediment transport (H, M, L):		Drainage area (acres):		
FISH PASSAGE	Culvert outlet drop (in):		Bankfull drop (in):		
	Pool size bankfull width (ft):			Pool size bankfull depth (ft):	
EROSION	Erosion potential (H, M, L):		□ potential for extreme erosion		
	Volume extreme erosion (<500, 500-1,000, 1-2K, 2-5K, >5K):			Past erosion (yd^3) (optional):	
	Past delivery (%) (optional):		Total past delivery (yd^3):		
FUTURE EROSION	Future erosion (ft): Width:		Depth: Length:	Future erosion(yd^3):	
	Future delivery (%):		Total future delivery (yd^3):		
COMMENT(S) ON PROBLEM:					

TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		
	check culvert size (Y/N):		□ bridge	□ no treatment	Mulch (ft^2):
TREATMENT OPTIONS	□ excavate soil	□ critical dip	□ ford	□ armored fill	Sill height (ft):
	Sill width (ft):	□ trash rack	□ Add downspout: Length (ft):		Diameter (in):
	□ repair culvert	□ clean culvert	□ install/replace culvert		
	Culvert: Diameter (in):		Length (ft):	□ flared inlet: Diameter(in):	
	□ reconstr. fill	□ armor fill face (U, D, B):		Armor area (ft^2): U: D:	
	□ clean or cut ditch, (ft):		□ remove ditch, (ft):		
	□ outslope road, (ft):		□ outslope & remove ditch, (ft):		
	□ outslope & retain ditch, (ft):			□ inslope road, (ft):	
	□ rolling dip, (#):		□ remove berm, (ft):		
	□ ditch relief culvert, (#):		Length (ft):	□ rock road surface, (ft^2):	
	□ cross road drain, (#):		□ other:		
HEAVY EQUIPMENT EXCAVATION DATA	Total vol. excavated (yds^3):		Volume put back in (yds^3):		
	Volume removed (yds^3):		Volume stockpiled (yds^3):		
	Volume endhauled (yds^3):		Distance endhauled (yds^3):		
	Excavation production rate: (yds^3/hr):				
EQUIPMENT HOURS	Excavator:	Dozer:	Backhoe:	Grader:	Loader:
	Dump truck:		Labor:	Other:	
COMMENT(S) ON TREATMENT:					

[1] *Consultation with a licensed geotechnical specialist is required to estimate slide volumes and to evaluate or develop treatment options. The location of these features should be noted on the field form and on maps, but the inventory crew should not estimate the sediment volumes for calculation of cost-effectiveness.*

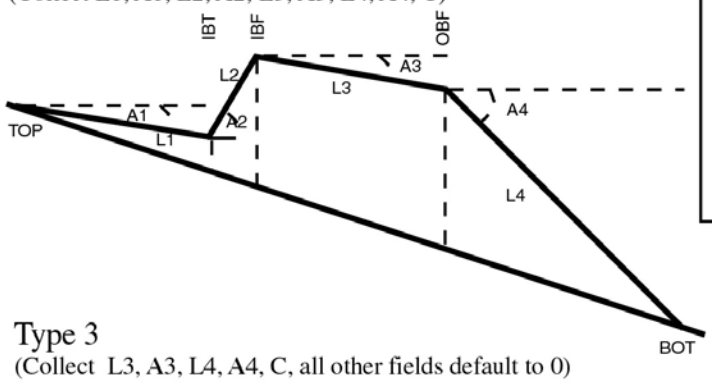
Type 1

(Collect L2, A2, L3, A3, L4, A4, C, all other fields default to 0)



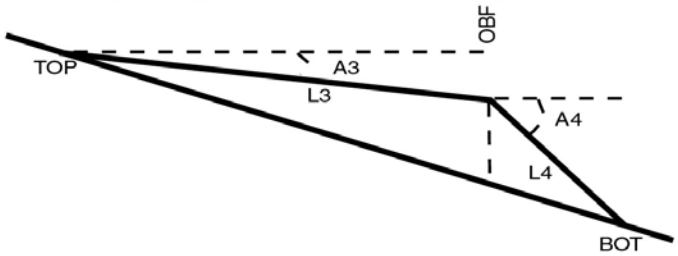
Type 2

(Collect L1, A1, L2, A2, L3, A3, L4, A4, C)



Type 3

(Collect L3, A3, L4, A4, C, all other fields default to 0)



Field data

Length of sediment fan (L1): _____ ft

Angle of sediment fan (A1): _____ degrees

Length of inboard fillslope (L2): _____ ft

Angle of inboard fillslope (A2): _____ degrees

Length of road bed (L3): _____ ft

Angle of road bed (A3): _____ degrees

Length of outboard fillslope (L4): _____ ft

Angle of outboard fillslope (A4): _____ degrees

Channel width (C): _____ ft

Sketch

APPENDIX X-B. INSTRUCTIONS FOR STREAM BANK INVENTORY DATA FORM

Use the *Stream Bank Inventory Data Form* in the assessment of past and potential erosion problems along stream channels, including determining their nature, cause, magnitude and treatment. Also, use it to identify and classify erosion problems along stream channels, to prioritize potential work sites, and to prescribe specific treatments aimed at protecting stream channels and fish habitat. *Part III* describes methodologies for stream channel classification, stream habitat inventories, and large woody debris and riparian inventories.

The *Stream Bank Inventory Data Form* provides a standardized protocol for evaluating stream-related erosion and identifying erosion control options. Also, use it to evaluate all types of riparian sediment sources. Where roads are in close proximity to a stream channel, there may be individual sites described by both the *Upslope Inventory Data Form* and the *Stream Bank Inventory Data Form*. If the proposed treatments are sufficiently different, retain both forms to describe the same location. However, do not duplicate recommended treatments and treatment times. Using the *Stream Bank Inventory Data Form*, field personnel can measure, describe and interpret landforms and erosion problems in a consistent and uniform manner. Enter the data collected into a database for analysis, leading to the preparation of a work plan for implementation.

General Information

Site Number: The identification number assigned to each site. This is a unique ID number for future reference. Also, write the Site Number on an aerial photo Mylar overlay. This number identifies each site in database searches. Use only numbers, not letters, for effective database searches.

Distance (ft.): Enter the stream channel distance, in feet, to the beginning of the site, from a known beginning point, usually a confluence, road, bridge, etc.

Date: Date of the survey.

Inspector(s): Record the names or initials of the inventory crew. List the data recorder first.

Watershed: Major drainage as described on the USGS 7.5 minute topographic map, for example Bull Creek.

Stream: As described on the USGS 7.5 minute topographic map.

Air Photo: List the flight line and frame number of the air photo used for mapping. Original field mapping information is contained on acetate or Mylar overlay for each of the aerial photos covering the assessment area.

Location (LB, RB, B): Enter the location of the site along the stream channel ("LB" = left bank, "RB" = right bank or "B" = both banks). Location is always determined when facing downstream.

Road Related: Check for erosion related to a road. If it is road-related, identify the corresponding road site number, if one exists, in the Comment(s) on Problem section.

Treat: Enter "Y" if recommended for treatment and "N" if not recommended for treatment.

Problem

Type: Check the appropriate type of problem at each locality. More than one problem may occur at a single site.

- debris slide: These slides may involve a substantial percentage of original bedrock and soil materials, or they may be composed of un-compacted spoil or road sidecast material. Debris slides move relatively fast and are typically shallow compared to larger deep-seated hillslope landslides. Stream side debris slides can range from small slope failures less than 10 yd^3 in volume, that are not visible on aerial photos and are only identifiable from a field inventory, to large landslides that can be easily identified from small scale aerial photos.
- debris torrent: Debris slides may or may not turn into fluid debris flows or torrents. Confinement, slope gradient and water content determine if a debris slide becomes a debris torrent. Torrents typically originate somewhere upslope or upstream and carry soil materials and organic debris to a hillslope or lower gradient stream channel where it is deposited.
- hillslope landslides of unknown depth: Usually cover relatively large areas with multiple scarp systems running through natural slopes and/or across roads and skid trails. Slow, deep-seated landslides characterized by emerging groundwater; leaning trees; active and inactive scarp systems; and episodic, seasonal movement from several feet to several hundred feet annually. Along a stream channel, a slow, deep-seated landslide may express itself as continuous length of raw, eroding stream bank, or as one or more shallow debris slides that are forming along the leading edge of the deeper slide mass. Some slides may not move annually. Most deep-seated landslides are difficult and expensive to control, if at all.
- torrent channel: The channel left after a debris torrent or mudflow has passed.
- bank erosion: The most common channel erosion problem encountered during a stream bank inventory. Bank erosion occurs wherever stream flow impinges against a soft stream bank. The erosion may occur in previously deposited alluvial materials (e.g., a terrace or flood plain surface) or along the base of the confining hillslope. Bank erosion may result in the development of debris slides where the hillslope erodes and undercuts. Bank erosion often occurs along the outside bend of a stream or river where stream flow diverts or deflects against a stream bank from woody debris (logs), boulders, a sediment deposit or other channel obstructions.
- LDA: Stream bank erosion related to a log debris accumulation.
- other: A problem other than those listed above. Describe in the Comment(s) on Problem Section.

Delivery: Check "past" for stream bank erosion that is unlikely to deliver additional sediment to the stream. Check "future" for a site currently delivering sediment to a stream channel. Check "both" for a site that contributed sediment in the past, and is likely to deliver sediment in the future.

Activity (A, IA, W): Enter "A" for an active feature such as a stream bank that is bare and erodes during each high flow period. Enter "IA" for a feature that appears inactive such as an older failure area that looks like it may no longer have the potential for further movement. Enter "W" for waiting if the feature is not currently active but shows substantial potential for future activity. An example of a waiting feature might include an unstable slope exhibiting scarps and leaning trees, but no indication of recent slope movement.

Age (Decade): Enter the estimated age, by decade, of the site. Age is typically determined using historical accounts, photos or other information to date the feature. Oftentimes use vegetation (leaning trees, recent sprouts, or vegetation size) to date features to within 10 years. A typical answer might be "1980's". For a continuously active feature, answer "1980 – 2000".

Stream Bank Slope (%): The slope of the bank at the site. This is the slope of the natural ground. Stand at the base of the erosion feature and take a clinometer reading looking upslope.

Land Use: Check if there is direct evidence for some type of land use contributing to the occurrence or activity of the erosion site. Describe the land use associated with the erosion site in the Comment(s) on Problem section.

Undercut by Stream: Check for a bank undercut by the stream. It is important to identify an existing or potential debris slide that is threatening to develop because of stream bank erosion.

Past Erosion

Estimates of past erosion and sediment delivery volumes provide an indication of erosion activity along the stream channel. Calculate the volume of past bank erosion and debris slides, the two most common erosion features, by multiplying average linear dimensions of width, depth and length.

Width (ft): Estimate the average width of past erosion in feet. Width is the average thickness of bank cutting.

Depth (ft): Estimate the average depth of past erosion in feet. Depth is the bank height.

Length (ft): Estimate the length of past erosion in feet. For stream banks, measure length along the stream channel.

Volume (yd^3): Estimate the volume of past erosion (yd^3) at the site. Sketch the site on the back of the form, including the measurements, recorded on the data form. Volume (yd^3) = (width x depth x length)/27. Assume that stream bank erosion is 100% delivered to the stream.

Future Erosion

Estimate future erosion by applying reasonable rates or by calculating debris slide volume and delivery (page X-41).

Future Erosion Potential (H, M, L): Estimate the potential for future significant erosion at this site, based on observations. This is a probability estimate, not an estimate of how much erosion is likely to occur. Enter "H" or high, "M" for moderate or "L" for low. High means that erosion is very likely to occur at this site.

Width (ft): Estimate the width of future erosion in feet. Width is the average thickness of bank cutting.

Depth (ft): Estimate the depth of future erosion in feet. Depth is the bank height.

Length (ft): Estimate the length of future erosion in feet. For stream banks, measure length along the stream channel.

Volume (yd^3): Estimate the volume of future erosion. Volume (yd^3) = (width x depth x length)/27. For stream bank erosion, delivery is 100%.

Comment(s) on Problem

The comments for each site generally describe the nature of the erosion problem as well as important site characteristics. Include enough information to clearly depict the site and differentiate it from other nearby sites. Describe the features contained in the sketch map on the data form.

Treatment

Immediacy (H, M, L): Enter "H" for high if the work needs to get done immediately. Base this prioritization on the severity of the potential erosion, its volume, its predicted activity level and the sensitivity of the resources at risk.

Complexity (H, M, L): Estimate the difficulty of performing the recommended treatment. For example, simply moving a small boulder to prevent flow deflection enter "L" for low, whereas performing heavy equipment treatments in remote locations requiring road construction, endhauling or riprap enter "H" for high. Explain in the Comment(s) on Treatment section.

Equipment or Labor (E, L, B): Enter one of these treatment types. Treat the site using heavy equipment (E), manual labor (L) or both (B).

Equipment Access (E, M, D): Estimate the degree of difficulty of getting appropriate heavy equipment to the work site. Use "E" for easy, "M" for moderate, or "D" for difficult.

Local Materials: Check if material is available and sufficient for treating the site.

Import Materials: Check if material (e.g., boulder riprap) needs to be imported to treat the site. If needing local and imported materials, check both answers.

Treatment Options

Check each of the recommended treatments prescribed for a work site (*Part VII*). The treatments include:

Excavate Soil: Check if the treatment option is to excavate soil and remove it from the site. Landslide excavations would fall under this category of treatment. Enter width, depth and length of excavated material, in feet. Calculate excavated volume, in cubic yards.

Rock Armor / Buttress: Check for sites where armoring the stream bank with boulders will eliminate or reduce erosion of a stream bank or toe of a landslide. Specify both the size (diameter or ton) and surface area of rock armor (ft^2) needed.

Log Protection: Check for use of logs and other organic debris to protect stream banks from erosion. Identify the size (length and diameter) of the woody debris, the length of the bank protected, and the bank area to be covered (ft^2). In the Comment(s) on Treatment section identify the anchoring method (if any), the source of the woody materials (local or imported) and describe the placement method.

Remove Logs / Debris: Check if logs, boulders or other debris in the channel are deflecting flow and aggravating bank erosion and sediment delivery, identify this as a possible treatment. Include treatment details in the Comments on Treatment section.

Boulder Deflectors: Check for use of boulder deflectors to protect stream banks from erosion. Identify the number of boulder deflectors. Identify the yds^3 of boulder to necessary for each deflector.

Bio-engineering: Check for bio-engineering. Describe the bio-engineering methods to be used in the Comment(s) on Treatment section.

Plant Erosion Control: Check if recommending planting for erosion control. Revegetation with grasses is a short-term (1 to 2 years) treatment to control surface erosion. Plant woody species, such as willow and coyote brush, for intermediate term revegetation. Planting conifer or hardwood trees will provide for long-term erosion control and stability. Planting conifers reestablishes a large woody debris source. Describe the planting recommendations in the Comment(s) on Treatment section.

Riparian Restoration: Check if recommending manipulation of the riparian zone. An example of vegetation manipulation is thinning red alders and planting of conifers for long-term restoration of streamside vegetation (*Part XI*).

Area Planted: Measure or estimate the size of the area to plant or treat, in square feet. Identify the spacing, species composition, and number of trees to be planted in the Comment(s) on Treatment section.

Exclusionary Fencing: Check if the erosion control treatment is to exclude grazing animals from the stream or riparian zone. Identify the length of fencing needed, in feet.

Other: Check if recommending some other treatment. Fully describe in the Comment(s) on Treatment section.

Equipment Hours

If heavy equipment is needed to perform one or more different tasks, then list the individual times that go together to add up to total equipment time for each piece of equipment. In the Comment(s) on Treatment section, itemize equipment times by task for all equipment, which includes:

Excavator: Estimate the hours of excavator time needed for direct excavation, log and rock placement, and for other tasks at the work site. Include time needed for developing access for all equipment.

Dozer: Estimate the hours of tractor time needed for direct excavation work, winching or other work tasks.

Dump Truck: Estimate the hours of dump truck time needed for endhauling excess spoil to stable storage locations, or for importing rock armor other materials to the project.

Backhoe: Estimate the hours of backhoe time needed for direct excavation at the work site. Estimate time for travel or other miscellaneous tasks.

Labor: Estimate the hours of laborers needed to perform such tasks as rock placement, planting, seeding, mulching, winching, cabling, and providing assistance to heavy equipment.

Other: Describe other tasks or equipment not listed above, such as a front-end loader or lowboy.

Comment(s) on Treatment

Include details for equipment or manual labor treatments and logistics. Be as specific as is possible, and relate the comments to the sketch map.

STREAM BANK INVENTORY DATA FORM

GENERAL	Site no:	Distance (ft):		Date:	Inspector(s):	
	Watershed:			Stream:		
	Air photo:		Location (LB, RB, B):		☐ road related	Treat (Y/N):
PROBLEM	Type:	☐ debris slide ☐ debris torrent ☐ hillslope failure of unknown depth and activity[2] ☐ torrent / debris flow channel[1] ☐ bank erosion ☐ LDA[3] ☐ other				
	Delivery:	☐ past	☐ future	☐ both	Apparent activity (A, IA, W):	
	Age (decade):		Stream bank slope (%):			
	☐ land use	☐ undercut by stream				
PAST EROSION	Width (ft):	Depth (ft):	Length (ft):		Volume (yd^3):	
FUTURE EROSION	Future erosion potential (H, M, L):		Width (ft):		Depth (ft):	
	Length (ft):			Volume (yd^3):		
COMMENT(S) ON PROBLEM:						
TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		Equipment or labor (E, L, B):	
	Equipment access (E, M, D):		☐ local materials		☐ import materials	
TREATMENT OPTIONS	☐ excavate soil	Width (ft):	Depth (ft):	Length (ft):	Volume (yds^3):	
	☐ rock armor/buttress		rock armor size (ft or ton):		rock armor area (ft^2):	
	☐ log protection		Log size: Length (ft): Bank length protected (ft):		Diameter (ft): Bank area to cover (ft^2):	
	☐ remove logs/debris				☐ boulder deflectors	
	Deflectors (#):		Deflector (yd^3):		☐ bio-engineering	
	☐ plant erosion control		☐ riparian restoration		Area planted (ft^2):	
	☐ exclusionary fencing		Length of fence (ft):		☐ other	
EQUIPMENT HOURS	Excavator:	Dozer:	Dump truck:	Backhoe:	Labor:	Other:
COMMENT(S) ON TREATMENT:						

[1] A debris torrent is a mudflow that originates as a debris slide and then fluidizes (through the addition of water) and flows down a stream channel. It typically ends as a deposit or dam of poorly sorted sediment and woody debris in a lower gradient section of channel. The process is the mudflow; the evidence of that process is the scoured channel through which the flow passed, and the sediment and debris that is deposited at the end of the flow path. The activity level is typically that of the potential debris slide that would form the source of the mudflow. Note: if you have identified a potential hillslope debris slide, treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.

[2] If a failure of unknown type and depth is identified, treatment prescriptions must be developed in consultation with a licensed geotechnical specialist.

[3] LDA is a log jam or accumulation of logs and woody debris in the channel that is causing bank erosion or other erosion and sediment delivery problems.

SKETCH

APPENDIX X-C. CASE STUDY #1

1999 S.B. 271 WATERSHED ASSESSMENT FOR PARSONS CREEK, MENDOCINO COUNTY, CALIFORNIA

prepared by
Pacific Watershed Associates

for
The U.C. Hopland Research and Extension Center and the California Department of Fish and Game

Background

Parsons Creek is a fourth or fifth order, steelhead producing tributary to the Russian River located approximately five miles east of Hopland, California. The majority of the watershed is located within the boundaries of the U.C. Hopland Research and Extension Center (HREC). The watershed is approximately 6 mi^2 in area upstream from the western HREC boundary on the mainstem of Parsons Creek (Figure X-C-1). Parsons Creek watershed is primarily composed of oak woodlands, chaparral, and converted and natural grasslands, which are managed for sheep and cattle grazing and various academic research projects.

Parsons Creek has recently been recognized as a viable steelhead producing tributary to the Russian River region of Northern California. Since the early 1900's, much of the forested and chaparral portions of the watershed have been converted to pasture.

By 1952 roads had been pioneered to the upper reaches of the watershed and more intensive livestock management practices had been implemented. These initial roads essentially circled the entire watershed and provided access to the upper reaches of the watershed.

By 1963 the road network had expanded to access most of the mid-slope portions of the watershed and many of the roads built prior to 1952 had been partially rerouted or abandoned due to their deteriorating condition. This time frame exhibits the most extensive, post 1952 new road construction, in the Parsons Creek watershed and provided access to the more remote areas of the watershed.

Over the next 33 years the road network of the Parsons Creek watershed expanded by only a fraction of the existing network. Most of these new roads were built as connecters to the main roads which already provided access to the majority of the watershed.

Currently there are over 40 miles of dirt road managed by six separate landowners on the Parsons Creek watershed with the majority of the roads (36 miles) managed by HREC. Of the 36 miles of road most are currently maintained with only a small portion abandoned or permanently gated to restrict vehicle use. These roads are currently used predominantly for ranching and research and receive light traffic and minimal heavy vehicle use.

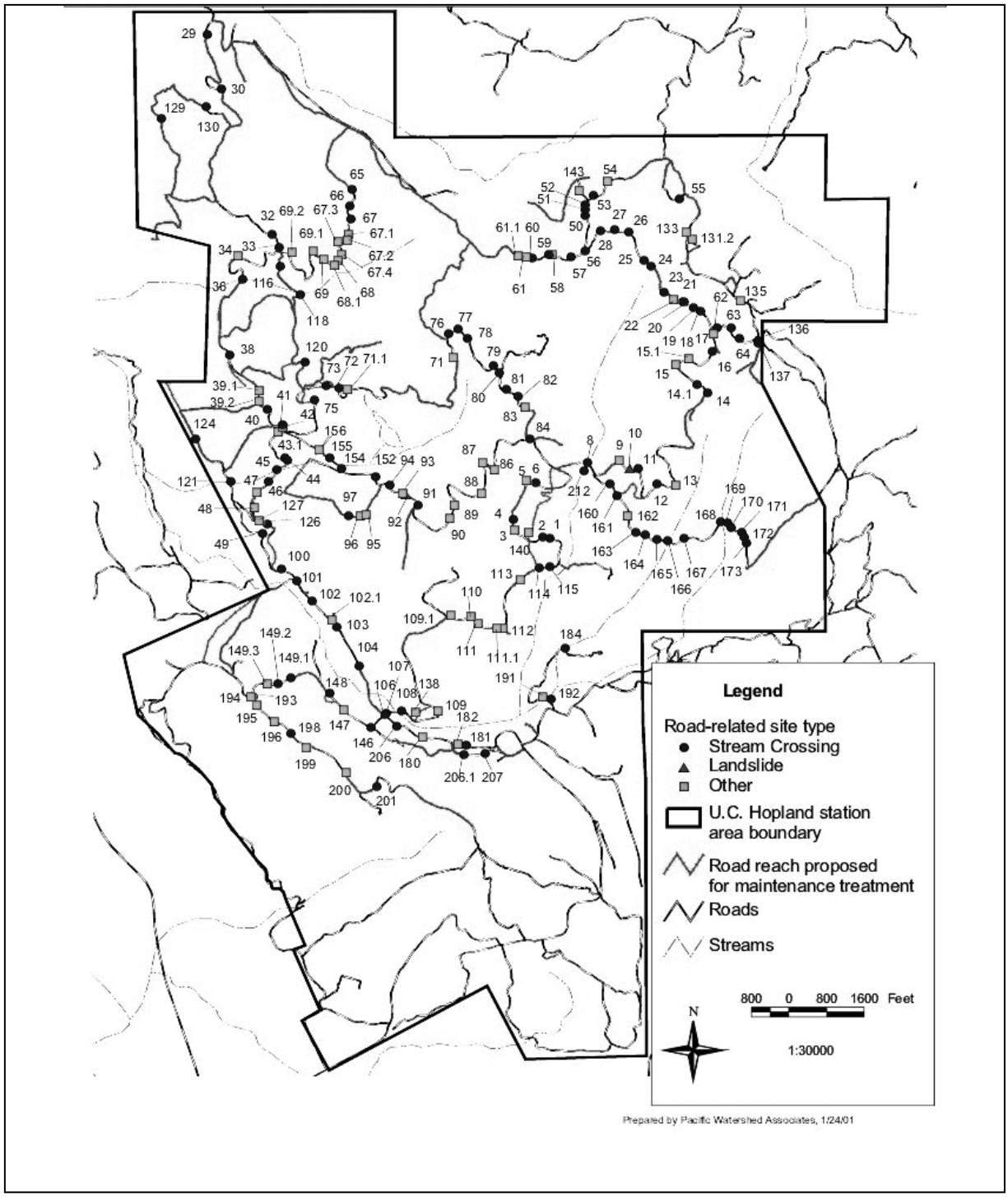


Figure X-C-1. Road-related sites with future sediment delivery, UC Hopland Experimental Station, Parsons Creek, Mendocino County, California.

Geologic setting of the Parsons Creek watershed

Sediments and rocks within the Parsons Creek watershed consist almost entirely of undifferentiated sedimentary and metamorphic rocks of the Franciscan formation. Most of the rocks found within the watershed have undergone severe post depositional deformation. This deformation ranges from pervasive fracturing to intense recrystallization. The most common rocks found in the watershed are Mesozoic marine sandstones, cherts and mudstones. These rocks tend to outcrop at higher elevations in the study area and where major tributary channels have cut through the overlying thick mantle of colluvium in the lower portions of the watershed. These rocks are extensively sheared and tend to erode into small fragments in all but the largest outcrops. Other rocks present in lesser amounts in the watershed include highly metamorphosed fragments of the oceanic lithosphere. These rocks vary in their degree of metamorphism and include greenschist and blueschist facies rocks. Metamorphic rocks rarely outcrop in the study area but tend to litter the tributary channels because of their resistence to erosion. The geology in the lower watershed is dominated by Quaternary alluvium and thick colluvial deposits, on the hillslopes. These deposits are interstratified where the hillsides are adjacent to the active and historic fluvial terraces.

The southern 60% of the Parsons Creek watershed is mantled by multiple, coalescing, mountain scale landslides. These landslides tend to dominate the topography resulting in large amphitheater shaped cavities in the upper headwall areas of the watershed and thick unconsolidated deposits in the lower sections. The slides are presently inactive, probably thousands of years old and are clearly unrelated to present land use activities and historic climatic fluctuations. Although the slides are inactive and old they do significantly influence the watershed drainage patterns and sediment sources for Parsons Creek. The toes of these large landslides appear to have merged and formed the southern margin of the lower Parsons Creek drainage, possibly dividing a historically more extensive drainage basin. Further up the hillside the deposits of the landslides mantle a high percentage of the southwest portion of the watershed. They vary in thickness but are typically less than 80 feet thick. These deposits consist of broken rock fragments, of various sizes and lithologies, jumbled within a matrix of heterogeneous sand and mud. This type of deposit is highly erodible and significantly affects the distribution of erosion within the watershed.

Parsons Creek watershed assessment and implementation

Perhaps the most important element needed for long term restoration of steelhead habitat, and the eventual recovery of salmonid populations in Parsons Creek, is the reduction of accelerated erosion and sediment delivery to the channel system. This summary report describes the watershed assessment and inventory process that was employed in the Parsons Creek Assessment.

It also serves as a prioritized plan-of-action for cost-effective erosion control and erosion prevention treatments for the Parsons Creek watershed. When implemented and employed in combination with protective land use practices, the proposed projects are expected to significantly contribute to the long term protection and improvement of salmonid habitat in the basin. The implementation of erosion control and erosion prevention work is an important step towards protecting and restoring watersheds and their anadromous fisheries (especially where sediment input is a limiting or potentially limiting factor to fisheries production, as is thought to be the case for Parsons Creek).

Project Description

The watershed assessment process consisted of two distinct project elements. These included: 1) a completed inventory of all future road-related sediment sources in the watershed, and 2) an inventory of sediment sources along the mainstem of Parsons Creek, totaling approximately 3.3 miles of stream channel in both the upper and lower watershed.

In the first phase of the Parsons Creek inventory project all roads within the study area were identified and age dated from historic aerial photography. Aerial photographs were analyzed to identify the location and approximate date of road construction. A composite map of the road systems in both lower and upper Parsons Creek was developed from GIS base maps produced by HREC. The base maps, updated through analysis of aerial photos, depict the primary road network in the watershed and show the location of sites with future erosion and sediment delivery to the stream system.

The second phase of the project involved a complete inventory of the road systems, selected hillslope areas and major stream channels. Technically, this assessment is neither an erosion inventory nor a road maintenance inventory. Rather, it is an inventory of sites where there is a potential for future sediment delivery to the stream system that could impact fish bearing streams in the watershed. All roads, including both maintained and abandoned routes, were walked and inspected by trained personnel and all existing and potential erosion sites were identified. Sites, as defined in this assessment, include locations where there is direct evidence that future erosion or mass wasting could be expected to deliver sediment to a stream channel. Sites of past erosion were not inventoried unless there was a potential for additional future sediment delivery. Similarly, sites of future erosion that were not expected to deliver sediment to a stream channel were identified but, were not included in the assessment.

In the final phase of the watershed assessment project, the mainstem of Parsons Creek was inventoried for bank erosion sites and stream side landslides. Data was collected on the location and volume of sediment sources along approximately 3.3 miles of the mainstem and the largest major tributary of Parsons Creek. Data collected included the type of erosional process, the current activity level, the volume of sediment delivery, and applicable treatment prescriptions at sites where work has been recommended. In addition, erosion sites were mapped on mylar overlays to the 1:14,000 scale aerial photos. Derivative site maps of the channel system were then produced (see channel maps in back of report).

Inventory Results

Approximately 36 miles of roads were inventoried for future sediment sources within the Parsons Creek watershed. Inventoried road-related erosion sites on HREC lands fell into one of two treatment categories: 1) upgrade sites – defined as sites on maintained open roads that are to be retained for access and management and 2) decommission sites – defined as sites exhibiting the potential for future sediment delivery that have been recommended for either temporary or permanent closure. Virtually all future road-related erosion and sediment delivery in the Parsons Creek watershed is expected to come from three sources: 1) the failure of road fills (landsliding), 2) erosion at or associated with stream crossings (from several possible causes), and 3) road surface and ditch erosion.

A total of 214 sites were identified with the potential to deliver sediment to streams. Of these, 180 sites were recommended for erosion control and erosion prevention treatment. Approximately 62% (n=131) of the sites are classified as stream crossings and 2% (n=6) as potential landslides (Figure X-C-1, Table X-C-1). The remaining 36% (n=77) of the inventoried sites consist of other sites which include ditch relief culverts and gullies.

Site Type	Number of sites or road miles	Number of sites or road miles to treat	Future delivery (yds^3)	Stream crossings w/a diversion potential (#)	Streams currently diverted (#)	Stream culverts likely to plug (plug potential rating = high or moderate)
Landslides	6	2	61	NA	NA	NA
Stream crossings	131	111	8,853	75	6	41
Other	77	67	1,356	NA	NA	NA
Total (all sites)	214	180	10,270	75	5	41
Persistent surface erosion[1]	14.94	14.94	14,608	NA	NA	NA
Totals	214	180	24,878	75	6	41

[1] Assumes 25' wide road prism and outbank contributing area, and 0.2' of road/cutbank surface lowering per decade.

Table X-C-1. Site classification and sediment delivery from all inventoried sites with future sediment delivery in the Hopland field station assessment area, Mendocino County, California.

Landslides Only those landslide sites with a potential for sediment delivery to a stream channel were inventoried. Potential landslides account for approximately 2% of the inventoried sites in the Parsons Creek assessment area (Figure X-C-1, Table X-C-1). Most of the potential landslide sites were found along roads where material had been sidecast during earlier construction and now show signs of instability. Potential landslides are expected to deliver nearly 61 yds^3 of sediment to Parsons Creek and its tributaries in the future. Correcting or preventing potential landslides associated with the road is relatively straightforward, and involves the physical excavation of potentially unstable road fill and sidecast materials.

There are a number of potential landslide sites located in the Parsons Creek assessment area that did not, or will not deliver sediment to streams. These sites were not inventoried using data sheets due to the lack of expected sediment delivery to a stream channel. They are generally shallow and of small volume, or located far enough away from an active stream such that sediment delivery is unlikely. For reference, all landslide sites were mapped on the mylar overlays of the aerial photographs, but only those with the potential for future sediment delivery were inventoried using a data sheet (Figure X-C-2).

ASAP____	**ROAD INVENTORY DATA FORM**						*Check____*
GENERAL	**Site No:** _____	GPS:	Watershed:		CALWAA:		
Treat (Y,N):	Photo: _____	T/R/S:	Road #:		Mileage: _____		
	Inspectors:_____	Date: _____	Year built:_____	Sketch (Y):			
	Maintained	Abandoned	Driveable	Upgrade	Decommission	Maintenance	
PROBLEM	Stream xing	Landslide (fill, cut, hill)	Roadbed (bed, ditch, cut)	DR-CMP	Gully	Other	
	Location of problem (U, M, L, S)	Road related? (Y)	Harvest history: (1=<15 yrs old; 2=>15 yrs old) TC1, TC2, CC1, CC2, PT1, PT2, ASG, No		Geomorphic association: Streamside, I.G., Stream Channel, Swale, Headwall, B.I.S.		
LANDSLIDE	Road fill	Landing fill	Hillslope failure; depth unk	Cutbank	Already failed	Pot. Failure	
	Slope shape: (convergent, divergent, planar, hummocky)			Slope (%) _____	Distance to stream (ft) _____		
STREAM	CMP	Bridge	Humboldt	Fill	Ford	Armored fill	
	Pulled xing: (Y)	% pulled _____	Left ditch length (ft) _____		Right ditch length (ft) _____		
	cmp dia (in) _____	inlet (O, C, P, R)	outlet (O, C, P, R)	bottom (O, C,P, R)	Separated?		
	Headwall (in) ____	CMP slope (%) _____	Stream class (1, 2, 3)	Rustline (in)			
	% washed out ____	D.P.? (Y)	Currently dvted? (Y)	Past dvted? (Y)	Rd grade (%) _____		
	Plug pot: (H, M, L)	Ch grade (%) _____	Ch width (ft) _____	Ch depth (ft) ____			
	Sed trans (H, M, L)	Drainage area (mi^2) _____					
EROSION	E.P. (H, M, L)	Potential for extreme erosion? (Y, N)		Volume of extreme erosion (yds^3): 100-500, 500-1000, 1K-2K, >2K			
Past erosion…	Rd&ditch vol (yds^3) (yds^3)_____	Gully fillslope/hillslope (yds^3)_____	Fill failure volume (yds^3) _____	Cutbank erosion (yds^3)_____	Hillslope slide vol. (yds^3)	Stream bank erosion (yds^3)	xing failure vol (yds^3)
	Total past erosion (yds) _____	Past delivery (%) _____	Total past delivery (yds) _____	Age of past erosion (decade)_____	_____	_____	_____
Future erosion…	Total future erosion (yds) _____	Future delivery (%) _____	Total future delivery (yds) _____	Future width (ft) _____	Future depth (ft) _____	Future length (ft) _____	
TREATMENT	Immed (H,M,L)	Complex (H,M,L)	Mulch (ft^2)				
	Excavate soil	Critical dip	Wet crossing (ford or armored fill) (circle)		sill hgt (ft) ___	sill width (ft) _____	
	Trash Rack	Downspout	D.S. length (ft) _____	Repair CMP	Clean CMP		
	Install culvert	Replace culvert	CMP diameter (in) _____	CMP length (ft) _____			
	Reconstruct fill	Armor fill face (up, dn)	Armor area (ft^2) _____	*Clean or cut ditch*	*Ditch length (ft)* _____		
	Outslope road (Y)	*OS and Retain ditch (Y)*	*O.S. (ft)* _____	*Inslope road*	*I.S. (ft)* _____	*Rolling dip*	*R.D. (#)* __
	Remove berm	*Remove berm (ft)* _____	*Remove ditch*	*Remove ditch (ft)* _____		*Rock road*	*- ft^2* _____
	Install DR-CMP	*DR-CMP (#)* _____	Check CMP size? (Y)	Other tmt? (Y)	No tmt. (Y)		
COMMENT ON PROBLEM:							
EXCAVATION VOLUME Total excavated (yds^3) _____ Vol put back in (yds^3) _____ Volume removed (yds^3) _____ Vol stockpiled (yds^3) _____ Vol endhauled (yds^3) _____ Dist endhauled (ft) _____ Excav prod rate (yds^3/hr) _____ **EQUIPMENT HOURS** Excavator (hrs) _____ Dozer (hrs) _____ Dump truck (hrs) _____ Grader (hrs) _____ Loader (hrs) _____ Backhoe (hrs) _____ Labor (hrs) _____ Other (hrs) _____ COMMENT(S) ON TREATMENT: Note: no excavation volume should be estimated for failure areas of unknown type and depth. Treatments must be prescribed in consultation with a licensed geotechnical specialist.							
	Vol stockpiled (yds^3)	Vol endhauled (yds^3) __	Dist endhauled (ft) ____	Excav prod rate (yds^3/hr) _____			
EQUIPMENT HOURS	Excavator (hrs) _____	Dozer (hrs) _____	Dump truck (hrs) _____	Grader (hrs) _____ _____			
	Loader (hrs) _____	Backhoe (hrs) _____	Labor (hrs) _____	Other (hrs) _____			
COMMENT(S) ON TREATMENT**:**							

Figure X-C-2.Road Inventory Data Form.

Stream crossings One hundred thirty one (131) stream crossings were inventoried in the Parsons Creek assessment area including 96 culverted crossings, 9 unculverted fill crossings, 1 bridge, 1 armored fill, 2 washed out crossings, and 22 fords crossings. An unculverted fill crossing refers to a stream crossing with no formal drainage structure to carry the flow through the road prism. Flow is either carried beneath or through the fill, or it flows over the road surface, or it is diverted down the road to the inboard ditch. Most unculverted fill crossings are located at small Class III streams that exhibit flow only in the larger runoff events. If the crossing has been made temporary or decommissioned by removing the majority of the crossing fill, then these crossings are commonly known as "pulled" crossings.

Approximately 8,853 yds^3 of future road-related sediment delivery in the Parsons Creek assessment area could originate from erosion at stream crossings (Table X-C-1). This amounts to nearly 36% of the total expected future sediment delivery from the road system. The most common problems which lead to erosion at stream crossings include: 1) crossings with undersized culverts, 2) crossings with culverts that are likely to plug, 3) stream crossings with a diversion potential and 4) crossings with gully erosion at the culvert outlet. The sediment delivery from stream crossing sites is always classified as 100% because any sediment eroded at the crossing site is then delivered to the channel. Even sediment which is delivered to small ephemeral streams will eventually be delivered to downstream fish-bearing stream channels.

At stream crossings, the largest volumes of future erosion can occur when culverts plug or when potential storm flow exceeds the culvert capacity (i.e., the culvert is undersized or prone to plugging) and flood runoff spills onto or across the road. When stream flow goes over the fill, part or all of the stream crossing fill may be eroded. Alternately, when flow is diverted down the road, either on the road bed or in the ditch (instead of spilling over the fill and back into the same stream channel), the crossing is said to have a "diversion potential" and the road bed, hillslope and/or stream channel that receives the diverted flow can become deeply gullied or destabilized. These hillslope gullies can be quite large and can deliver significant quantities of sediment to stream channels. Alternately, diverted stream flow which is discharged onto steep, potentially unstable slopes can also trigger large hillslope landslides. Of the 131 stream crossings inventoried in the Parsons Creek watershed, 75 have the potential to divert in the future and 6 streams are currently diverted at stream crossing sites (Table X-C-1).

Three road design conditions indicate a high potential for future erosion at stream crossings. These include 1) undersized culverts (the culvert is too small for the 100 year design storm flow), 2) culverts that are prone to plugging with sediment or organic debris and 3) stream crossings with a diversion potential. The worst scenario is for the culvert to plug and the stream crossing to wash out or the stream to divert down the road in a major storm. These road and stream crossing conditions are easily recognizable in the field and have been inventoried in the Parsons Creek watershed.

Approximately 85% (n=111) of the stream crossings inventoried in the Parsons Creek assessment area will need to be upgraded for the roads to be considered "storm-proofed". For example, 31% (n=41) of the existing culverts have a "moderate" to "high" plugging potential and nearly 57% of the stream crossings exhibit a diversion potential (Table X-C-1). Because most of the roads were constructed many years ago, culverted stream crossings are typically under-designed for the100

year storm flow. At stream crossings with undersized culverts or where there is a diversion potential, corrective prescriptions have been outlined on the data sheets and in the following tables. Preventative treatments include such measures as constructing critical dips (rolling dips) at stream crossings to prevent stream diversions, installing larger culverts wherever current pipes are under-designed for the 100 year storm flow (or where they are prone to plugging), installing culverts at the natural channel gradient to maximize the sediment transport efficiency of the pipe and ensure that the culvert outlet will discharge on the natural channel bed below the base of the road fill, installing debris barriers and/or downspouts to prevent culvert plugging and outlet erosion, respectively, and armoring the downstream fill face of the crossing to minimize or prevent future erosion.

"Other"sites – A total of 77 other sites were also identified in the Parsons Creek assessment area. The main cause of existing or future erosion at these sites is surface runoff and uncontrolled flow from long sections of undrained road surface and/or inboard ditch. Uncontrolled flow along the road or ditch may affect the road bed integrity as well as cause gully erosion on the hillslopes below the outlet to ditch relief culverts. Road runoff is also a major source of fine sediment input to nearby stream channels. In the Parsons Creek assessment area, we measured approximately 14.94 miles of road surface and/or road ditch (representing 42% of the total inventoried road mileage) which currently drains directly to stream channels and delivers ditch and road runoff and sediment to stream channels. These roads are said to be hydrologically connected to the stream channel network. When these roads are being maintained and used for ranch access, they may represent a potentially important source of chronic fine sediment delivery to the stream system.

We estimate 1,356 yds^3 of sediment will be delivered to streams from the 77 other specific sites inventoried (Table X-C-1). From the 14.94 miles of connected road segments, we calculated over 14,608 yds^3 of sediment will be delivered to stream channels in the Parsons Creek watershed over the next 10 years if no efforts are made to change road drainage patterns. This will occur through a combination of 1) cutbank erosion delivering sediment to the ditch triggered by dry ravel, rainfall, freeze-thaw processes, cutbank landslides and brushing/grading practices, 2) inboard ditch erosion and sediment transport, 3) mechanical pulverizing and wearing down of the road surface, and 4) erosion of the road surface during wet weather periods.

Treatment Priority

An inventory of future or potential erosion and sediment delivery sites is intended to provide information which can guide long range transportation planning, as well as identify and prioritize erosion prevention, erosion control and road decommissioning activities in the watershed. Not all of the sites that have been recommended for treatment have the same priority, and some can be treated more cost-effectively than others. Treatment priorities are evaluated on the basis of several factors and conditions associated with each potential erosion site:

- the expected volume of sediment to be delivered to streams (yds^3),
- the potential or likelihood for future erosion (high, moderate, low),
- the urgency of treating the site (treatment immediacy – high, moderate, low),
- the ease and cost of accessing the site for treatments, and
- recommended treatments, logistics and costs.

Treatments

Basic treatment priorities and prescriptions were formulated concurrent with the identification, description and mapping of both potential sources of road-related sediment delivery and road maintenance sites with no potential sediment delivery. Table X-C-2 and Figure X-C-3 outline the treatment priorities for all 173 inventoried sites with future sediment delivery that have been recommended for treatment in the Parsons Creek watershed assessment area. Of the 173 sites with future sediment delivery, 26 sites were identified as having a high or high-moderate treatment immediacy with a potential sediment delivery of approximately 4,520 yds^3. Eighty two (82) sites were listed with a moderate or moderate-low treatment immediacy and account for nearly 4,206 yds^3 of future sediment delivery. Finally, 65 sites were listed as having a low treatment immediacy with approximately 1,544 yds^3 of future sediment delivery.

Treatment Priority	Upgrade sites (# and site #)	Decommission sites (# and site #)	Problem	Future sediment delivery (yds^3)
High	**7** (site #: 41, 86, 104, 118, 148, 166, 172)	**0**	6 stream crossings, 1 other	747
High Moderate	**19** (site #: 4, 13, 14, 24, 25, 36, 40, 43, 44, 47, 64, 72, 75, 91, 94, 102, 110, 113, 163)	**0**	14 stream crossings, 5 other	3,773
Moderate	**29** (site #: 8, 10, 15, 19, 20, 22, 33, 34, 43.1, 48, 65, 68, 69, 80, 82, 88, 92, 97, 111, 116, 124, 131.2, 149.1, 160, 168, 170, 171, 181, 199)	**1** (site #: 127)	17 stream crossings, 2 landslides, 11 other	2,055
Moderate Low	**53** (site #: 1, 2, 5, 6, 9, 11, 12, 17, 21, 23, 26, 28, 29, 30, 38, 42, 45, 46, 49, 52, 54, 56, 57, 59, 62, 63, 68.1, 71.1, 76, 77, 79, 81, 83, 84, 93, 101, 106, 109, 109.1, 114, 121, 129, 149.2, 149.3, 152, 154, 155, 161, 164, 165, 167, 195, 206)	**4** (site #: 126, 133, 138, 212)	42 stream crossings, 15 other	2,151
Low	**65** (site #: 3, 14.1, 15.1, 16, 18, 27, 32, 39.1, 39.2, 42.1, 50, 51, 53, 55, 58, 60, 61, 61.1, 66, 67, 67.1, 67.2, 67.3, 67.4, 69.1, 69.2, 71, 73, 78, 87, 89, 90, 95, 96, 100, 102.1, 103, 107, 108, 111.1, 112, 115, 120, 130, 135, 136, 137, 143, 146, 147, 156, 162, 169, 173, 180, 182, 184, 191, 192, 193, 194, 196, 198, 200, 201,)	**2** (site #: 140, 207)	32 stream crossings, 35 other	1,544
Total	**173**	**7**	**180**	**10,270**

Table X-C-2. Treatment priorities for all inventoried sediment sources in the Hopland field station assessment area, Mendocino County, California.

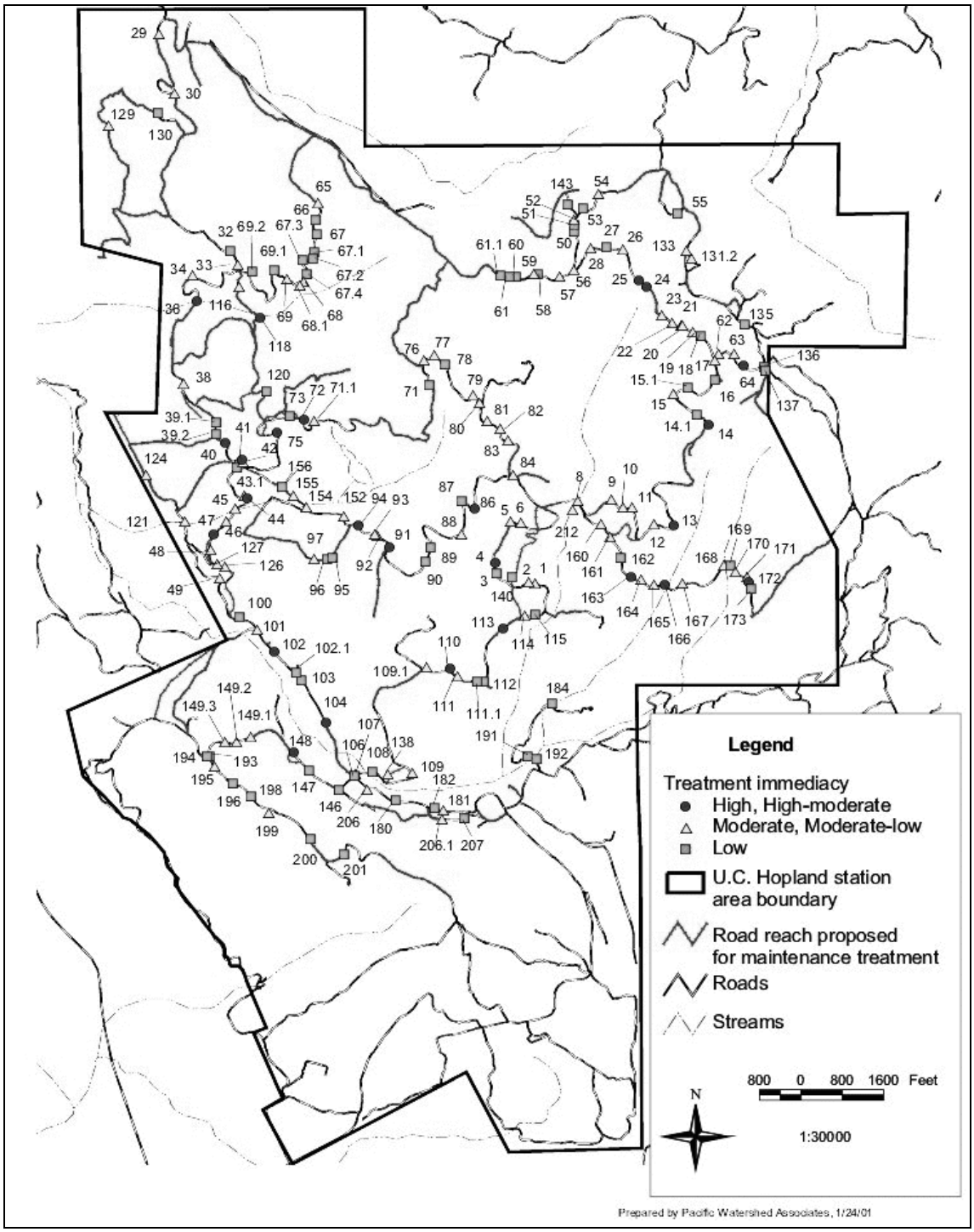


Figure X-C-3. Treatment Immediacy (priority) for inventoried road-related sites, UC Hopland Experimental Station, Parsons Creek, Mendocino County, California.

Table X-C-3 summarizes the proposed treatments for sites inventoried on all roads in the Parsons Creek assessment area, including both the upper and lower watershed areas. These prescriptions include all upgrading measures. The database, as well as the field inventory sheets, provide details of the treatment prescriptions for each site. Most treatments require the use of heavy equipment, including an excavator, tractor, dump truck, grader and/or backhoe. Some hand labor is required at sites needing new culverts, downspouts, flared inlets or culvert repairs, trash racks or for applying seed, plants and mulch following ground disturbance activities. A total of 71 critical rolling dips have been recommended to prevent future stream diversions at road crossings (Table X-C-3). A total of 89 culverts are recommended for installation at stream crossings. Eighty-five will replace existing undersized or rotten stream crossing culverts with culverts sized for the 100 year storm, and 4 culverts are recommended for installation at currently unculverted small streams.

It is estimated that erosion prevention work will require the excavation and disposal of approximately 6,171 yds^3 at 22 sites. Approximately 98% of the volume excavated is associated with upgrading or properly excavating stream crossings and nearly 2% of the volume is proposed for excavating potentially unstable road fills (landslides). Most of the stream crossing volume is associated with removal of channel stored sediment above the current culvert inlet. A total of 45 yds^3 of 0.5 to 1.5 foot diameter, mixed and clean rip-rap sized rock will be needed to construct eight proposed armored wet crossings (Table X-C-3). We have recommended 232 rolling dips be constructed at selected locations along the road, at spacings dictated by the steepness of the road. A minimum of twenty five (25) new ditch relief culverts are recommended to be installed along the road routes inventoried. Some proposed rolling dips can be replaced with additional ditch relief culverts, but the total cost for additional ditch relief culverts are not included here.

Equipment Needs and Costs

Treatments for the 180 sites identified with future sediment delivery in the Parsons Creek assessment area will require approximately 312 hours of excavator time and 454 hours of tractor time to complete all prescribed upgrading, road closure, erosion control and erosion prevention work (Table X-C-4). Excavator and tractor work is not needed at all the sites that have been recommended for treatment and, likewise, not all the sites will require both a tractor and an excavator. Approximately 8 hours of dump truck time has been listed for work in the basin for endhauling excavated spoil from stream crossings and at unstable road and landing fills where local disposal sites are not available. Approximately 358 hours of labor time is needed for a variety of tasks such as installation or replacement of culverts, installation of debris barriers and downspouts.

Estimated costs for erosion prevention treatments – Prescribed treatments are divided into two components: a) site specific erosion prevention work identified during the watershed inventories, and b) control of persistent sources of road surface, ditch and cutbank erosion and associated sediment delivery to streams. The total costs for road-related erosion control at sites with future sediment delivery is estimated at approximately $331,345 for an average cost-effectiveness value of approximately $13.31 per cubic yard of sediment prevented from entering Parsons Creek and its tributaries (Table X-C-5).

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	71	To prevent stream diversions	Outslope road and remove ditch	97	Outslope and remove ditch for 37,342 feet of road to improve road surface drainage
Install CMP	4	Install a CMP at an unculverted fill	Outslope road and retain ditch	8	Outslope and retain ditch for 1,840 feet of road to improve road surface drainage
Replace CMP	85	Upgrade an undersized CMP	Install rolling dips	232	Install rolling dips to improve road drainage
Excavate soil	23	Typically fillslope & crossing excavations; excavate a total of 7,019 yds^3	Cross road drain	2	Install cross road drains to improve road drainage
Down spouts	5	Installed to protect the outlet fillslope from erosion	Remove berm	13	Remove 2,815 feet of berm to improve road surface drainage
Wet crossing	8	Install rocked ford and armored fill crossing using 45 yds^3 rip-rap	Install ditch relief CMP	25	Install ditch relief culverts to improve road surface drainage
Install flared inlet	2	Install flared inlet to increase intake capacity	Clean/cut ditch	4	Clean/cut 618 feet of ditch
Clean CMP	1	Remove debris and/or sediment from CMP inlet	Rock road surface	323	Rock road surface using 3,654 yds^3 road rock (includes road rock for 14 site specific locations, and post installation for 214 rolling dips, 75 stream crossings and 20 ditch relief culverts
Inslope road	1	Inslope 210 feet of road to improve road drainage	Other	10	Miscellaneous treatments
Remove ditch	1	Remove 130 feet ditch to improve road drainage	No treatment recommended	34	

Table X-C-3. Recommended treatments along all inventoried roads in the Hopland field station assessment area, Mendocino County, California.

Overall site specific erosion prevention work: Equipment needs for site specific erosion prevention work at sites with future sediment delivery are expressed in the database, and summarized in Table X-C-4 and Table X-C-5, as direct excavation times, in hours, to treat all sites. These hourly estimates include only the time needed to treat each of the sites, and do not include travel time between work sites, times for basic road surface treatments that are not associated with a specific site, or the time needed for work conferences at each site. These additional times are accumulated as logistics and must be added to the work times shown in Table X-C-4 to determine total equipment costs as shown in Table X-C-5.

Treatment Immediacy	No. of Sites	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Dump Trucks (hrs)	Backhoe (hrs)	Labor (hrs)
High, High/Moderate	26	4,920	151	173	0	23	81
Moderate, Moderate.Low	87	946	124	201	8	154	194
Low	67	305	37	80	0	69	83
Total	**180**	**6,171**	**312**	**454**	**8**	**246**	**358**

Table X-C-4. Estimated heavy equipment and labor requirements for treatment of all inventoried sites with future sediment delivery, Hopland field station assessment area, Mendocino County, California.

The costs in Table X-C-5 are based on a number of assumptions and estimates, and many of these are included as footnotes to the table. The costs provided are assumed reasonable if work is performed by outside contractors, with no added overhead for contract administration and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road upgrading and road decommissioning operations on forest lands. The use of inexperienced operators would require additional technical oversight and supervision in the field. All recommended treatments conform to guidelines described in *The Handbook for Forest and Ranch Roads* (PWA 1994) for the California Department of Forestry, Natural Resources Conservation Service and the Mendocino County Resource Conservation District.

Table X-C-5 lists a total of 225 hours for supervision time for detailed pre-work layout, project planning (coordinating and securing equipment and obtaining plant and mulch materials), on-site equipment operator instruction and supervision, establishing effectiveness monitoring measures, and post-project cost-effectiveness analysis and reporting. It is expected that the project coordinator will be on-site full time at the beginning of the project and intermittently after equipment operations have begun.

Stream channel surveys

Approximately 3.3 miles of stream channel, extending from the private property boundary in the lower basin to the upper reaches in grasslands and oak forests of the upper watershed, was inventoried to identify past and current sediment sources (Figure X-C-1). The goals of the channel assessment were three fold: 1) to evaluate the general condition of stream banks throughout the reach, 2) to document the dominant processes and extent of sediment production along stream side slopes, 3) to determine locations where effective stream bank protection or re-vegetation efforts could be employed to reduce erosion and promote long term recruitment of large organic debris to the main channel of Parsons Creek.

Cost Category[1]		Cost Rate[2] ($/hr)	Estimated Project Times			Total Estimated Costs[5] ($)
			Treatment[3] (hours)	Logistics[4] (hours)	Total (hours)	
Move-in; move-out[6] (Lowboy expenses)	Excavator	95	4	—	4	380
	D-5 tractor	70	4	—	4	280
Heavy Equipment requirements for site specific treatments	Excavator	115	312	94	406	46,690
	D-5 tractor	85	454	136	590	50,150
	Dump Truck	60	8	2	10	600
	Backhoe	65	246	74	320	20,800
Heavy Equipment requirements for road drainage treatments	Excavator	115	60	18	78	8,970
	D-5 tractor	85	101	30	131	11,135
	Backhoe	65	50	15	65	4,225
	Grader	85	65	20	85	7,225
Laborers[7]		20	487	146	633	12,660
Rock Costs: (includes trucking for 3,654 yds^3 of road rock and 45 yds^3 of rip-rap sized rock)						62,883
Culvert materials costs (750' of 18', 2,110' of 24", 820' of 30", 400' of 36", 280' of 42", 200' of 48", 130' of 54", 60' of 60", 190' of 72". Costs included for couplers and flared inlets)						91,735
Mulch, seed and planting materials for 4.3 acres of disturbed ground[8]						2,358
Layout, Coordination, Supervision, and Reporting[9]						11,254
Total Estimated Costs						**$ 331,345**
Overall project cost-effectiveness: $ 13.31 spent per cubic yard saved						

[1]Costs for tools and miscellaneous materials have not been included in this table. Costs for administration and contracting are variable and have not been included. Costs and dump truck time (if needed) for re-rocking the road surface at sites where upgraded roads are outsloped are not included.
[2] Costs listed for heavy equipment include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.
[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.
[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.
[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.
[6] Lowboy hauling for tractor and excavator, 4 hours round trip for the following areas within Parsons Creek. Costs assume 2 hauls for two pieces of equipment (one to move in and one to move out).
[7] Additional labor hours are included for the following: 1) 54 hours for seeding and mulching activities and 2) 75 hours for ditch relief culvert installation.
[8] Seed costs equal $6/pound for erosion control seed. Seed costs based on 50# of erosion control seed per acre. Straw costs include 50 bales required per acre at $5 per bale. Sixteen hours of labor are required per acre of straw mulching.
[9] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, training of equipment operators, supervision during equipment operations, supervision of labor work and post-project documentation and reporting). Supervision times based on 30% of the total excavator time plus 1 week prior and 1 week post project implementation.

Table X-C-5. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on all inventoried sites with future sediment delivery in the Hopland field station, Parsons Creek, Mendocino County, California.

Aerial photos (1:14,000) were used as a base map to record stream channel observations. The channel survey started at the downstream boundary of the HREC ownership and extended upstream through HREC properties (Figure X-C-1). The details of the channel mapping data is shown in three separate maps covering the lower to upper basin and three additional maps covering the same area but with the erosional sites sorted by treatment priority. The individual

channel maps depict the location of debris landslides, deep-seated landslides, and sites of bank erosion. Bank erosion sites exceeding 10 yds^3 and debris landslides exceeding 50 yds^3 were quantified and described using the stream channel inventory data forms (Figure X-C-4). The location of bank erosion sites less than 10 yds^3 and debris landslides less than 50 yds^3 are shown on the strip maps, but have not been further described.

STREAM CHANNEL INVENTORY DATA FORM						
General	Site #:	Date:	Mappers:	Air Photo:	Watershed:	Stream:
	Bank (L/R):	Treat?(Y)				
Problem	Debris Slide	Hillslope failure of unknown depth and activity	Torrent channel	Bank erosion	Log jam:	Other:
	Past, future, both	Activity (A, W, IA):	Age (decade):	Hillslope (%)	Land use:	Undercut (Y)
Erosion	Past width:	Past depth:	Past length:	Past vol:	Past del (%)	Past yld (yds):
E.P.:	Future Width	Future depth:	Future length:	Future vol:	Fut del (%)	Fut yld (yds):
Treatment	Immed: (H, M, L)	Complexity: (H, M, L)	Eqpt or labor (E, L, B):		Access: (Easy, Moderate, Hard)	
	Excavate soil	Rock armor/buttress	Log protection	Remove logs/debris	Plant	Other
Hours:	Excavator:	Dozer:	Dump truck:	Backhoe:	Labor:	Other:
Problem:						
Treatment:						

Figure X-C-4. Stream Channel Inventory Data Form.

Besides documenting locations of past and current erosion and landsliding along the channel, efforts were made to document other important channel features. These included:

- the location of fish habitat structures and concentrations of large woody debris;
- the location of log jams;
- stream gradients, and
- the location of tributary stream junctions

All information collected in the field was compiled into a catalog of channel features by station number to assist in future channel surveys. The six channel strip maps summarize the data that was collected for the 3.3 miles of inventoried stream channel.

Channel survey results

A total of 117 sites of significant erosion were identified during the stream channel surveys. A total of 60 sites of past and active bank erosion were mapped along the lower reaches and main tributary to Parsons Creek (Table X-C-6). Bank erosion sites averaged 342 yds^3 in volume.

Stream side debris slides have generated over twice as much sediment delivery to the channel system than did bank erosion in the Parsons Creek watershed. Fifty seven debris slides in the >50 yds^3 class averaged nearly 1218 yds^3 in volume and accounted for 39,631 yds^3 of sediment delivery (Table X-C-6). Some of these debris slides were associated with roads near the inner gorge of Parsons Creek.

Reach	**Reach Length (feet)**	**Bank Erosion site >10 yds^3**			**Debris slides >50 yds^3**		**%**
		No.	Length (ft)	Delivery ($yds^{3)}$	No.	Delivery ($yds^{3)}$	BE/DS
Mainstem[1]	7,628	26	5,236	4,278	4	2,749	87/13
Largest Tributary of Parsons Creek	9,708	34	3,267	12,164	53	37,382	39/61
Total	17,336	60	8,503	16,442	57	40,131	----

[1] Sites 182.1 and 183 were quantified on the road erosion inventory but contributed an additional 19,925 yds^3 to the stream channel which could be added to the total Mainstem past erosion volume.

Table X-C-6. Bank erosion and small stream side debris slides along inventoried stream reaches, Parsons Creek, Mendocino County, California.

When evaluating erosion sites on Parsons Creek it is clear that the dominant erosion processes change from the mainstem to the main tributary. On the mainstem, where stream gradients are low, the channel is unconfined and meandering, and fluvial terraces are the dominant sediment source, bank erosion is the most common type of erosional process. On the main tributary where gradients are high, the channel is confined, and thick heterogeneous, low strength colluvial sediments are the dominant sideslope material, debris landsliding is the most common erosional process (Table X-C-6). Thirty seven sites have been identified as treatable along the mainstem and main tributary to Parsons Creek. These sites have been sorted by treatment priority and are summarized in (Table X-C-7).

Of the treatable sites, 2 are high priority, 4 are high moderate priority, 14 are moderate priority, 6 are moderate low priority, and 11 are low priority. Treating erosional sites along Parsons Creek is not as straight forward as treating erosion related to roads. Most of the sites of future erosion along Parsons Creek are in remote locations with little to no access by road. In most cases pioneering a road to allow heavy equipment access may generate more sediment and long term maintenance costs than is justifiable by either a sediment savings cost analysis or sediment production standpoint. The two high treatment priority sites are along the mainstem of Parsons Creek and have been deemed high priority due to their proximity to, and possible effect on, main access roads managed by HREC. These two sites do not have high future sediment delivery and are therefore not very cost-effective to treat but they are easily accessible and should be monitored for increased activity.

Treatment Priority	Upgrade sites (# and site #)	Problem	Future sediment delivery (yds^3)
High	**2** (site #: 312, 314)	2 bank erosion	94
High Moderate	**4** (site #: 305, 316, 320, 416)	3 bank erosion, 1 other	1,715
Moderate	**14** (site #:300, 302, 306, 308, 309, 313, 326, 327, 333, 344, 360, 361, 364, 381)	12 bank erosion, 2 debris landslides	2,076
Moderate Low	**6** (site #: 301, 304, 307, 311, 315, 362)	5 bank erosion, 1 debris landslide	77
Low	**11** (site #: 310, 321, 323, 339, 343, 348, 351, 351.1, 354, 369, 386)	4 bank erosion, 7 debris landslides	114
Total	**37**	**26 bank erosion 10 debris landslides 1 other**	**5,786**

Table X-C-7. Treatment priorities for treatable sediment sources along inventoried stream reaches in the Hopland field station assessment area, Mendocino County, California.

Sediment source summary

We extrapolated the data collected in the stream channel inventory to the other main tributaries of Parsons Creek to try to come up with an estimate of total past streamside erosion within the HREC management boundary. This was done by determining the ratio of air photo identified sites to sites actually documented during the stream inventory along the main tributary. Using this data and the known ratio of bank erosion sites to debris slides on the main tributary an estimate of the number of unidentified erosional sites for the other 4 tributaries was determined. These estimated erosional sites were then multiplied by the average erosion volume of non-air photo identified bank erosion (221 yds^3) and debris landslides (421 yds^3) respectively on the surveyed main tributary. The total estimated erosional volume of unidentified slides for the four un-inventoried tributaries was then quantified (Table X-C-8). Based on our field observations, this probably represents a maximum erosion volume. Reconnaissance of the un-surveyed tributaries suggests that the density of sites is lower for the four un-surveyed tributaries than the main tributary. Furthermore the thickness of the colluvial deposits, which are the main source of sediment along the main tributary, is thinner to the north especially in the upper portions of tributaries three and four. Other factors including stream size, road influence, conversion from chaparral to pasture, grazing practices, and other management activities most likely influence the number and size of erosion sites along the four un-surveyed tributaries.

Reach	Reach length	Air photo sites	Estimated volume of air photo identified sites (yds^3)	Estimated volume of non-visible sites (yds^3)	Total estimated erosional volume (yds^3)
Mainstem	7,628	2	460	6,567[1]	7,027
Largest Tributary of Parsons Creek	9,708	29	37,981	11,565	49,546
Tributary 1	9,700	7	4,181	5,565	9,746
Tributary 2	6,934	6	7,144	4,452	11,596
Tributary 3	8,321	5	2,679	3,760	6,439
Tributary 4	8,321	6	6,027	4,452	10,479
Total	**50,612**	**57**	**58,472**	**36,361**	**94,833**

[1]Mainstem Parsons Creek is alluvial and has abundant bank erosion sites that are not identifiable on air photos

Table X-C-8. Estimated past sediment delivery from air photo interpretation and data extrapolation for the mainstem and five largest tributaries of Parsons Creek, Mendocino County, California.

Table X-C-9 summarizes the estimated past sediment delivery to the Parsons Creek Watershed from road and streamside erosion for the last 30 years. Of a total of 201,771 yds^3 of estimated past erosion 43% is road related and 57% is streamside sediment delivery. The fact that most of the streamside sediment delivery occurred along reaches of stream bounded by thick, highly erodible, colluvial deposits suggests that the erosion is natural, although some channel incision from road related runoff and channel bed aggradation is possible. Surface erosion from converting chaparral to pasture is evident from our field observations but is difficult to quantify and has not been considered in this study.

Conclusion

The expected benefit of completing the erosion control and prevention planning work lies in the reduction of long term sediment delivery to Parsons Creek, an important steelhead stream. A critical first-step in the overall risk-reduction process is the development of a watershed transportation analysis and plan. In developing this plan, all roads in an ownership or sub-watershed are considered for either decommissioning or upgrading, depending upon the risk of erosion and sediment delivery to streams, and the future use levels. Not all roads are high risk roads and those that pose a low risk of degrading aquatic habitat in the watershed may not need immediate attention. It is therefore important to rank and prioritize roads in each sub-watershed, and within each ownership, based on their potential to impact downstream resources, as well as their importance to the overall transportation system and to management needs.

Good land stewardship requires that roads either be upgraded and maintained, or intentionally closed (put-to-bed). The old practice of abandoning roads, by either installing barriers to traffic

(logs, tank traps or gates) or simply letting them naturally revegetate, is no longer considered acceptable. These roads typically continue to fail and erode for decades following abandonment.

Site Type	Number of sites or road miles	Past erosion (yds^3)	% Total
Total road inventory sites (all sites)[1]	214	43,189	21
Estimated Persistent past surface erosion[2]	14.94	43,824	22
Quantified stream past erosion sites[3]	117	76,498	38
Estimated stream past erosion sites	59	38,260	19
Totals	**390**	**201,771**	**100**

[1] The road inventory documented 63,114 yds^3 of past erosion. At sites 182.1 and 183 the past erosion volume totaled 19,925 yds^3 but both features are non-road related debris slides (i.e. the road had little to no influence on the slides). Subtracting the 19,925 yds^3 of past erosion equals 43,189 yds^3 of past road related sediment delivery.
[2] Assumes 25' wide road prism and cutbank contributing area, and 0.2' of road/cutbank surface lowering per decade for all existing roads for 3 decades. This is the current road connectivity, we have no way of estimating past connectivity.
[3] The channel surveys documented 56,573 yds^3 of past sediment delivery (Table X-C-6). We have added the volume of sediment delivery from sites 182.1 and 183 of the road survey (19,925) to the channel survey to total 75,498 yds^3

Table X-C-9. Estimated total past sediment delivery for Parsons Creek Watershed over the last 30 years, Hopland field station assessment area, Mendocino County, California.

Currently unused, unmaintained and/or abandoned roads in Parsons Creek were evaluated for either upgrading or permanent or temporary decommissioning. Road upgrading consists of a variety of techniques employed to erosion-proof and to storm-proof a road and prevent unnecessary future erosion and sedimentation. Erosion-proofing and storm-proofing typically consists of stabilizing slopes and upgrading drainage structures so that the road is capable of withstanding both annual winter rainfall and runoff, as well as a large storm event without failing or delivering excessive sediment to the stream system. All roads in Parsons Creek have been prescribed for upgrading. The goal of road upgrading is to strictly minimize the contributions of fine sediment from roads and ditches to stream channels, as well as to minimize the risk of serious erosion and sediment delivery when large magnitude, infrequent storms and floods occur.

A plan was submitted in May to the California Department of Fish and Game to implement suggested sediment reduction upgrades for the high, high moderate, and moderate treatment priority sites within the HREC property boundary. As of February 1, 2001 it is our understanding that the proposal has been funded and implementation work will be begin as soon as the funding becomes available and CEQA is completed.

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APPENDIX X-D. CASE STUDY #2

2002 – 2003 REDWOOD CREEK SB 271

ROAD DECOMMISSIONING PROJECT FOR 1300 ROADS

Contract # P0110305

for

The Redwood Creek Watershed,
Humboldt County, California

prepared for

PCFWWRA,
California Department of Fish and Game,
and Simpson Resource Company

by

Pacific Watershed Associates
Arcata, California
(707) 839-5130
January 2004

PROJECT OVERVIEW
SB 271 Road Decommissioning Project
Redwood Creek, Humboldt County, California

INTRODUCTION

Redwood Creek, with its mouth located near Orick, California, has long been recognized as one of the more important salmon and steelhead producing watersheds in the region. Approximately 59 miles of the mainstem and 50 miles of tributary streams are utilized by anadromous salmonids in this 285 square mile watershed. The purpose of this watershed implementation project was to assist in protecting and restoring a quality habitat for fisheries, by reducing the amount of anthropogenic sediment that contributes to the stream system. This project was made possible by funding from the California Department of Fish and Game (through SB 271 funding). Simpson Resource Company provided partial matching funds. More than 4.4 miles of inner gorge and stream-side road, including fifty-six sites that threatened to deliver sediment into the Redwood Creek system, were decommissioned. This report documents the erosion prevention project that was completed in 2003.

BACKGROUND

In 1999 field work began on a SB 271 funded watershed assessment project that included 33,000 acres of the Redwood Creek watershed immediately upstream from Redwood National Park boundaries (Figure X-D-1). This area was identified in the federal legislation expanding Redwood National Park as the Park Protection Zone (PPZ). Approximately 225 miles of road were inventoried for sediment sources within this assessment area.

The PPZ assessment area is typical of the region, where land is privately managed for timber harvest and agricultural production, with the exception of several areas. The BLM manages over 920 acres in the upper Lacks Creek area and several rural residential land holdings also exist within the assessment area. Three major landowners (Simpson Resource Company, Barnum Timber Company, and Stover Ranch) control in excess of 95% of the watershed area in the PPZ.

Roads constructed to support timber harvesting activities were built as areas were entered for first and second cycle logging activities. Some major routes (Old K & K Road, K & K Road, and Dolly Varden Road) were constructed for off-highway log hauling prior to 1958. These routes were aligned across steep inner gorge slopes using Humboldt stream crossings and sidecast construction techniques.

Road systems are now widely recognized throughout the region as one of the most significant, and perhaps the most easily controlled, sources of sediment production and delivery to stream channels. Redwood Creek is underlain by erodible and potentially unstable geologic substrate, and both field observations and aerial photo analysis suggests that roads have been a significant source of accelerated sediment production in the watershed (E.P.A. 1998). In Redwood Creek, as elsewhere, excess sediment input to stream channels triggered by large rainfall events is one of the most significant factors affecting or threatening salmonid populations.

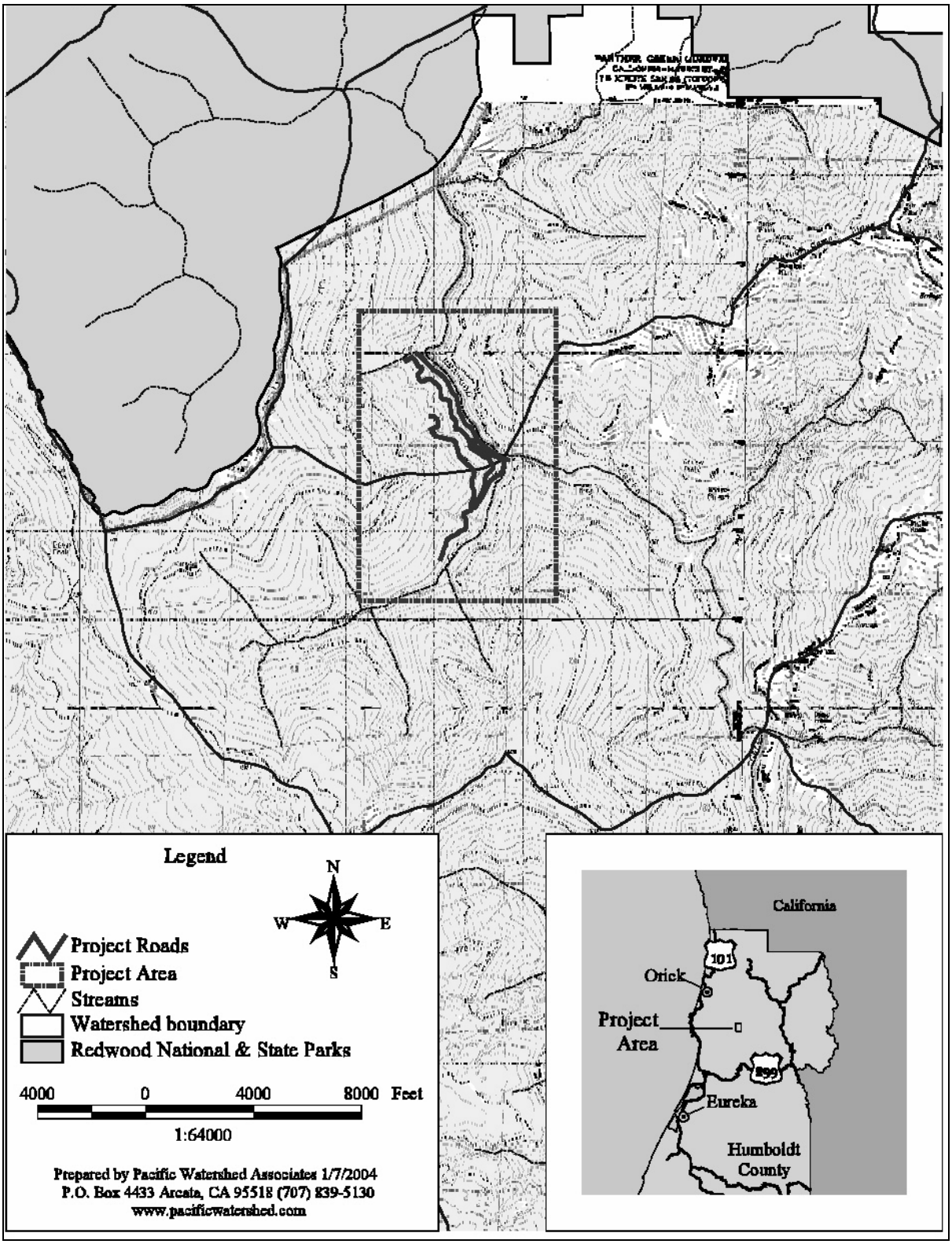

Figure X-D-1. Project Location Map Redwood Creek Road Decommissioning and Erosion Prevention Project Panther Creek USGS Quadrangle, Humboldt County, California.

Field inventories and data base analyses for the Redwood Creek watershed identified several high priority, high yield abandoned roads and road segments that threaten to deliver large quantities of sediment to the stream system if they are left untreated. Seven of these high priority road segments, totaling 4.4 miles, were decommissioned as a part of this project (Figure X-D-2). These included abandoned logging roads that had been constructed along the steep inner gorges of Redwood Creek and Panther Creek (tributary to Redwood Creek).

PROJECT OBJECTIVES

This road decommissioning project was designed to protect and improve salmonid habitat through controlling and preventing road-related erosion on several inner gorge slopes in the Redwood Creek watershed. The primary objective of the project was to implement cost-effective erosion control and erosion prevention work on high priority roads that were identified as a part of the comprehensive watershed assessment and inventory project for the basin.

The implementation of erosion control and erosion prevention work is perhaps the most important step to protecting and restoring watersheds and their anadromous fisheries, especially where sediment input is a limiting or potentially limiting factor to fisheries production, as is thought to be the case for the Redwood Creek watershed. Unlike many watershed improvement and restoration activities, erosion prevention and “storm-proofing” has an immediate benefit to the streams and aquatic habitat of the basin. It helps ensure that the biological productivity of the watershed’s streams is not impacted by future human-caused erosion, and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment, rather than depositing additional sediment from managed areas. Roads treated for this implementation project have been identified as high priority for immediate implementation so that fill failures, stream crossing washouts and stream diversions do not degrade the stream system. The decommissioning work completed on this project is a significant step toward realization of long term salmon habitat protection and improvement in the Redwood Creek watershed.

LOCATION

This erosion control and erosion prevention project was focused on the area of Redwood Creek watershed downstream from the mouth of Panther Creek. It includes seven road segments (4.4 miles) in the lower watershed on Simpson Resource Company lands (Figure X-D-2). The attached maps (Figure X-D-2 and Figure X-D-3) depict the locations of the implementation projects as well as the specific sites that were treated for erosion prevention along each of the road segments.

PROJECT DESCRIPTION

The primary emphasis of the Redwood Creek watershed erosion prevention project was to treat existing and potential sediment sources identified along abandoned stream-side and inner gorge roads (Figure X-D-2 and Figure X-D-3). All roads that were treated were high priority road reaches that threatened to deliver substantial volumes of sediment to Redwood Creek or to Panther Creek if they were left untreated. A number of sites had already failed and many others showed signs of pending and potential failure and sediment delivery.

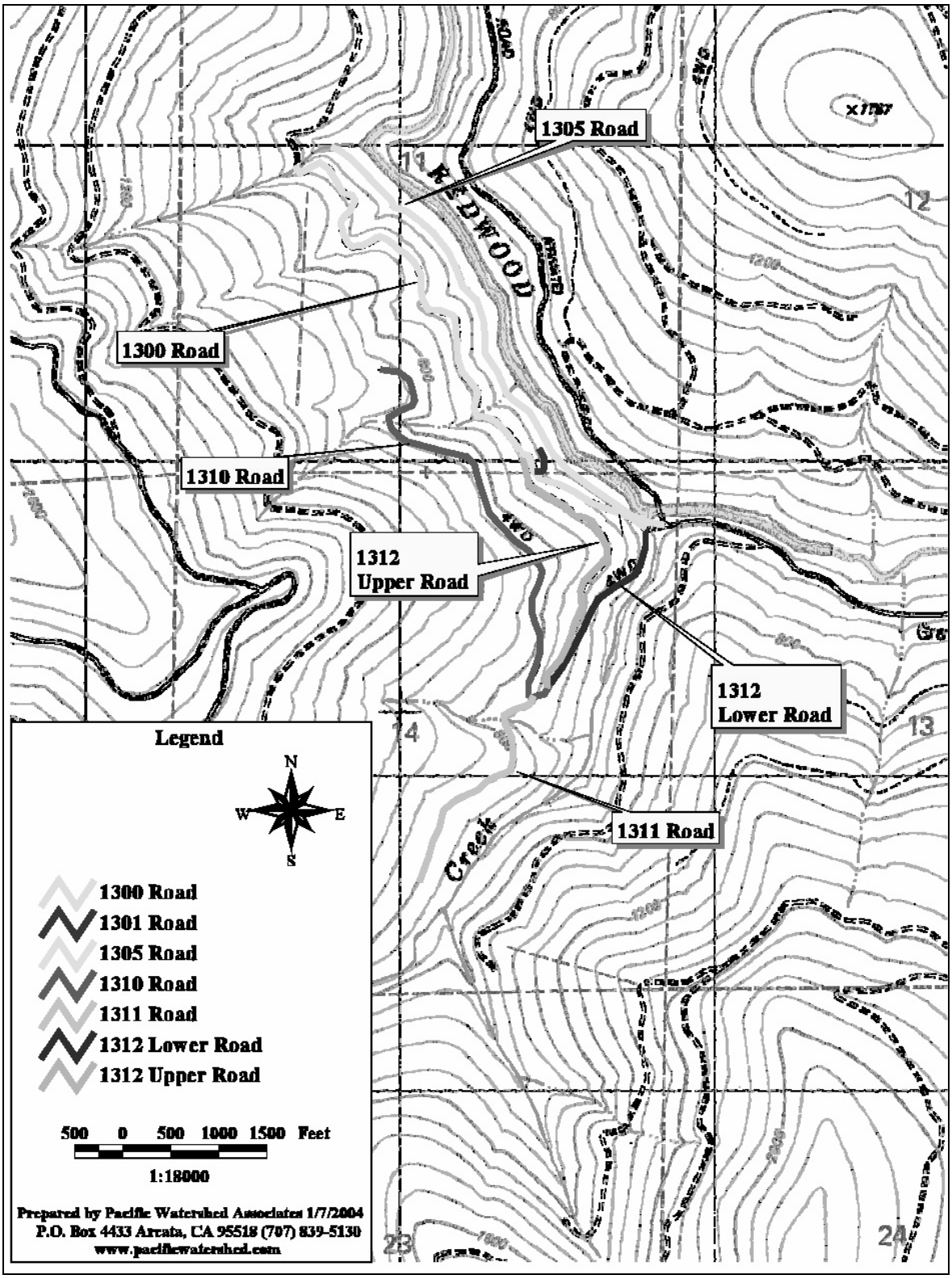

Figure X-D-2. Road location map Redwood Creek Road Decommissioning and Erosion Prevention Project Humboldt County, California.

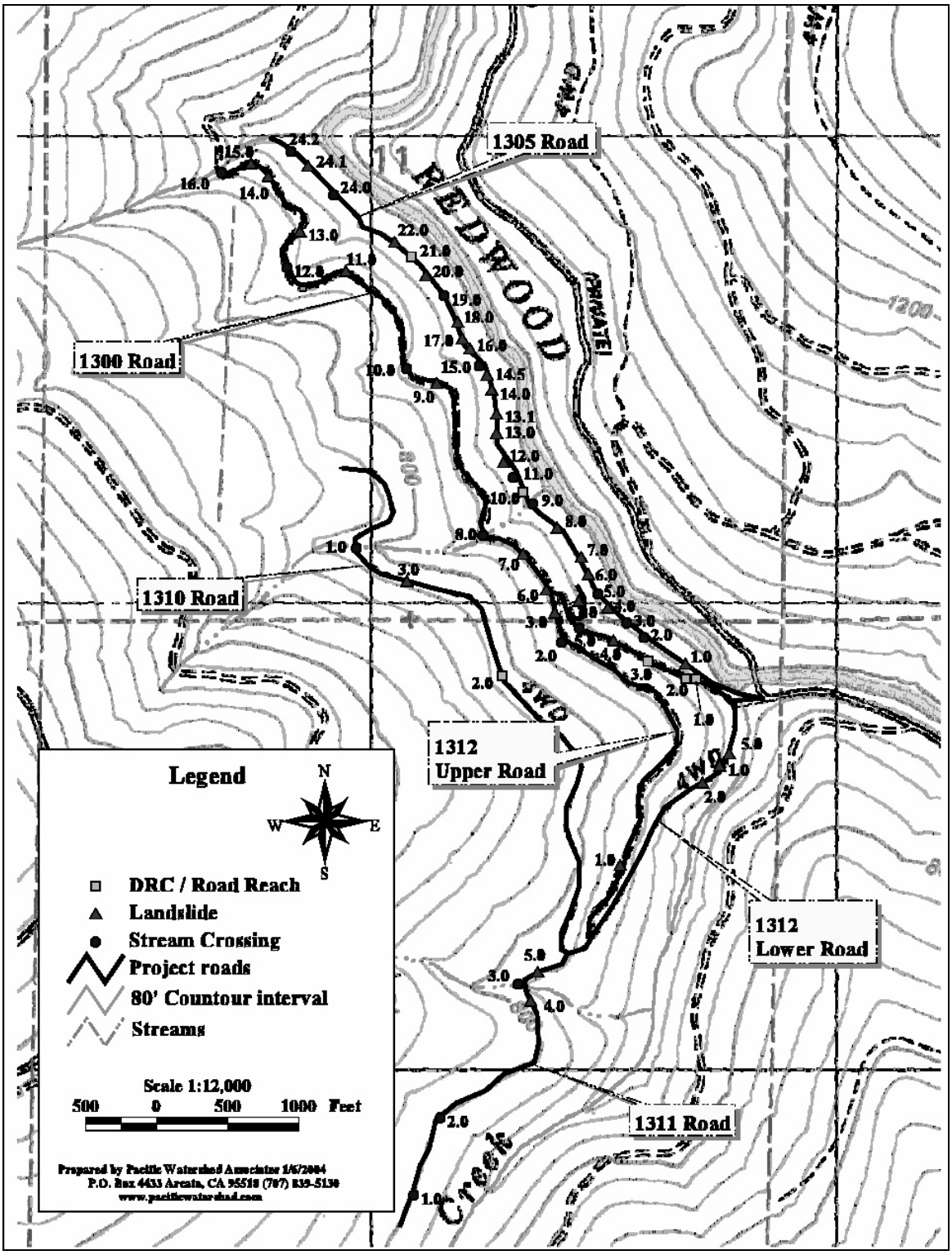

Figure X-D-3. Site location map, Redwood Creek Road Decommissioning and Erosion Prevention Project, Humboldt County, California.

This road decommissioning (closure) plan was aimed at old, abandoned high risk roads located within stream-side and inner gorge areas. Overall recommendations for the road reaches, as well as site-specific treatment prescriptions, were prepared for each road proposed for decommissioning. Only sites which would likely deliver sediment to a stream channel if left untreated were targeted for implementation.

General heavy equipment treatments for *road decommissioning* have been tested, described and evaluated elsewhere (Harr and Nichols 1993; Weaver and others 1987; Weaver and Sonnevil 1984; Weaver and Hagans 1994). Decommissioning essentially involves reverse road construction, except that full topographic obliteration of the road bed is not normally required to accomplish cost-effective sediment prevention goals. In order to protect the aquatic ecosystem, our goal was to hydrologically decommission the roads; that is, to minimize the adverse effect of the road on natural hillslope stability and watershed hydrology. From least intensive to most intensive, decommissioning included many of the following tasks[4]:

1. Road ripping or decompaction, in which the surface of the road or landing is "decompacted" or disaggregated using mechanical rippers. This action reduces surface runoff and often dramatically improves revegetation.

2. Cross-road drains, (deep waterbars) are installed at 50, 75, 100 or 200-foot intervals, or as necessary at springs and seeps, to disperse road surface runoff, especially on roads that are to be permanently or temporarily decommissioned. Cross-road drains are large ditches or trenches excavated across a road or landing surface to provide drainage and to prevent the collection of concentrated runoff on the former road bed. In some locations, such as stream-side zones, mild outsloping may be used instead of cross road drain construction.

3. In-place stream crossing excavation (IPRX) is a decommissioning treatment that is employed at locations where roads or landings were built across stream channels. The fill (including the culvert or Humboldt log crossing) is completely excavated and the original stream bed and side slopes are exhumed. Excavated spoil is stored at nearby stable locations where it will not erode, sometimes being pushed several hundred feet from the crossing by bulldozer tractor(s). A stream crossing excavation typically involves more than simply removing the culvert, as the underlying and adjacent fill material must also be removed and stabilized. Side slopes are excavated to about a 2:1 slope so that they can be mulched and seeded with minimal post-project erosion.

4. Exported stream crossing excavation (ERX) is a decommissioning treatment where stream crossing fill material is excavated and spoil is hauled off-site for storage. Spoil is moved farther up- or down-road from the crossing, due to the limited amount of stable storage locations at the excavation site. This treatment frequently requires dump trucks to endhaul spoil material to the off-site location.

5. In-place outsloping (IPOS) ("pulling the sidecast") calls for excavation of unstable or potentially unstable sidecast material along the outside edge of a road prism or landing, and

[4]Many of these and other erosion prevention and erosion control techniques are describe in the ➢Handbook for Forest and Ranch Roads (PWA, 1994)

placement of the spoil on the roadbed against the corresponding, adjacent cutbank, or within several hundred feet of the site. Placement of the spoil material against the cutbank usually blocks access to the road and is used in road decommissioning. In road upgrading, the excavated material can be used to build up the road bed and convert an insloped, ditched road to an outsloped road.

6. Exported outsloping (EOS) is comparable to in-place outsloping, except spoil material is moved off-site to a permanent, stable storage location. Where the road prism is very narrow, where there are springs along the road cutbank or where continued use of the road is anticipated, spoil material is typically not placed against the cutbank and material is endhauled to a spoil disposal site. This treatment frequently requires dump trucks to endhaul spoil material. This is typically a decommissioning treatment as part or all of the roadbed is removed.

Only in relatively few instances does hydrologic decommissioning have to include full recontouring of the original road bed. Typically, potential problem areas along a road are isolated to a few locations (perhaps 10% to 20% of the full road network to be decommissioned) where stream crossings need to be excavated, unstable landing and road sidecast needs to be removed before it fails, or roads cross potentially unstable terrain and the entire prism needs to be removed. Most of the remaining road surface simply needs permanently improved surface drainage, using decompaction, road drains and/or partial outsloping.

Certain road segments included in this proposal contained a high density of treatment sites and subsequent decommissioning work involved relatively large portions of the road bed. Successfully decommissioning most roads typically costs a fraction of complete or total topographic road obliteration. Costs are highly dependent on the frequency and nature of the potential erosion problems along the alignment. Specific hours and costs for the Redwood Creek decommissioning project are included on the attached data tables.

We have included profiles and cross sectional diagrams of selected sites. For the sake of simplicity, specific details and drawings for each sediment treatment site are not included with this report, but are available for review and evaluation. For each treatment site, there is a detailed field data form describing site conditions, risk of future erosion, and details of the proposed treatment. For all stream crossing sites, we have prepared sketch maps, as well as cross sections and profile surveys, and design drawings for the proposed excavation.

The specific erosion prevention plan for these routes includes (for each site recommended for treatment) the recommended treatment prescription, treatment specifications, needed materials and equipment (including heavy equipment), estimated equipment times (hours), needed labor, and estimated costs to complete the project. This implementation information was included in the data forms and actual heavy equipment hours have been detailed in the attached treatment tables. All treatments for specific sites, whether roads, road segments, or other specific sites, were discussed with the landowner and land manager to ensure they were in conformance with existing or future management plans for the watershed areas.

SCHEDULE OF WORK

This road decommissioning project was administered by the Pacific Coast Fish, Wildlife and Wetlands Restoration Association. Actual project design, layout, implementation and reporting was conducted under the supervision of Pacific Watershed Associates of McKinleyville, California. On-the-ground implementation (road decommissioning) work was performed in the summer of 2002 and 2003 (Table X-D-1). All heavy equipment work was completed during summer low flow periods when impacts to water quality could be minimized or avoided.

In July, August, September, October and November 2002, the 1300, 1301, 1305, 1310, 1312 Upper and the 1312 Lower Roads were treated for permanent closure. In June and July 2003, the 1311 Road was treated for permanent closure. These roads were located along, or crossed, the steep inner gorge slopes of Class 1 and Class 2 stream channels. Each road that was treated showed evidence of substantial past erosion, as well as considerable future potential for erosion and sediment delivery.

Road Number	Length (ft.)	Number of Sites Treated	Dates of Operation	Heavy Equipment Hours[1]		
				Excavator	Dozer	Dump Truck
1300 Road	6,178	16	July 24 – October 13 ,2002	298.5	308.5	349.5
1301 Road	475	1	October 8,2002	6.5	6.5	0
1305 Road	4,716	25	August 9 – September 18,2002	162	174.5	163
1310 Road	4,488	3	July 28 – July 30,2002	24	24	38
1311 Road	2,270	5	June 25 – July 21,2003	192	109.25	115.25
1312 Upper Road	3,010	3	October 10 – November 5,2002	122	121.5	163.75
1312 Lower Road	1,742	3	September 18 – October 15,2002	31.5	33	2
Total	**22,879**	**56**	**July 23 – November 5,2002and June 25 – July 21,2003**	**836.5**	**777.25**	**831.5**

[1] Equipment hours do not include road opening and development of off-site spoil disposal areas.

Table X-D-1. Equipment work schedule and hours, Redwood Creek Decommissioning 2002-2003.

IMPLEMENTATION

Mike McDonald Construction of Trinity Center, CA was the primary equipment operator for the project area and McCullough Construction of Salyer, CA was the secondary equipment operator for the project area. Mike McDonald Construction carried out treatments using a CAT 325C hydraulic excavator, CAT D-6 high track bulldozer, 10 yd^3 dump trucks, and a CAT 22 yd^3 off-highway dump truck. McCullough Construction carried out treatments using a Komatsu hydraulic excavator, Komatsu (D-7 equivalent) bulldozer and several 10 yd^3 dump trucks (Table X-D-1). The excavators were used to: 1) open access to each site (brushing and filling of gullies), 2) excavate soil and organic debris (logs and chunks) from the stream crossings, 3) place small

volumes of excavated spoil on stable slopes near the decommissioned stream crossings, 4) decompact (rip) the road roadbed between stream crossing locations (especially if fill was to be stored on the old road surface), 5) outslope the old road bed between sites, 6) "mulch" the treated road with logs, limbs and brush and 7) construct cross-road drains on the decommissioned roads.

The bulldozer was used to help reconstruct the roads and stream crossings for access by the dump trucks, to push excavated material to nearby disposal sites, to work off-site spoil disposal sites where excavated material was dumped and to rip (decompact) old road surfaces. Up to three 10 yd^3 dump trucks were used to haul excavated spoil from the inner gorge stream crossing sites to stable storage areas.

Two separate equipment crews treated sections of seven roads in Redwood Creek (Figure X-D-2 and Figure X-D-3). Because the roads had not been used for some time, it was estimated that 91 hours of excavator and dozer time would be required to open the seven road reaches treated in this project. A total of fifty-six (56) sites were treated along 4.4 miles of road surface (Table X-D-1).

The original inventory identified 20 stream crossings, 31 landslides and 8 other sites that were all in need of treatment. By the time the project was undertaken in 2002, three sites were removed (one road fill landslide and two washed out stream crossings on the 1305 Road) from the proposed work area. The three sites (24.1, 24.2 and 25) occurred along the last 300' of the 1305 Road. It was determined that the risk of sediment production caused by road opening and backfilling the washed out stream crossings would be greater than maintaining abandonment of the road segment. The predicted heavy equipment hours, actual heavy equipment hours and predicted excavation volumes for each treatment site are detailed at the end of this report.

It was estimated that 44,287 yds^3 of sediment would have to be excavated from the original 59 work sites identified in the initial road inventory, and that treatment of these sites would prevent the delivery of 26,425 yds^3 of sediment to Redwood Creek. Actual excavation volumes differ due to the removal of work sites by the time implementation was conducted in 2002 and due to an enlarged excavation on one stream crossing (see deviations from the original work plan). Because much of the excavated sediment was stored locally, it was not possible to determine the exact volume of material that was moved during the project.

Table X-D-2 describes the types and number of sites that were originally proposed for treatment on each road segment, as well as a general description of each decommissioned road. Landslide sites included road fill failures and instabilities, cutbank slides, hillslope slumping and large rotational slides. Stream crossings included culverted and unculverted crossings as well as Humboldt log crossings.

The 1300 Road contours along the left bank/inner gorge hillslope of Redwood Creek (Figure X-D-2). This abandoned road varies from approximately 150' – 750' above mainstem Redwood Creek and crosses five class 2 and class 3 streams that drain directly to Redwood Creek. The initial inventory identified five stream crossings, eight potential road fill landslides and three other sites. The five stream crossings that were decommissioned empty directly into Redwood

Creek. All sites on this road were straight forward, were treated as originally prescribed and equipment hours were relatively close to the original estimates.

A total of 6,178 feet of road length with 16 sites were treated on the 1300 Road. This took the equipment crew 32 working days and approximately 299 hours for the excavator, 309 hours for the dozer and 350 hours for dump trucks, not including all time necessary for road opening and clearing of spoil sites. All decommissioned stream crossings were seeded and straw mulched to help inhibit surface erosion.

The 1301 Road is located just off the 1300 Road near site # 5 (Figure X-D-2). This abandoned road is a 475 feet spur with a terminal landing. Only one potential road fill landslide site was identified during the initial road inventory. This site exhibited active scarps with up to 3 feet of vertical displacement and up to12 feet back from the outboard fill, perched on 70% slopes 20 feet above a Class 2 stream channel. The site was treated as originally prescribed and equipment hours were relatively close to the original estimates.

The 1305 Road contours directly above the left stream bank of Redwood Creek (Figure X-D-2). This abandoned road varies from approximately 30 to 75 feet above mainstem Redwood Creek and crosses ten Class 2 and Class 3 streams that drain directly to Redwood Creek. The initial inventory identified ten stream crossings, fourteen potential road fill landslides and four other sites. This road exhibited nearly continuous fillslope instabilities along most of the road length with the exception of the northern-most 500 feet. Most sites on this road were straight forward, were treated as originally prescribed and equipment hours were relatively close to the original estimates. One noted exception to the initial treatment plan was the elimination of three sites from the proposed work. As previously mentioned, it was determined that the risk of sediment production caused by road opening and backfilling of the washed out stream crossings would be greater than simply leaving the sites untreated.

A total of 4,716 feet of road length with 25 sites were treated on the 1305 Road. This took the equipment crew 28 working days and approximately 162 hours for the excavator, 175 hours for the dozer and 163 hours for dump trucks. All decommissioned stream crossings were seeded and straw mulched to help inhibit surface erosion.

Road Number (site list)	Location	Road Description	Number of sites of future sediment delivery (#)		
			Stream Crossing	Landslides	Other
1300 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16)	Redwood Creek	Abandoned road contours along left side of Redwood Creek and parallels above 1305 Road. Multiple medium size culverted and Humboldt stream crossings actively eroding and delivering sediment to Redwood Creek. Road exhibited multiple fillslope instabilities with potential sediment delivery.	5	8	
1301 (1)	Redwood Creek	Short 475 foot spur road with terminal landing. One Potential road fill failure perched directly above left approach of site # 5 on 1300 Road.	0	1	0
1305 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 13.1, 14, 14.5, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 24.1, 24.2)	Redwood Creek	Abandoned stream-side road contours directly above the left bank of Redwood Creek. Road averages 30' – 75' above Redwood Creek at bankfull level. Multiple small, poorly culverted, actively eroding Humboldt crossings and nearly continuous road fill failure problems.	10	14	4
1310 (1, 2, 3)	Redwood Creek	Abandoned road contours along left hillslope of Redwood Creek and parallels above 1312 and 1300 Roads. Relatively low gradient (30-45%) hillslope setting. One washed out stream crossing, one potential road fill failure in a headwater swale setting and one road reach / DRC delivery location on this road.	1	1	1
1311 (1, 2, 3, 4, 5)	Panther Creek	Abandoned inner gorge road contours along left hillslope 600' – 800' above Panther Creek. Several medium sized culverted stream crossings, one enormous eroding Humboldt stream crossing and several potential road fill failures perched above site # 3 on this road.	3	2	0
1312 Upper (1, 2, 3)	Panther and Redwood Creeks	Short abandoned tie road contours along left hillslope of Redwood and Panther Creeks. Road parallels above 1312 Lower and 1300 Roads. One very large potential road fill failure, one medium sized eroding stream crossing and one smaller potential road fill failure on this road.	1	2	0
1312 Lower (1, 2, 5)	Panther Creek	Abandoned inner gorge road contours uphill along left hillslope 200' – 500' above Panther Creek. Road exhibited nearly continuous fillslope instabilities and one very large past debris slide taking out 250' road prism width.	0	3	0
Total			**20**	**31**	**8**

Table X-D-2. 2002-2003 Decommissioned sites for Redwood Creek – 1300 roads.

The 1310 Road is located along the left hillslope of Redwood Creek (Figure X-D-2). This abandoned road parallels above the 1300 Road and is located along a gentler hillslope setting.

The initial inventory identified one washed-out stream crossing, one potential road fill failure and one road reach / DRC delivery location. This road segment was less critical and exhibited lower potential for future sediment delivery. The sites on this road were straight forward, were treated as originally prescribed and equipment hours were relatively close to the original estimates.

A total of 4,488 feet of road length with 3 sites were treated on the 1310 Road. This took the equipment crew 3 working days and approximately 24 hours for the excavator, 24 hours for the dozer and 38 hours for dump trucks.

The 1311 Road contours along the left bank / inner gorge hillslope of Panther Creek (Figure X-D-2). This abandoned road varies from approximately 500 to 700 feet above mainstem Panther Creek and crosses three Class 2 and Class 3 streams that drain directly to Panther Creek. The initial inventory identified three stream crossings and two potential road fill landslide sites. Four out of five sites on this road were straight forward, were treated as originally prescribed and equipment hours were relatively close to the original estimates.

Site # 3 on the 1311 Road turned out to be the noted exceptional site in the project area. This site was a large Class 2 Humboldt stream crossing with active collapsing fill and decomposing logs backed up by large sediment deposits and flanked on the left and right approaches by future road fill failures (sites 4 & 5). This site was a chronic sediment producer and had a very large future potential yield. The initial inventory estimated this site to have a future delivery of 1,868 yds^3 and an excavation volume of 3,481 yds^3. Upon further field review and volumetric analysis it was determined that the actual volumes were much larger. The estimated excavation volume for this site was 9,413 yds^3 and the revised potential future delivery prior to excavation was 4,750 yds^3. These volumes are reflected in Table X-D-3.

A total of 2,270 feet of road length with 5 sites were treated on the 1311 Road. This took the equipment crew 23 working days and approximately 192 hours for the excavator, 109 hours for the dozer and 115 hours for the 22 yd^3 dump truck. All decommissioned stream crossings were seeded and straw mulched to help inhibit surface erosion.

The 1312 Upper & Lower Roads are located along the left bank / inner gorge hillslope of Panther and Redwood Creeks (Figure X-D-2). The initial inventory identified one stream crossing and five potential road fill landslide sites. The 1312 Lower Road exhibited nearly continuous fillslope instabilities as well as one large past debris slide that removed the entire road prism for 250 feet. The 1312 Upper Road had one medium sized stream crossing, one minor potential road fill failure and one very large potential road fill failure. The sites on these roads were straight forward, were treated as originally prescribed and equipment hours were relatively close to the original estimates.

Treatment Category	Sites to Treat[1] (#)	Cross Road Drains (#)	Total Volume Excavated[2] (yds^3)	Volume Sediment Saved[3] (yds^3)	Cost Effectiveness[4] ($/$yds^3$ saved)	Total Project Costs[5] ($)
Proposed	59	26	44,287	26,425	11.91	314,809
As Built	56	67	49,488	28,954	11.90	344,520

[1] Three sites were eliminated from the project. Reasons specified in the report.
[2] Total volume excavated increased from the proposed estimate. Site # 3, 1311 Road, stream crossing excavation volume was significantly larger than the original estimate. Excavation volumes from sites 24, 24.1 and 24.2 on the 1305 Road were removed from the "As Built" figure.
[3] Total volume of sediment saved increased from the proposed estimate due to a post inventory volume revision of site # 3, 1311 Road. Future erosion volumes from sites 24, 24.1 and 24.2 on the 1305 Road were removed from the "As Built" figure.
[4] Cost effectiveness increased slightly from the proposed estimate due to the volume of sediment saved and total project costs changing.
[5] Total project costs includes all equipment and labor time, materials, subcontractor costs, project management and overhead (all costs included). Simpson Resource Company provided a $129,836 cost share. National Park Service provided a $20,000 cost share. CDF&G grant monies provided $184,809 + $9,875.

Table X-D-3. Deviations from the original proposed treatment plan, Redwood Creek Road Decommissioning Project – 1300 roads.

A total of 4,752 feet of road length with 6 sites were treated on the 1312 Upper & Lower Roads. This took the equipment crew 25 working days and approximately 154 hours for the excavator, 155 hours for the dozer and 166 hours for dump trucks. The decommissioned stream crossing was seeded and straw mulched to help inhibit surface erosion.

COSTS

Total costs were broken down for the entire project area, based on cost categories listed (Table X-D-4). Rates for equipment were as follows: excavator $125/hr and $110/hr, dozer $95/hr and $90/hr, 10 yd^3 dump trucks $65/hr and $60/hr, 22 yd^3 dump truck $130/hr and labor $21/hr. Costs in Table X-D-4 include all road opening and equipment mobilization time. It also reflect costs for straw, seed, administrative overhead and technical oversight, which includes general layout, heavy equipment oversight and monitoring, plot documentation, resurveying and reporting. Total inclusive costs for decommissioning these seven roads in the Redwood Creek watershed was approximately $344,520.

DEVIATIONS FROM THE ORIGINAL WORK PLAN

Table X-D-3 shows specific deviations from the original proposed treatment plan. These deviations were caused by a variety of factors but generally because it was determined that the project would benefit if these changes were made (i.e.; reduced future erosion at stream crossing sites where excavation volumes enlarged and decreased surface runoff on road reaches due to construction of additional cross road drains). It should be expected that as work is being implemented some variation from the original work plan is necessary to accommodate unforeseen complications. The variations that were made to the original work plan were motivated by improving the overall effectiveness of the project and to reduce the likelihood of future erosion and sediment delivery.

Cost Category	Total Hours	Cost Rate[1] (average $/hr)	Total Costs ($)
Personnel Costs			
Project Manager	250	30	7,500.00
Heavy Equipment Costs			
Excavator	1,134.25	119	134,581.25
Dozer	1,078.75	93	100,068.75
10 yd^3 Dump Truck	916	61	55,688.00
22 yd^3 Dump Truck	115.5	130	15,047.50
Water Truck	28.5	55	1,567.50
Low-Boy Transport	17	82	1,401.50
Truck and Trailer	8	30	240.00
Subcontractor Costs			
Sub Labor	182	21	3,831.00
Sub Technical Oversight, Layout and Reporting	355	50	17,750.00
Mulch, Seed and Erosion Control Materials			3,356.79
Administrative Overhead @ 1.023%			3,487.71
Total Project Costs			**344,520**
Estimated Sediment Savings: 28,954 yds^3			
Overall Project Cost-Effectiveness: $ 11.90 / yd^3 saved			

[1] Cost rates listed are averages. Within several equipment categories different rates were billed for different pieces of equipment.

Table X-D-4. Total costs for road-related erosion control and erosion prevention work on all sites in the Redwood Creek Road Decommissioning Project – 1300 roads.

MONITORING

Before the project commenced, photo point stations were established for many of the project work sites. These photo points were used to document the work sites before, during and following the excavation. Examples of before and after photo point shots have been included in the report to depict excavated stream crossings, landslides and outsloped roads in the Redwood Creek Road Decommissioning Project.

Each decommissioned stream crossing was surveyed prior to treatment and re-evaluated after equipment had completed excavation work. A select number of representative decommissioned stream crossings were re-surveyed following equipment operations. depicts surveyed profiles and cross sections of three stream crossings. Also, a typical pre- and post-excavation road profile of a landslide excavation was surveyed at site # 7 on the 1300 Road. The plotted surveys show the original ground profile, the design profile and the as built profile that was surveyed following heavy equipment excavation work at the three sites. Each of the stream crossings have been excavated to a stable longitudinal and cross sectional profile.

CONCLUSION

The expected benefit of completing the erosion control and prevention work lies in the reduction of long term sediment delivery to Redwood Creek and Panther Creek, important salmonid

streams. The purpose of this project was to permanently reduce the amount of sediment that could have eroded and been delivered to Redwood Creek and its tributaries. It is estimated that over 49,000 cubic yards of material was excavated in this project. This volume includes the volume that was endhauled to spoil disposal sites as well as excavated material that was stored locally on-site. In the initial inventory, it was estimated that approximately 26,425 yds^3 of sediment had a high potential to deliver to Redwood Creek and Panther Creek.

With the extensive restoration of these 56 specific sites a significant amount of sediment that once threatened these salmon bearing streams no longer poses a threat. Although it is difficult to assess the immediate benefits of the decommissioning project to fish habitat, the lasting benefit of removing over 49,000 cubic yards of material, and preventing the delivery of over 28,954 yds^3 to the Redwood Creek system should help promote habitat recovery over the next several decades.

PROJECT LOCATION DIRECTIONS AND LANDOWNER ADDRESS

The project area can be reached by the following directions. From Arcata, California travel east on highway 299 for 5 miles and take the “Blue Lake” exit. Continue east for 3 miles to “Korbel” lumber mill. Take a left at the first guard station and continue through the lumber mill to the K & K Road. On the K & K Road travel northwesterly for 14 miles to the mouth of Panther Creek. Park here and cross the foot bridge over Panther Creek. At this location is the intersection of the 1312 Lower Road and 1300 Road in the project area.

Landowner address:
Simpson Resource Company
PO Box 68
Korbel, CA 95550

REFERENCES

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Weaver, W.E., D.K. Hagans and M.A. Madej. 1987. Managing forest roads to control cumulative erosion and sedimentation effects. In: Proc. Of the California watershed management conference, Report 11 (18-20 Nov. 1986, West Sacramento, Calif.), Wildland Resources Center, Univ. of California, Berkeley, California. 6 pages.

Weaver, W.E. and R.A. Sonnevil. 1984. Relative cost-effectiveness of erosion control for forest land rehabilitation, Redwood National Park. In: Erosion Control…Man and Nature, Proceedings of Conference XV, Intl Erosion Control Assoc, Feb 23-24, 1984, Denver, CO. pages 83-115.

Erosion Prevention Implementation Results, 2002-2003 Road Decommissioning Project, Redwood Creek Watershed

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	DRC	4	4	4	4	0	0	431	0
2	DRC	4	7	4	7.5	0	0	100	0
3	DRC	6	13	6	12.5	0	0	150	0
4	Landslide	3	8	3	8	6	0	256	0
5	Crossing	8	51	8	55	8	2	390	
6	Landslide	23	29.5	23	29.5	46	59	2599	182
7	Landslide	4	29.5	4	29.5	8	49	311	152
8	Crossing	6	14	6	14	12	28	279	84
9	Landslide	8	14	8	14	8	17	833	54
10	Crossing	75	44.5	75	44.5	75	85.5	2538	262
11	Landslide	12	10	12	10	12	20	1426	30
12	Crossing	14	17	14	17	28	32	698	
13	Landslide	3	6	3	6	0	12	291	
14	Landslide	16	20.5	16	20.5	32	41	1574	
15	Landslide	10	10.5	10	10.5	20	0	925	0
16	Crossing	61	20	61	26	122	4	2438	
Subtotal – 1300 Rd		257	298.5	257	308.5	377	349.5	15239	764

[1] Hours included only for site specific treatment and not for road reaches between sites, road opening or clearing and grubbing.
[2] Predicted equipment hours listed do not include "logistics" hours.
[3] Fields left blank indicate no operator record was kept for the number of dump truck loads removed. On the 1311 Road a 20 yd^3 off-highway dump truck was used instead of standard 10 yd^3 dump trucks.

Table X-D-5. Decommissioning data for the 1300 Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Landslide	5	6.5	5	6.5	0	0	324	0
Subtotal – 1301 Rd.		5	6.5	5	6.5	0	0	324	0

Table X-D-6. Decommissioning data for the 1301 Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Landslide	11	4	11	4	0	0	1460	0
2	Crossing	5	20.5	5	34.5	0	0	366	0
3	Crossing	4	2.5	4	1	0	0	207	0
4	Landslide	8	8.5	8	8.5	16	0	900	0
5	Crossing	2	3.5	2	3.5	0	0	54	0
6	Landslide	3	4	3	4	0	0	277	0
7	Landslide	4	3	4	3	0	0	388	0
8	Landslide	6	11.5	6	11.5	12	0	574	0
9	Crossing	7	11	7	11	14	11	359	25
10	Road Reach	5	5	5	5	10	5	527	20
11	Crossing	6	18	6	18	0	16	379	65
12	Landslide	2	5	2	5	0	8	111	28
13	Landslide	6	4	6	4	0	8	711	32
13.1	Landslide	2	4	2	4	0	8	138	16
14	Landslide	4	6	4	6	0	9	438	40
14.5	Landslide	4	4	4	4	8	8	402	16
15	Crossing	4	10	4	10	8	20	157	40
16	Landslide	3	7	3	7	6	14	277	30
17	Landslide	4	4	4	4	8	8	324	19
18	Landslide	8	3	8	3	16	6	850	21
19	Crossing	2	7	2	7	4	14	74	43
20	Landslide	9	6	9	6	0	12	1283	30
21	DRC	4	2.5	4	2.5	0	0	381	0
22	Landslide	3	4.5	3	4.5	0	9	267	20
23	Road Reach	2	3.5	2	3.5	0	7	100	30
24	Crossing	8	0	8	0	0	0	429	0
24.1	Landslide	2	0	2	0	0	0	111	0
24.2	Crossing	3	0	3	0	0	0	191	0
Subtotal – 1305 Rd.		131	162	131	174.5	102	163	11,735	475

Table X-D-7. Decommissioning data for the 1305 Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Crossing	13	10	13	10	26	20	648	
2	DRC	8	8	8	8	0	6	200	
3	Landslide	5	6	5	6	10	12	407	
Subtotal – 1310 Rd		26	24	26	24	36	38	1255	

Table X-D-8. Decommissioning data for the 1310 Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Crossing	10	24.5	10	0	0	3	962	18
2	Crossing	4	5.5	4	0	0	0	248	0
3	Crossing	78	148	78	103.25	0	102.25	4981	529
4	Landslide	4	8	4	0	8	4	941	20
5	Landslide	3	6	3	6	0	6	419	37
Subtotal – 1311 Rd		99	192	99	109.25	8	115.25	7551	604

Table X-D-9. Decommissioning data for the 1311 Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Landslide	51	113.5	51	113.5	102	163.75	3824	410
2	Crossing	6	5.5	6	5	6	0	271	0
3	Landslide	3	3	3	3	3	0	292	0
Subtotal – 1312U Rd		60	122	60	121.5	111	163.75	4387	410

Table X-D-10. Decommissioning data for the 1312 Upper Road Redwood Creek Watershed, Humboldt County, California.

Site #	Site type[1]	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
1	Landslide	5	2.5	5	2.5	15	0	620	0
2	Landslide	9	14.5	9	16	9	2	1083	8
5	Landslide	14	14.5	14	14.5	28	0	2093	0
Subtotal – 1312L Rd		28	31.5	28	33	52	2	3796	8

Table X-D-11. Decommissioning data for the 1312 Lower Road Redwood Creek Watershed, Humboldt County, California.

Heavy Equipment Work	Predicted Excavator Hrs[2]	Actual Excavator Hrs	Predicted Dozer Hrs[2]	Actual Dozer Hrs	Predicted Dump truck Hrs[2]	Actual Dump Truck Hrs	Predicted Excavated Volume (yds^3)	Dump truck loads removed[3]
Totals	606	836.5	606	777.25	686	831.5	44,287	2,261

Table X-D-12. Decommissioning data for the Redwood Creek Watershed, Humboldt County, California.

Selected Photo-point Photos of the 2002-2003 Redwood Creek Road Decommissioning Project

Figure X-D-4. Site #8, 1300 Road, before excavation.
This picture was taken just above the top of the stream crossing, looking downstream. This Humboldt crossing has been brushed out and is ready to be excavated

Figure X-D-5. Site #8, 1300 Road, after excavation. This picture was taken from the same viewpoint as above. The stream crossing has been excavated, mulched and seeded. See same view below after heavy rainfall (Figure X-D-6).

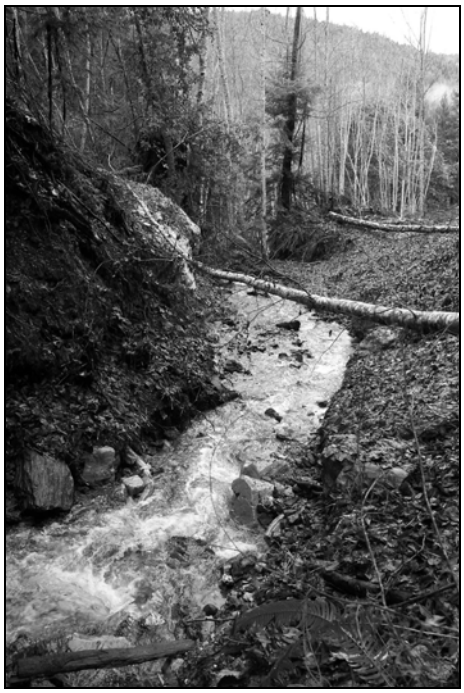


Figure X-D-6. Site # 8, 1300 Road, after excavation. Same viewpoint as Figure X-D-4 during heavy rainfall event.

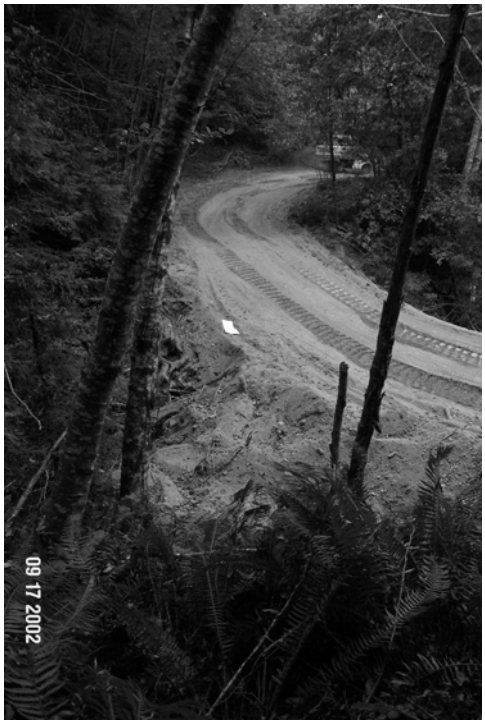


Figure X-D-7. Site #8, 1300 Road, before excavation. Picture taken 30 feet up the right bank, near the right hinge line of this stream crossing. The stream crossing has been excavated, mulched, and seeded. Note location of the two trees for reference.

Figure X-D-8. Site # 8, 1300 Road, after excavation. This picture (and Figure X-D-7) was taken 30 feet up the right bank, near the right hinge line of this stream crossing. The stream crossing has been excavated, mulched and seeded. Note location of the two trees for reference.

Figure X-D-9. Site # 12, 1300 Road, before excavation. This picture was taken 20 feet above the top of the stream crossing and along the left bank, looking downstream. The stream crossing has been brushed out and is ready to be excavated.

Figure X-D-10. Site #12, 1300 Road, after excavation. This picture was taken from the same viewpoint as Figure X-D-9. The stream crossing has been excavated, mulched and seeded. Upon excavation it was determined that the original watercourse meandered to the right prior to entering the Bot. Armor was placed along the left bank to prevent stream bank erosion (see arrow).

Figure X-D-11. Site #10, 1305 Road, during excavation. A potential road fill landslide was excavated at this site. Unstable outboard road fill was excavated and endhauled to a stable storage location, creating an outsloped road surface (see Figure X-D-12).

Figure X-D-12. Site #10, 1305 Road, after excavation. This picture was taken from the same viewpoint as Figure X-D-11. The unstable road fill has been completely excavated, mulched and seeded, leaving an outsloped road surface. Because this road exhibited nearly continuous road fill instabilities, a similar nature of treatments were applied to the remaining road, along with stream crossing excavations.

Figure X-D-13. Site # 11, 1305 Road, before excavation. This picture was taken 30 feet above the top of the stream crossing and along the left bank, looking downstream. The stream crossing has been brushed out and is ready to be excavated. A large "Humboldt" log is visible just left of the mossy alder tree in the right-center portion of the picture (see arrow).

Figure X-D-14. Site #11, 1305 Road, after excavation. This picture was taken from the same viewpoint asX-D-13. The stream crossing has been excavated, mulched and seeded. See same view below after heavy rainfall (Figure X-D-15).

Figure X-D-15. Site # 11, 1305 Road, after excavation. This picture was taken from the same viewpoint as above (Figure X-D-13 and Figure X-D-14) during a heavy rainfall event. Note the stream channel bed has developed a self armoring "lag" deposit during the first season's rainfall. Redwood Creek is in the background.

Figure X-D-16. Site # 13, 1305 Road, before excavation. A potential road fill landslide was excavated at this site. Unstable outboard fill was excavated and endhauled to a stable storage location, creating an outsloped road surface (see Figure X-D-17).

Figure X-D-17. Site #13, 1305 Road, after excavation. This picture was taken from the same viewpoint as Figure X-D-16. The unstable road fill has been completely excavated, mulched and seeded, leaving an outsloped road surface. In the background is one of the main spoil sites for this road. The sloped surface can be seen extending up above the old road bench (see arrows).

Figure X-D-18. Site #3, 1311 Road, before excavation. This is a 3 shot panoramic compilation photo taken from the cutbank on the right approach to this Humboldt stream crossing. The site has been brushed out and a temporary flex pipe has been installed along the right hinge line to divert active flow around the work area.

Figure X-D-19. Site # 3, 1311 Road, after excavation. This is a 2 shot panoramic compilation photo taken from near the same location as the previous picture. The site has been completely excavated, large woody debris removed from the fill during the excavation has been redistributed along the stream crossing slopes and seed & mulch has been applied to the bare slope areas.

Figure X-D-20. Site # 3, 1311 Road, during excavation. This picture was taken near the Bot of the stream crossing. The picture view is looking upstream with the outboard edge of the road in the upper center portion of the photo. Some fill has been excavated from the outboard edge of the road downslope towards the Bot and a swath of brush as been cleared to the Bot, in preparation for continued excavation.

Figure X-D-21. Site # 3, 1311 Road, after excavation. This picture was taken near the same location as the previous photo. The stream crossing has been excavated and an abundance of woody debris has been redistributed along the banks and the channel.

Figure X-D-22. Site #3, 1311 Road, after excavation. This picture was taken from near the Top looking downstream.

Figure X-D-23. Site #3, 1311 Road, after excavation. This picture was taken from near the right bank looking upstream.

Figure X-D-24. Site # 2, 1312 Lower Road, before excavation. A potential road fill landslide was excavated at this site. Unstable outboard road fill was excavated and stockpiled locally along the cutbank behind the site, creating an outsloped road surface (see below).

Figure X-D-25. Site # 2, 1312 Lower Road, after excavation. This picture was taken from the same viewpoint as above. The unstable road fill has been completely excavated, mulched and seeded, leaving an outsloped road surface. Note trees and brush removed during excavation have been used a ground surface mulch. Panther Creek (not visible in photo) is located to the right.

Figure X-D-26. Site # 5, 1312 Lower Road, before excavation. A potential road fill landslide was excavated at this site. Unstable outboard road fill was excavated and stockpiled locally along the cutbank behind the site, creating an outsloped road surface (see below).

Figure X-D-27. Site # 2, 1312 Lower Road, after excavation. This picture was taken from the same viewpoint as above. The unstable road fill has been completely excavated. Straw mulch and seed had not yet been spread in this picture (note straw bales near former cutbank).

Selected Pre- & Post-excavation Profiles and Cross Sections of the 2002-2003 Redwood Creek Road Decommissioning Project

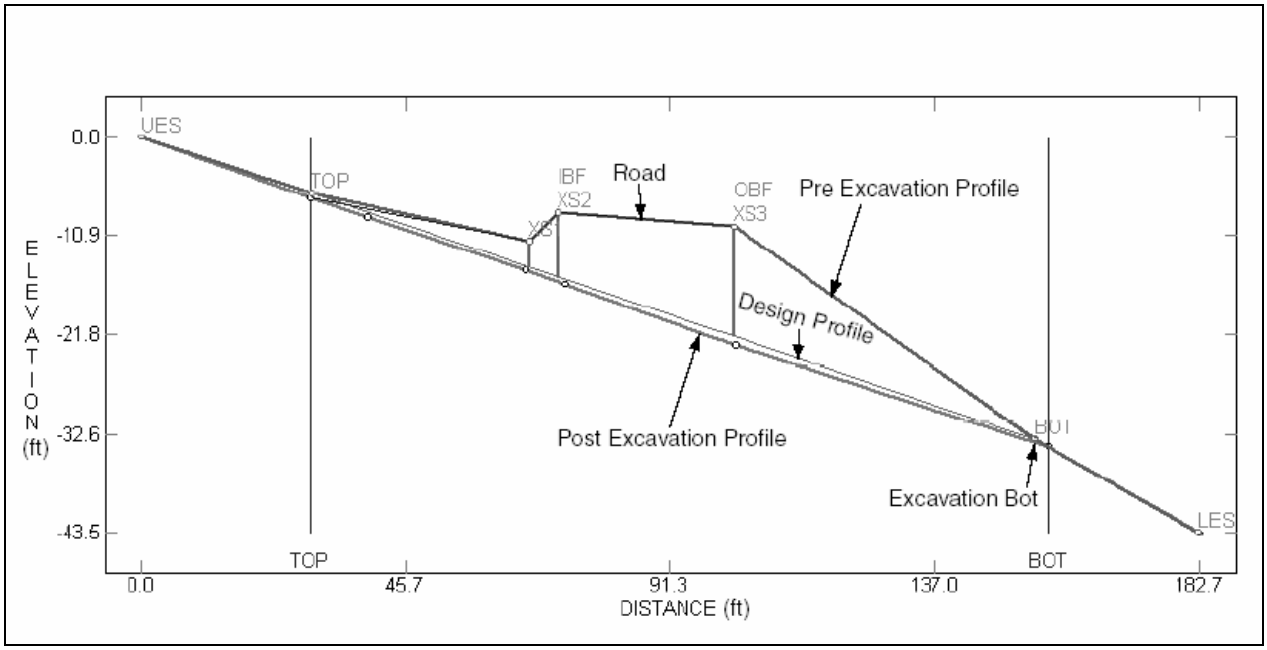


Figure X-D-28. Redwood Creek 1300 Road Site #12 – Stream Crossing Pre & Post Excavation Profiles.

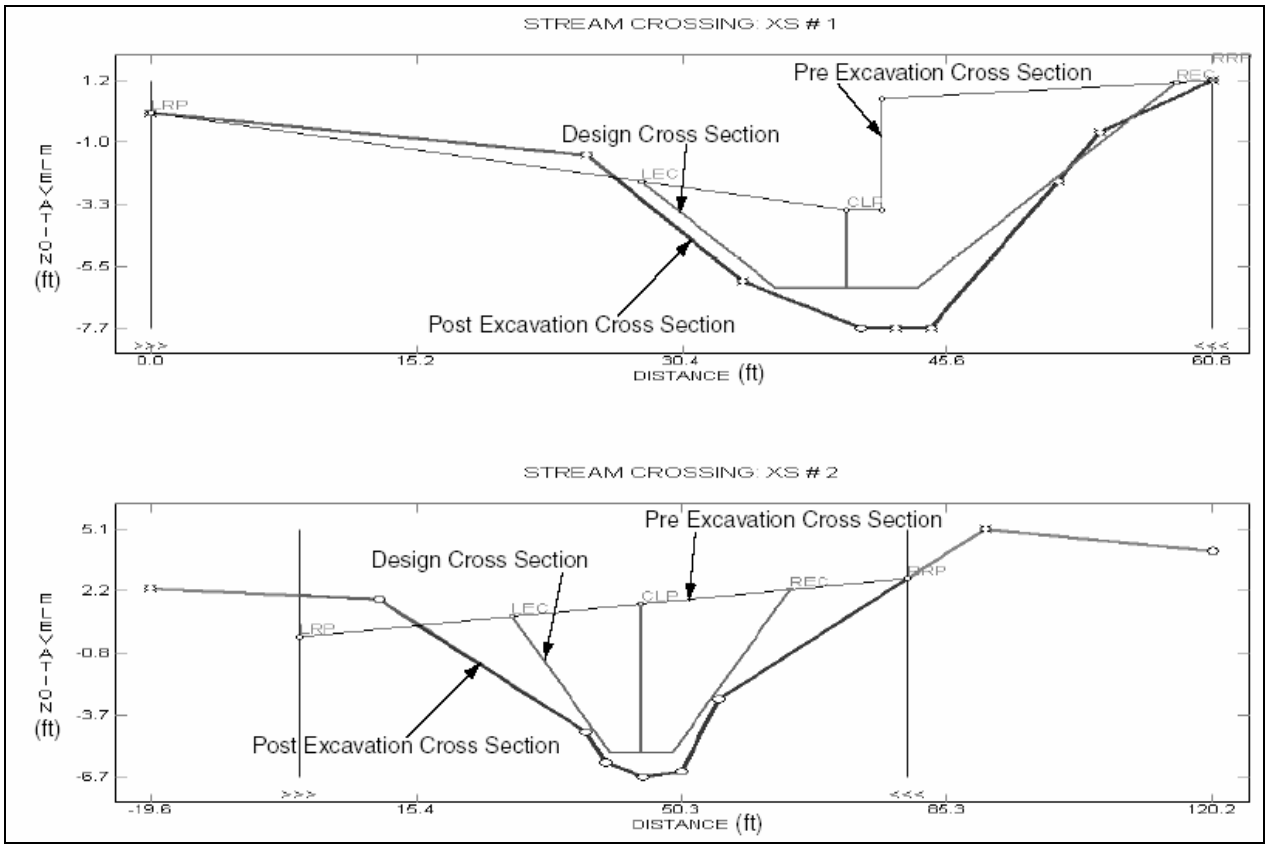


Figure X-D-29. Redwood Creek 1300 Road Site #12 – Stream Crossing Pre & Post Excavation Cross Sections.

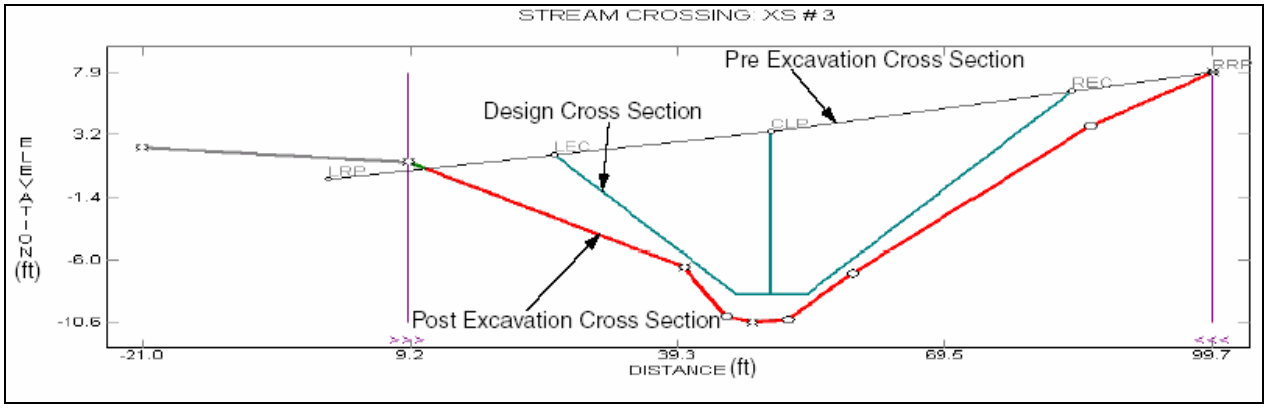


Figure X-D-30. Redwood Creek 1300 Road Site #12 – Stream Crossing Pre & Post Excavation Cross Sections.

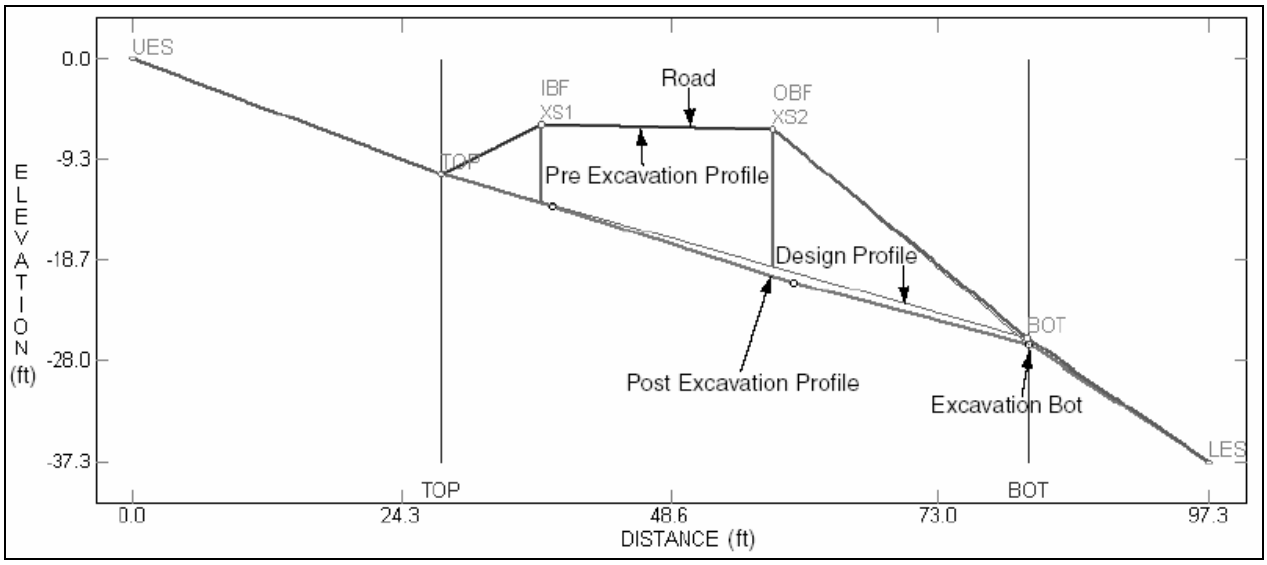


Figure X-D-31. Redwood Creek 1305 Road Site #11 – Stream Crossing Pre & Post Excavation Profiles.

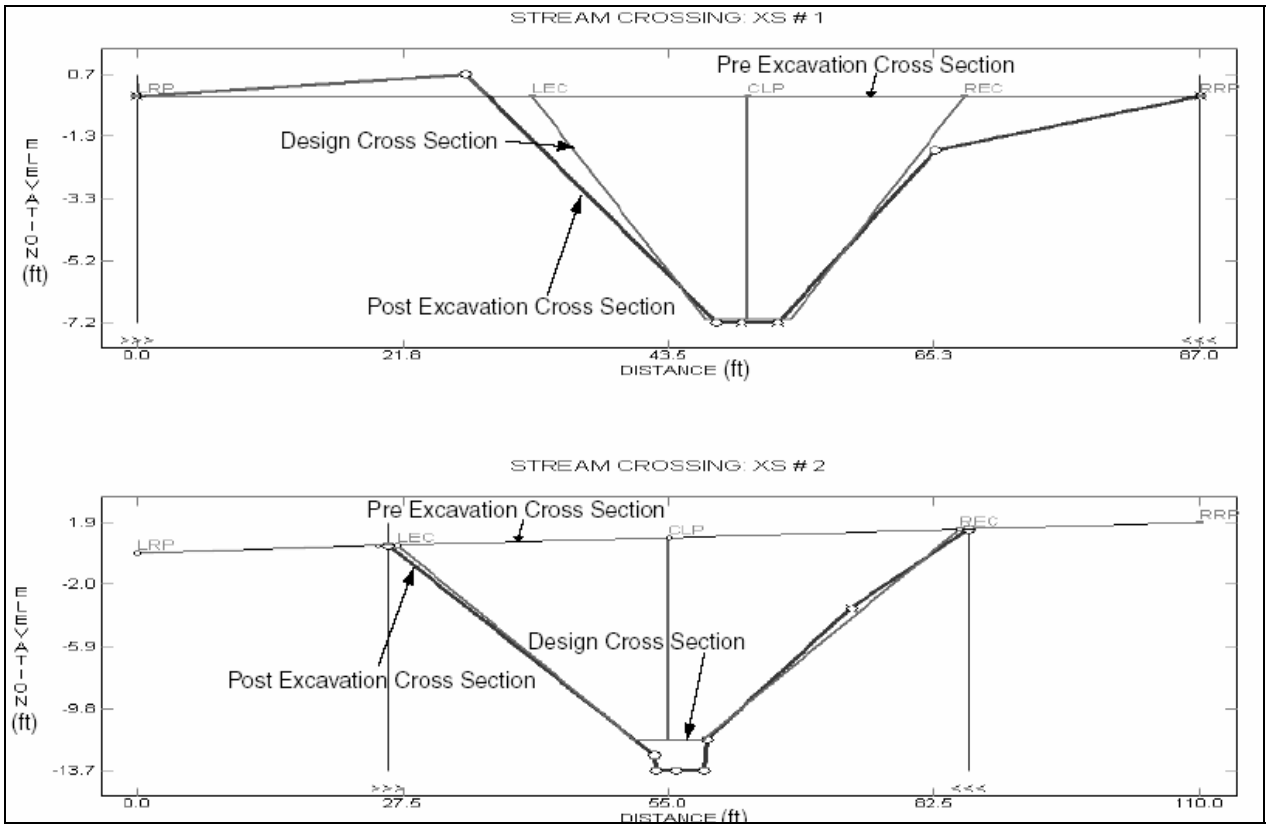


Figure X-D-32. Redwood Creek 1305 Road Site #11 – Stream Crossing Pre & Post Excavation Cross Sections.

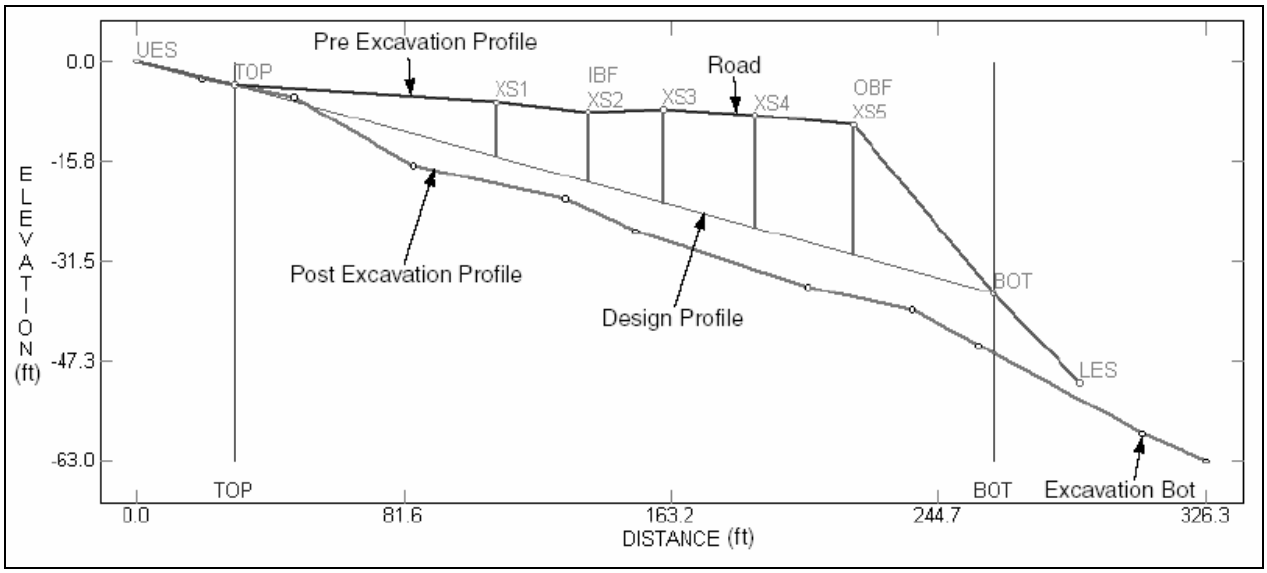


Figure X-D-33. Redwood Creek 1311 Road Site #3 – Stream Crossing Pre & Post Excavation Profiles.

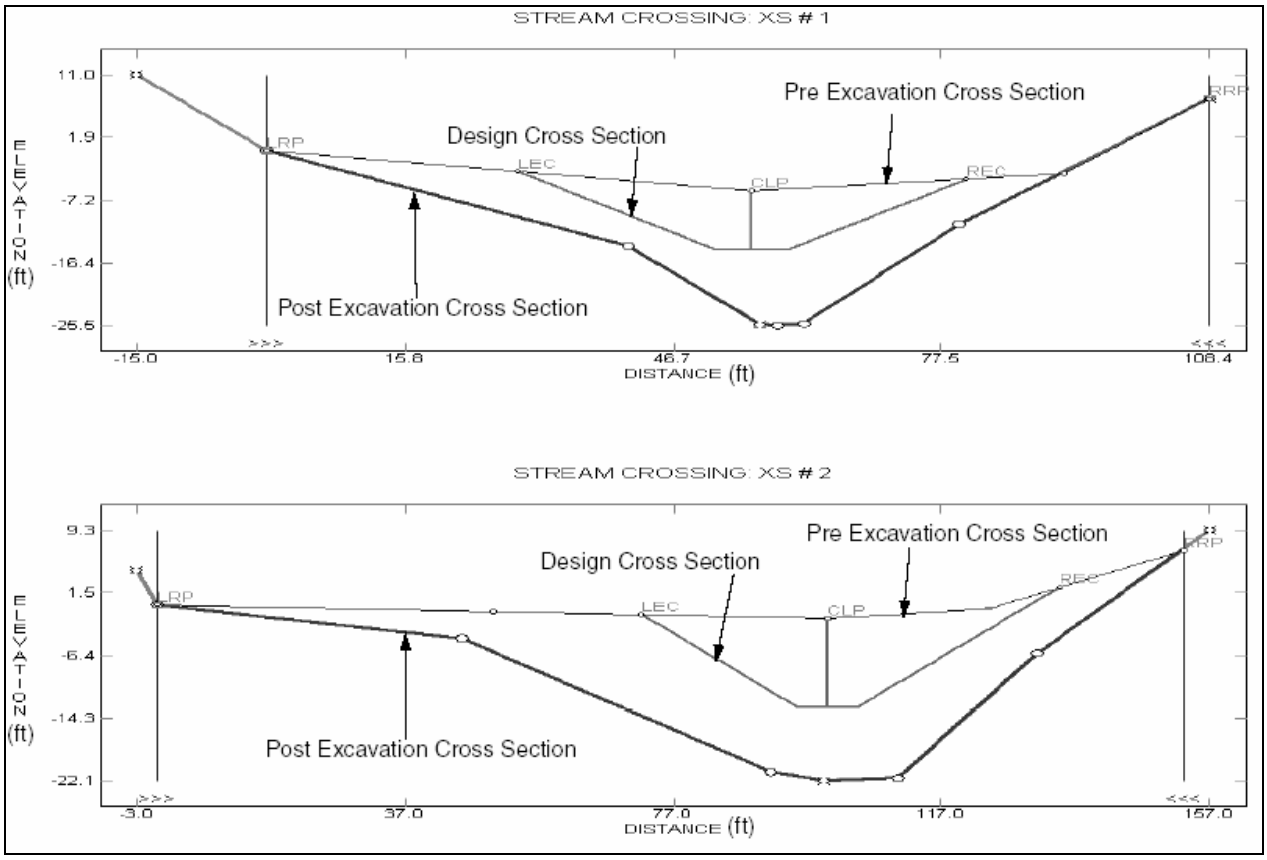


Figure X-D-34. Redwood Creek 1311 Road Site #3 – Stream Crossing Pre & Post Excavation Cross Sections.

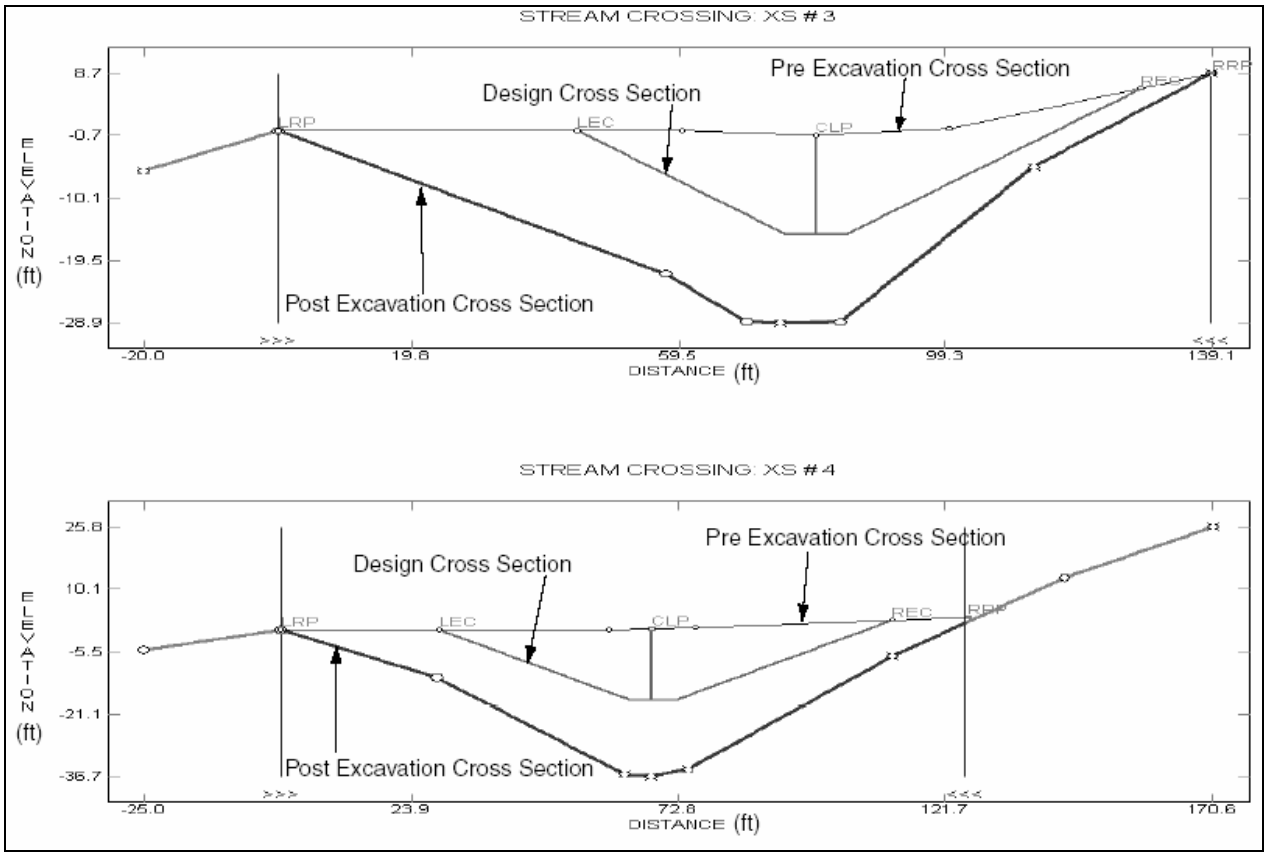


Figure X-D-35. Redwood Creek 1311 Road Site #3 – Stream Crossing Pre & Post Excavation Cross Sections.

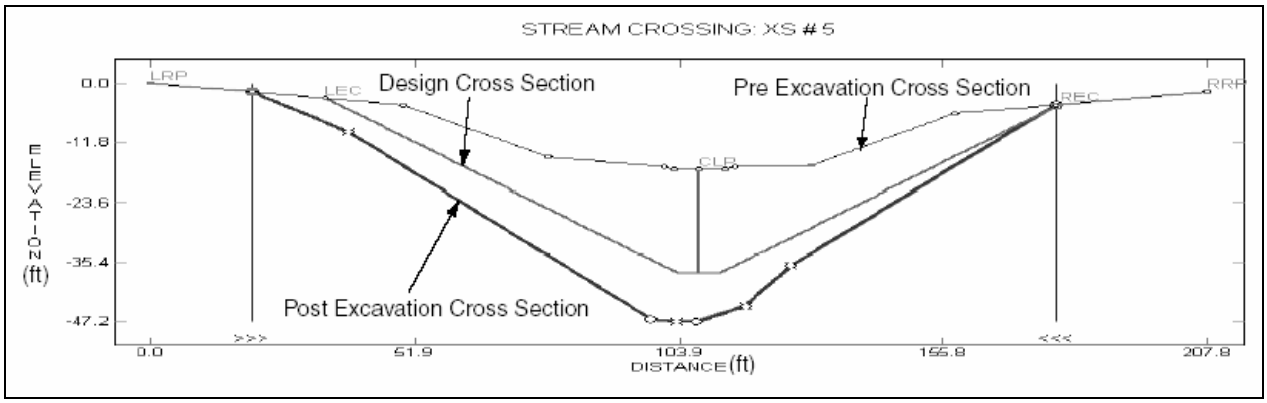


Figure X-D-36. Redwood Creek 1311 Road Site #3 – Stream Crossing Pre & Post Excavation Cross Sections.

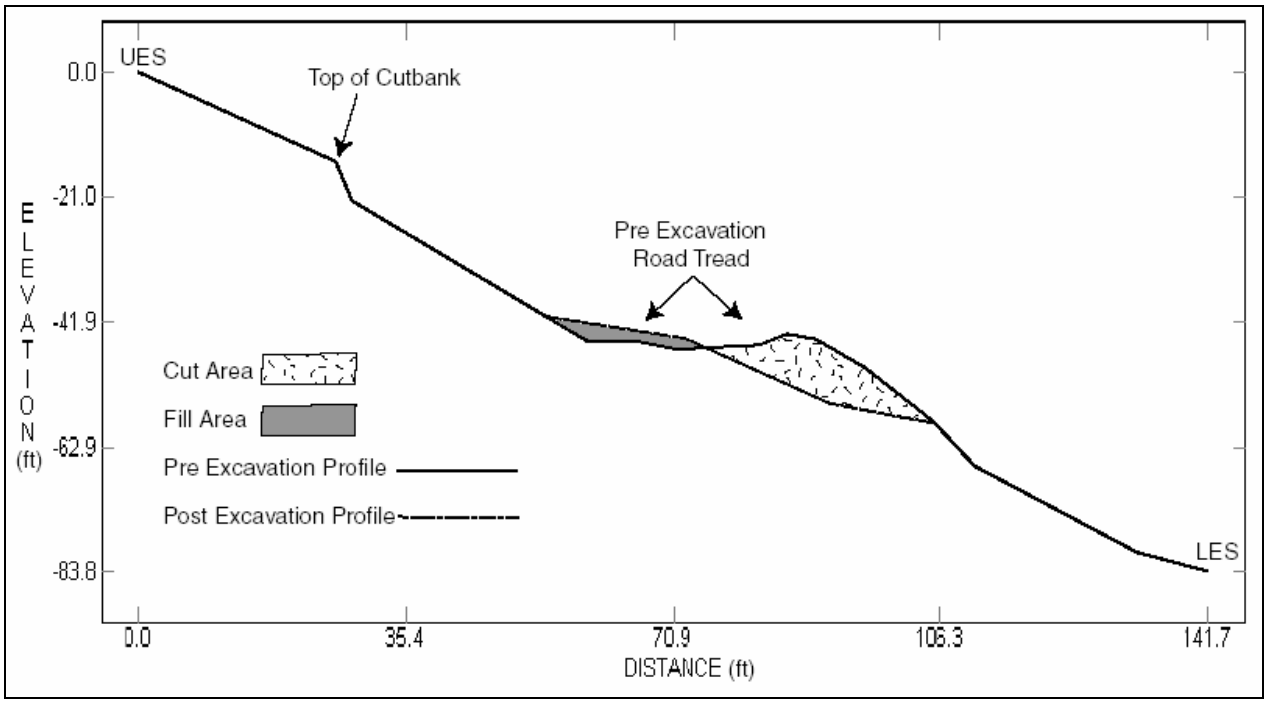


Figure X-D-37. Redwood Creek 1300 Road Site #7 – Road Fill Failure Site Pre- & Post-Excavation Profiles.

Coordinates for Site Locations 2002-2003 Redwood Creek Road Decommissioning Project

Road Name	Site #	X coordinate	Y coordinate
1300	1	423,695.41	4548,833.07
1300	2	423,674.04	4548,834.17
1300	3	423,591.82	4548,870.07
1300	4	423,519.74	4548,914.47
1300	5	423,447.11	4548,942.15
1300	6	423,375.04	4549,023.55
1300	7	423,325.16	4549,100.56
1300	8	423,239.10	4549,141.12
1300	9	423,139.62	4549,466.70
1300	10	423,076.31	4549,498.49
1300	11	422,945.03	4549,706.51
1300	12	422,818.42	4549,715.55
1300	13	422,845.82	4549,792.01
1300	14	422,777.86	4549,909.31
1300	15	422,741.68	4549,936.72
1300	16	422,678.37	4549,918.90
1301	1	423,444.92	4548,999.98
1305	1	423,674.04	4548,864.59
1305	2	423,585.24	4548,922.14
1305	3	423,548.79	4548,953.39
1305	4	423,507.41	4548,984.36
1305	5	423,486.30	4549,015.60
1305	6	423,465.75	4549,057.26
1305	7	423,450.13	4549,093.43
1305	8	423,398.06	4549,155.92
1305	9	423,345.71	4549,207.99
1305	10	423,325.43	4549,234.57
1305	11	423,304.33	4549,266.27
1305	12	423,283.77	4549,296.24
1305	13	423,268.15	4549,358.72
1305	13.1	423,268.43	4549,400.38
1305	14	423,257.74	4549,452.45
1305	14.5	423,247.05	4549,483.70
1305	15	423,231.43	4549,504.80
1305	16	423,211.15	4549,540.70
1305	17	423,195.53	4549,561.80
1305	18	423,185.11	4549,597.70
1305	19	423,156.34	4549,654.44
1305	20	423,116.87	4549,697.19
1305	21	423,085.63	4549,737.75
1305	22	423,049.18	4549,769.27
1305	23	422,977.37	4549,805.44
1305	24	422,919.27	4549,871.22
1305	24.1	422,863.91	4549,932.06
1305	24.2	422,827.19	4549,963.85
1310	1	422,966.96	4549,113.44
1310	2	423,279.66	4548,838.28
1310	3	423,076.58	4549,041.09
1311	1	423,090.83	4547,726.14
1311	2	423,147.84	4547,892.50
1311	3	423,314.74	4548,178.62
1311	4	423,341.05	4548,142.17
1311	5	423,356.40	4548,204.10
1312 Upper	1	423,533.72	4548,432.95
1312 Upper	2	423,408.47	4548,911.73
1312 Upper	3	423,393.12	4548,974.76
1312 Lower	1	423,746.94	4548,645.89
1312 Lower	2	423,710.49	4548,609.99
1312 Lower	5	423,767.49	4548,672.47

Table X-D-13. Universal Transverse Mercator (UTM) coordinates for site locations Redwood Creek Road Decommissioning Project – 1300 Roads Humboldt County, California.

UPSLOPE INVENTORY DATA FORM

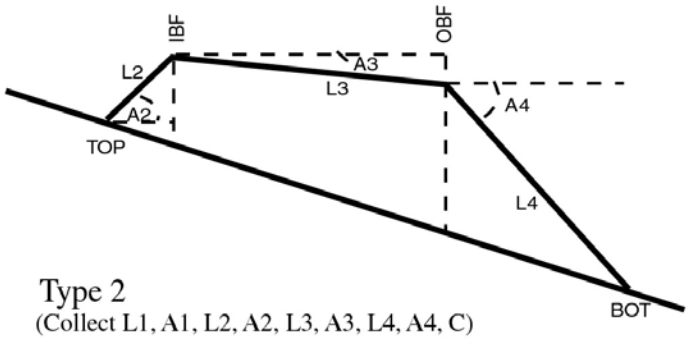
ASAP (Y, N)_____

GENERAL	Site no:	Treat (Y/N):	Watershed:	Quad:	
	GPS:		CALWAA:	Photo:	
	T/R/S:		Road name/#:	Drivable (Y/N):	
	Mileage:		Inspector(s):	Date:	Year built:
	Surface: □ rock □ native □ paved		Status: □ maintained □ abandoned □ decommissioned		
	Proposed: □ upgrade □ decommission			Sketch (Y/N):	
PROBLEM	Stream crossing (Y/N):		Landslide: □ fill □ hill □ cut	Roadbed: □ bed, □ ditch, □ cut	
	□ ditch relief culvert		□ gully □ bank erosion	Road related (Y/N):	
	Other non-road related site: □ home □ agricultural □construction □ mining □ other site				
LANDSLIDE	□ road or landing fill		□ hillslope debris slide (>50% original ground)		□ cutbank slide
	□ deep-seated landslide		□ potential failure	□ past failure	Slope (%):
	Distance to stream (ft):				
STREAM	□ culvert □ bridge		□ Humboldt □ fill	□ ford	□ armored fill
	□ excavated crossing		% excavated:		
	Ditch road length (ft): Left:		Right:	Culvert diameter (in):	
	Pipe condition (O, C, R, P): Inlet:		Bottom: Outlet:	□ separated	
	Headwall (in):		Culvert slope (%):	Stream class (1,2,3):	
	Culvert rust-line (in): Inlet:		Outlet:	Culvert undersized (Y, M, N):	
	Washed out (%):		Diversion potential (Y/N):	□ currently diverted	
	Road grade (%):		Plug potential (H, M, L):	Plugged (%):	
	Channel gradient (%):		Channel width (ft):	Channel depth (ft):	
	Sediment transport (H, M, L):		Drainage area (acres):		
FISH PASSAGE	Culvert outlet drop (in):		Bankfull drop (in):		
	Pool size bankfull width (ft):			Pool size bankfull depth (ft):	
EROSION	Erosion potential (H, M, L):		□ potential for extreme erosion		
	Volume extreme erosion (<500, 500-1,000, 1-2K, 2-5K, >5K):			Past erosion (yd^3) (optional):	
	Past delivery (%) (optional):		Total past delivery (yd^3):		
FUTURE EROSION	Future erosion (ft): Width:		Depth: Length:	Future erosion(yd^3):	
	Future delivery (%):		Total future delivery (yd^3):		
COMMENT(S) ON PROBLEM:					

TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		
	check culvert size (Y/N):		□ bridge	□ no treatment	Mulch (ft^2):
TREATMENT OPTIONS	□ excavate soil	□ critical dip	□ ford	□ armored fill	Sill height (ft):
	Sill width (ft):	□ trash rack	□ Add downspout: Length (ft):		Diameter (in):
	□ repair culvert	□ clean culvert	□ install/replace culvert		
	Culvert: Diameter (in):		Length (ft):	□ flared inlet: Diameter(in):	
	□ reconstr. fill	□ armor fill face (U, D, B):		Armor area (ft^2): U: D:	
	□ clean or cut ditch, (ft):		□ remove ditch, (ft):		
	□ outslope road, (ft):		□ outslope & remove ditch, (ft):		
	□ outslope & retain ditch, (ft):			□ inslope road, (ft):	
	□ rolling dip, (#):		□ remove berm, (ft):		
	□ ditch relief culvert, (#):		Length (ft):	□ rock road surface, (ft^2):	
	□ cross road drain, (#):		□ other:		
HEAVY EQUIPMENT EXCAVATION DATA	Total vol. excavated (yds^3):		Volume put back in (yds^3):		
	Volume removed (yds^3):		Volume stockpiled (yds^3):		
	Volume endhauled (yds^3):		Distance endhauled (yds^3):		
	Excavation production rate: (yds^3/hr):				
EQUIPMENT HOURS	Excavator:	Dozer:	Backhoe:	Grader:	Loader:
	Dump truck:		Labor:	Other:	
COMMENT(S) ON TREATMENT:					

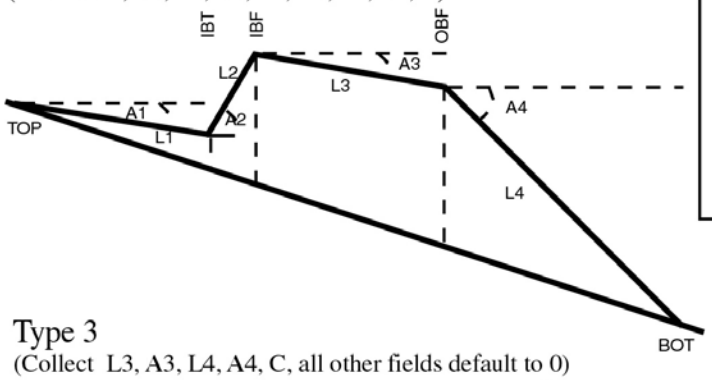
Type 1

(Collect L2, A2, L3, A3, L4, A4, C, all other fields default to 0)



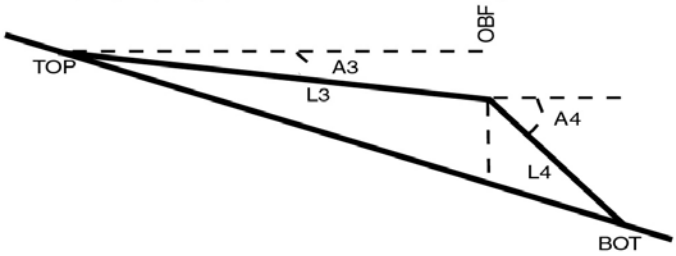
Type 2

(Collect L1, A1, L2, A2, L3, A3, L4, A4, C)



Type 3

(Collect L3, A3, L4, A4, C, all other fields default to 0)



Field data

Length of sediment fan (L1): _____ ft

Angle of sediment fan (A1): _____ degrees

Length of inboard fillslope (L2): _____ ft

Angle of inboard fillslope (A2): _____ degrees

Length of road bed (L3): _____ ft

Angle of road bed (A3): _____ degrees

Length of outboard fillslope (L4): _____ ft

Angle of outboard fillslope (A4): _____ degrees

Channel width (C): _____ ft

Sketch

STREAM BANK INVENTORY DATA FORM

GENERAL	Site no:	Distance (ft):		Date:	Inspector(s):	
	Watershed:			Stream:		
	Air photo:		Location (LB, RB, B):		☐ road related	Treat (Y/N):
PROBLEM	Type:	☐ debris slide	☐ debris torrent		☐ slow, deep-seated landslide	
		☐ torrent channel		☐ bank erosion	☐ LDA	☐ other
	Delivery: ☐ past		☐ future	☐ both	Activity (A, IA, W):	
	Age (decade):		Stream bank slope (%):			
	☐ land use	☐ undercut by stream				
PAST EROSION	Width (ft):	Depth (ft):	Length (ft):		Volume (yd^3):	
FUTURE EROSION	Future erosion potential (H, M, L):		Width (ft):		Depth (ft):	
	Length (ft):			Volume (yd^3):		

COMMENT(S) ON PROBLEM:

TREATMENT	Immediacy (H, M, L):		Complexity (H, M, L):		Equipment or labor (E, L, B):	
	Equipment access (E, M, D):		☐ local materials		☐ import materials	
TREATMENT OPTIONS	☐ excavate soil	Width (ft):	Depth (ft):	Length (ft):	Volume (yds^3):	
	☐ rock armor/buttress		rock armor size (ft or ton):		rock armor area (ft^2):	
	☐ log protection		Log size: Length (ft):		Diameter (ft):	
			Bank length protected (ft):		Bank area to cover (ft^2):	
	☐ remove logs/debris				☐ boulder deflectors	
	Deflectors (#):		Deflector (yd^3):		☐ bio-engineering	
	☐ plant erosion control		☐ riparian restoration		Area planted (ft^2):	
	☐ exclusionary fencing		Length of fence (ft):		☐ other	
EQUIPMENT HOURS	Excavator:	Dozer:	Dump truck:	Backhoe:	Labor:	Other:

COMMENT(S) ON TREATMENT:

SKETCH

CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL

PART XI

RIPARIAN HABITAT RESTORATION

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ACKNOWLEDGEMENTS

Circuit Rider Productions, Inc. (CRP) developed Part XI, Riparian Habitat Restoration under a grant agreement with the California Department of Fish and Game. Circuit Rider Productions, Inc, is a community-based agency dedicated to the enhancement of human and ecological systems. CRP has been engaged in ecological restoration in California since 1976. The following CRP staff collaborated in the development of Part XI, Riparian Habitat Restoration:

Name and Title	**Role in Project**
Rob Evans, Restoration Projects Manager	principal plant and habitat photographer
Karen Gaffney, Restoration Ecologist	principal writer, miscellaneous photography
Katherine Gledhill, Environmental Educator	editing, desktop publishing
Cheryl Dean, Ecologist/Research Coordinator	research, editing, technical writing
Greg Fisher, Ecological Services Technician	research, technical writing

The editors of Volume II of the Manual wish to thank those who reviewed this part of the Manual and provided comments or ideas on riparian restoration. From the California Department of Fish and Game these include: Chris Ramsey, Glenn Yoshioka, Shirley Lipa and Doug Albin.

Special recognition goes to the members of the California Coastal Salmonid Restoration Grant Peer Review Committee for funding the printing of Part XI. Without the financial support of this committee the development and printing of Volume II of the Manual would not be possible.

PART XI. RIPARIAN HABITAT RESTORATION

INTRODUCTION

Natural riparian habitat includes the assortment of native plants that occur adjacent to streams, creeks and rivers. These plants are well adapted to the dynamic and complex environment of streamside zones.

Approximately 95% of the historic riparian habitat has been lost in California, making way for cities, agriculture, mining and other development. The riparian area provides one of the richest habitats for large numbers of fish and wildlife species which depend on it for food and shelter. Many species, including coho and Chinook salmon, steelhead, yellow-billed cuckoo and the red-legged frog, are threatened or endangered in California. Others are rapidly declining.

Most landowners wish to protect their riparian resources while optimizing the value and productivity of their property. These two goals sometimes seem to conflict. An understanding of riparian habitat and stream processes can help landowners conserve riparian resources, and still manage their property productively, and even enhance their property value.

California residents, landowners, land managers, and agencies are increasingly interested in conserving and enhancing watersheds and implementing management practices that are more fish friendly. The riparian corridor is the critical interface between terrestrial and aquatic systems. Increasing numbers of individuals and community groups are involved in habitat conservation and restoration projects in riparian areas. Part XI is intended to encourage and help facilitate the stewardship and restoration of riparian habitat in California watersheds.

In addition to providing basic information about riparian corridors, this Part is intended to assist agencies, landowners, schools and community groups with the planning and implementation of native plant revegetation projects. A plant identification section at the end of Part XI provides detailed descriptions and photographs of plants commonly found along central and north coast California rivers and streams.

STREAM PROCESSES AND RIPARIAN HABITAT

The plant species found in riparian communities differ widely depending upon the character of the watershed and the stream's location within the watershed. The composition of a riparian community is determined by many things, including the reach type, stream slope (gradient), channel confinement, aspect, light availability, water availability, flooding and soil conditions.

For example, at the headwaters of a stream, the gradient is often steep and the riparian vegetation may not vary from the surrounding forest plant community. Further downstream, as the gradient decreases, the riparian corridor begins to differ from the surrounding forest plant community. The riparian canopy is often dominated by trees such as alder, ash, maple, box elder, and oaks, while the surrounding forest may be dominated by conifers. In alluvial areas, sunny openings on gravel bars often provide habitat for species such as mulefat and willow.

Different age classes and species of riparian habitat at different elevations

Streams and their tributaries often cut through broad alluvial valleys. In these alluvial zones, where the substrate is dominated by sand, gravel and silt, the stream freely moves (meanders) back and forth over time, creating and removing riparian habitat naturally. The ability of the stream to move through this meander corridor is what allows the development of diverse riparian forests. Streams in these alluvial areas may have historically included a broad floodplain mature forest with backwater sloughs, oxbow lakes and floodplain wetlands. These diverse habitat features are important for salmonids and other wildlife. Riparian corridors that are wide enough to allow for stream meandering should require little maintenance over the long term. A substantial riparian zone can help to reduce erosion damage to adjacent lands, as well as filter sediment and pollutants. However, due to the high value of agricultural lands as well as the proximity of urban development and other land uses, natural stream movement may not be possible in all managed watersheds.

Russian River meander corridor

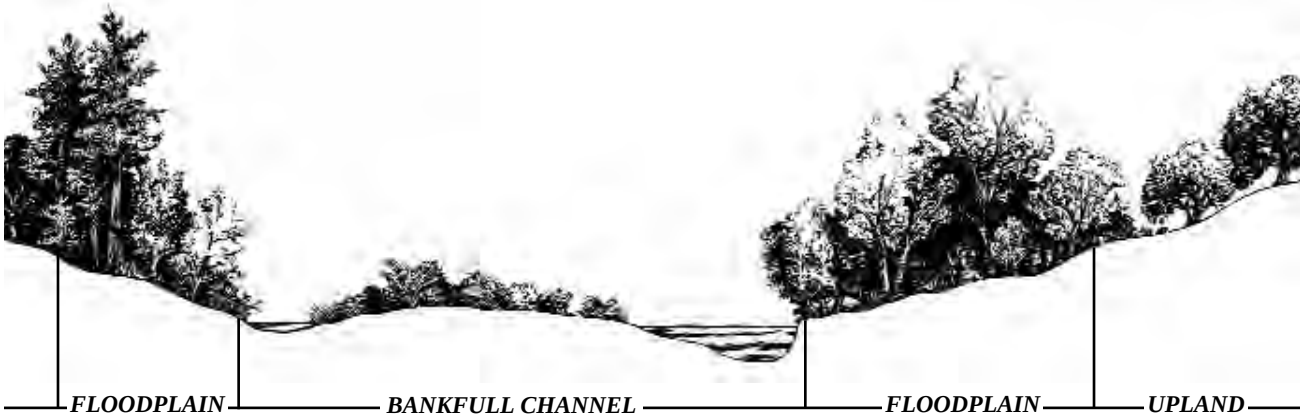
Within the bankfull channel (an area which is regularly flooded), plants are adapted to high levels of flood disturbance during the winter, while tolerating the hot, dry conditions of the gravel bars during the summer. Very few species have the ability to survive in this harsh channel environment; those that do include alder, willow, cottonwood and mulefat. They are called pioneer species, because they colonize recently disturbed sites.

Bankfull channel with small seedlings of pioneer species

The seeds of cottonwood and willow float through the air in the spring just as the water level is beginning to recede. Millions of seeds land on moist gravel bars and germinate there. As the summer progresses, the roots of these tiny seedlings follow the receding water table. Those plants that cannot stay connected to the water table face certain death on the desert-like gravel bar. Those plants that survive the summer drought and winter flood cycle will grow at incredible rates, up to 15 feet per year. As they grow, these pioneer species may begin to trap sediments, and can influence the movement of the stream.

The floodplain is elevated above the bankfull channel and is characterized by many more species than found in the bankfull channel. Floodplain areas support plants that are less adapted to flood scour and do not require as much summer moisture.

Floodplain riparian forests are some of the most important, *and the most impacted*, habitats in California. Intact riparian forests tend to be a dense tangle of large trees in the over-story, and smaller trees, vines, downed wood, and various herbs and fungi in the under-story. The diversity of plants and complexity of habitats in these mature riparian forest zones supports an incredible number of animal species.



Representative cross-section of riparian area

FISH AND WILDLIFE VALUES OF RIPARIAN HABITAT

Salmonids (including coho, Chinook and steelhead) rely on healthy riparian habitat. Riparian trees shade the stream channel, helping to cool the water and retain high levels of dissolved oxygen. Native streamside vegetation provides leaf litter which is eaten by many aquatic insects. These insects are in turn consumed by fish. Roots of riparian plants provide fish with shelter from predators. When large riparian trees fall into the stream, they supply an important structural element in creeks and rivers which helps form pools, sort the substrate, and provide shelter for fish and other aquatic organisms.

Salmonid

Salmonid

Riparian zones along intermittent streams also provide salmonid habitat. Coho salmon and steelhead spawn in the upper reaches of streams and their tributaries while they are flowing in winter. The fry emerge and migrate down to the perennial reaches before the tributaries dry up in summer. These tributaries also serve as important sources of food, spawning gravel, and woody debris that are flushed into the mainstem of a stream during storms. Therefore, alterations to the riparian zones of these seasonal tributaries can have a significant impact on salmonids.

Pacific tree frog (Hyla regilla)

In addition to the important role they play in the salmonid life cycle, riparian areas support an abundance of other wildlife species. Over half of the reptiles and three-fourths of the amphibians in California, including the western pond turtle, red-legged frog and various tree frogs, live in riparian areas. Large numbers of migratory and resident birds rely on streamside habitat. Over one-hundred native species of land mammals are dependent on the riparian zone, including raccoons, ringtails, and river otters. Black-tailed deer utilize riparian zones for fawning.

In an intact riparian corridor, there is a layering effect of plant sizes, shapes and ages that promotes wildlife diversity. A mature riparian forest has a low layer of groundcover, an intermediate layer of shrubs and small trees, and a high canopy of trees and vines. These different layers provide many sites for shelter and food for birds, insects and mammals. In addition, large trees will mature and die, leaving standing snags that provide habitat for cavity nesting birds and other terrestrial wildlife.

Bobcat

Finally, riparian areas act as wildlife corridors, providing important routes for the movement of aquatic species (fish, amphibians, insects), land animals (reptiles and mammals), and birds within a watershed. Stream corridors can be thought of as the circulatory system of the watershed, allowing terrestrial wildlife and fish to migrate up and downstream.

HUMAN VALUES OF RIPARIAN HABITAT

Riparian habitat provides many benefits to streamside landowners. For example, a wide strip of riparian vegetation can offset flood damage to adjacent agricultural lands by acting as a filter for trees and other debris that may wash in during large floods. Riparian vegetation also traps fine sediments and other pollutants contained in terrestrial runoff, thereby preserving instream water quality. Because of their deep roots and dense growth, riparian trees, shrubs, and grasses provide excellent protection against bank erosion, helping to stabilize streambanks.

In addition to assisting with flood protection and erosion control, riparian vegetation may play a role in integrated pest management. Cavity nesting riparian bird species such as kestrels and owls prey on rodents. Other cavity nesting birds such as wrens, tree swallows, oak titmice and bluebirds may help reduce populations of pest insects. Bobcats, coyotes and foxes also use riparian areas to prey on rodents.

Kestrel

Indigenous cultures have relied upon riparian plants for thousands of years, using streamside and wetland plants for basketmaking, as a source of food, and for medicinal purposes.

HUMAN IMPACTS TO RIPARIAN HABITAT

More than 95% of the historic riparian forests in California have been lost due to land use change since European settlement. Logging, urban development, dams, water diversions, gravel mining, and agriculture have all contributed to this loss.

The straightening of creeks for commercial, residential and agricultural activities, and floodplain development, has reduced the width and maturity of the riparian zone, and accordingly changed the river's form through erosional and depositional processes. Dams retain sediment, cut off critical salmonid spawning habitat and may either augment or reduce the natural flow regime. These changes have contributed to the decline of wild salmonids. California rivers once meandered across their forested floodplains, overflowing their banks as a result of winter rains, thus creating a complexity of habitat types. Currently many rivers and creeks have been severely confined, degraded and simplified, resulting in a significant loss of salmonid habitat and biological diversity in general.

Non-Native Invasive Plant Species

Humans have modified riparian areas throughout California in a variety of ways. One of the more serious impacts to native habitats is the introduction of non-native plant and animal species. Invasive plants are a topic of increasing concern for landowners and conservationists. Exotic or non-native plants, such as giant reed (*Arundo donax*) and tamarisk, have spread rapidly and taken over thousands of acres of streamside habitat. These invasive species exclude native vegetation, may increase fire danger and often use large amounts of water, decreasing available resources for fish, wildlife and humans.

Exotic plants usually do not support the same diversity of wildlife found in native riparian forests. If plants such as giant reed or periwinkle dominate the riparian zone, native riparian plants cannot become established. When this happens, the habitat values are often degraded or lost. For example, when an invasive grass such as giant reed becomes established in a riparian area, out-competing native trees such as bay laurel, cottonwood and big leaf maple, the long term consequence is that the large woody debris, shade canopy and leaf litter provided by native species are lost. This results in changes in stream temperature and modification of instream structure and the aquatic food chain. The once complex riparian forest that provided shade, food and structure for salmonids and other species is transformed into a monoculture of grass with very little habitat value. Because riparian species are not especially long lived (20-80 years is typical) invasive species can have extremely negative effects on riparian areas in a relatively short period of time.

Giant reed (Arundo donax)

The following species are common exotic invasive plants found in northern and central California riparian areas, and are pictured in Appendix XI-B:

Common Name	Latin Name	Plant Type
acacia	*Acacia* spp.	tree
cape ivy	*Delairea odorata*	vine
English ivy	*Hedera helix*	vine
eucalyptus	*Eucalyptus* spp.	tree
fennel	*Foeniculum vulgare*	herb
floating primrose	*Ludwigia peploides*	emergent/aquatic
giant reed	*Arundo donax*	grass
Himalayan blackberry	*Rubus discolor*	vine
pampas grass	*Cortaderia selloana*	grass
pepperweed	*Lepidium latifolium*	herb
periwinkle	*Vinca major*	vine
poison hemlock	*Conium maculatum*	herb
tamarisk	*Tamarix* spp.	shrub/tree
teasel	*Dipsacus fullonum*	herb
tree of heaven	*Ailanthus altissima*	tree
yellow star thistle	*Centaurea solstitialis*	herb

Agricultural/Riparian Interface: Pierce's Disease

Pierce's Disease is a fatal disease of grapevines caused by the bacterium *Xylella fastidiosa* which is transmitted by the blue-green sharpshooter insect (*Graphocephela atropunctata*). Certain riparian plants are hosts for the bacteria as well as feeding and breeding hosts for the blue-green sharpshooter. These plants include both native and non-native species and are listed below. In the past, a common practice was to remove all riparian plants adjacent to vineyards in an effort to reduce the incidence of Pierce's Disease. Recent practices have changed to reflect a more surgical approach to removal that only focuses on those plants that are systemic hosts for the bacteria. In systemic host plants, the *Xylella* bacteria spreads systematically throughout the plant after being bitten by the insect. However, in propagative host plants, the bacteria remain at the point of infection and do not spread systemically. Propagative host species are therefore not a high priority for removal. Species such as the invasive, non-native periwinkle (*Vinca major*) are systemic hosts for the bacteria and a breeding/feeding host for the blue-green sharpshooter. These plants are a high priority for removal from an economic perspective, and their removal benefits native riparian habitat as well.

Periwinkle (Vinca major)

The following perennial plants are the major breeding hosts for the blue-green sharpshooter and most are systemic hosts of Pierce's Disease in Napa, Sonoma, and Mendocino counties. Removal of these species has been shown to significantly reduce the number of blue-green sharpshooters in riparian areas and adjacent vineyards (The Pierce's Disease/Riparian Habitat Workgroup, 2000):

NON-NATIVE HOST PLANT LIST

Common name	Latin name
Himalayan blackberry	*Rubus discolor*
periwinkle	*Vinca major*
wild grape*	*Vitis* sp.

* (escaped cultivar or *Vitis californica* hybrid)

NATIVE HOST PLANT LIST

Common name	Latin name
blue elderberry	*Sambucus mexicana*
California blackberry	*Rubus ursinus*
California grape	*Vitis californica*
mugwort	*Artemisia douglasiana*
mulefat	*Baccharis salicifolia*
stinging nettle	*Urtica dioica*

Himalayan blackberry (Rubus discolor)

Mugwort (Artemesia douglasiana)

For more information on the complex topic of Pierce's Disease in north coast streams, visit *www.cnr.berkeley.edu/xylella*, or call your local University of California Cooperative Extension office.

CONSERVATION AND MANAGEMENT OF RIPARIAN HABITAT

Riparian zone in winter with leafless deciduous trees

Many landowners already have intact, healthy riparian corridors on their properties and simply want to preserve these areas in their present state. Others may have riparian areas that are in need of management, due to problems with invasive plants, Pierce's Disease or changes from upstream and downstream land uses. Many landowners are also interested in active restoration of native riparian habitats. The following sections discuss methods for preserving, managing and restoring healthy riparian corridors.

Conserving Riparian Habitat

Healthy riparian corridors require little maintenance over the long term. A stream system that has enough room to move around will sustain a diversity of plant and animal species. Leaving the stream enough elbow room may also protect adjacent land uses from excessive erosion or flood damage.

For those landowners who wish to preserve the integrity of their riparian zones, regular monitoring is recommended. Monitoring can be as simple as walking the stream yearly or seasonally, assessing changes in the stream after a storm or checking for invasive plants or trash that may have been carried in during a flood. More detailed habitat inventory methods are described in Part III of the *California Salmonid Stream Habitat Restoration Manual.*

Conservation of riparian habitat can also be accomplished by placing an easement over the stream corridor. Some conservation easements provide permanent deed guidelines for riparian land uses. Placement of a conservation easement may also provide a tax benefit to the landowner. Some land trust organizations purchase easements from willing sellers.

For more information about conservation easements and land trust organizations, visit the Land Trust Alliance website at *www.lta.org*.

Managing Riparian Habitats

Vegetation Management

In some cases, active management of the riparian zone may be required. Landowners who have concerns about Pierce's Disease may choose to remove certain plants from the riparian areas adjacent to their farming operation. Additionally, invasive plants, such as giant reed, ivy or tamarisk, should be removed before they become a significant problem.

Manual cutting of giant reed biomass

Surgical removal of native and non-native plants along with re-planting of natives is preferred to the wholesale removal of all riparian habitat. While planning for any riparian vegetation project, contact the Department of Fish and Game for technical assistance. Depending on the project, permits may be required from several different local, state or federal agencies. See Part VI for more information on permits.

The following non-toxic treatments require a significant commitment of time and labor. These treatments need to be based on an understanding of each plant's physiology (i.e., timing of flowering, size and structure of the root system, etc.). For example, a species such as yellow star thistle may be partially controlled by mowing, but the mowing treatment must take place prior to seed development, or it will cause seed dispersal and make the problem worse. Root removal options will vary according to the species. Young tamarisk or tree of heaven seedlings can be pulled using hand tools, but mature plants may require heavy equipment, potentially a cause of excessive disturbance and siltation in the riparian zone. Disturbed areas should be treated to prevent siltation to the stream. Species such as Himalayan blackberry and periwinkle may have extensive root

Riparian forest invaded by periwinkle

systems that are difficult to track down and remove. Burning may be accomplished with a backpack torch, but can only take place when there is no threat of wildfire. Tarping is usually implemented after the rainy season has ended. Tarps are then removed prior to the next rainy season. Removal of undesirable plants should be followed with a revegetation program using appropriate native plants which may help to prevent recolonization by other invaders.

There are a variety of non-toxic ways to remove unwanted plant species, and each option should be thoroughly evaluated. Listed below are some non-toxic control options for a variety of invasive non-native plant species. In general, invasive species control will take several years, and will require very careful monitoring and removal of re-growth to ensure success.

Common Name	Latin Name	Removal Options
acacia	*Acacia* spp.	root removal
cape ivy	*Delairea odorata*	root removal
English ivy	*Hedera helix*	root removal, burning
eucalyptus	*Eucalyptus* spp.	root removal
fennel	*Foeniculum vulgare*	root removal, mowing, burning
giant reed	*Arundo donax*	tarping, hand removal (gravel bars)
Himalayan blackberry	*Rubus discolor*	root removal, burning
pampas grass	*Cortaderia selloana*	root removal
pepperweed	*Lepidium latifolium*	root removal, mowing
periwinkle	*Vinca major*	root removal, tarping
poison hemlock	*Conium maculatum*	root removal, mowing, burning
tamarisk	*Tamarix* spp.	root removal, burning
teasel	*Dipsacus fullonum*	root removal, mowing
tree of heaven	*Ailanthus altissima*	root removal
yellow star thistle	*Centaurea solstitialis*	root removal, mowing, burning

If herbicide is being used for the control of invasive plants, extra care should be taken to avoid impacts to the aquatic environment, as well as overspray onto native vegetation. Soils in the riparian zone are very porous. The absolute minimum effective amount of herbicide (per the label) should be used, as excess herbicide is likely to be transported through the air or soils into the stream. Certain herbicides are specially formulated to be less toxic to aquatic organisms and are more appropriate for use in or near aquatic environments. Consultation with your local Agricultural Commissioner's office is required by law.

The following websites provide additional information about invasive species and control options:

http://www.caleppc.org (California Exotic Pest Plant Council)
http://www.cdfa.ca.gov/phpps/ipc/noxweedinfo/ (California Department of Food and Agriculture)
http://ceres.ca.gov/tadn/ (Team Arundo del Norte)
http://endeavor.des.ucdavis.edu/weeds/ (CalWeed Database)

Large Woody Debris

Riparian trees that fall into the stream play an important role in the aquatic system. They provide structure to the stream environment, helping to form pools as well as habitat for a variety of organisms. Large woody debris is an important factor in the recovery of salmonid populations. It is, therefore, desirable to retain a wide riparian corridor with large trees that may be recruited into the stream.

Historically, the approach by many agencies and landowners has been to keep the stream channel clean and open, by removing any log debris accumulation. It was believed that these large trees presented a passage problem for fish. It has since been recognized that fish, especially salmonids, are capable of passing over or through most debris accumulation. Substantial retention of sediment above debris accumulation may indicate a potential fish passage problem. Streams with large woody debris provide good quality salmon habitat.

Large woody debris creates pool habitat

Streamside landowners are understandably concerned that large fallen trees may divert the stream towards their banks, causing massive erosion and loss of land. In these cases, large trees are often removed from the system prior to the next flood event. In recent years, there has been a trend towards modification of large debris accumulation, rather than complete removal. An example of this might include pruning tree limbs and allowing the trunk to remain in the stream. This approach allows for the habitat benefits associated with large woody debris, while resolving problems such as fish passage. Contact the California Department of Fish and Game for more information on this topic. See Part VII on barrier modification and log structures for habitat enhancement.

Large woody debris provides structure to the stream environment

RESTORATION OF NATIVE RIPARIAN HABITATS

Natural Regeneration and Exclusionary Fencing

Riparian systems are often capable of rapid natural regeneration after a disturbance such as a flood, fire or other event causing modification to the landscape. The gravel bars and banks in the bankfull channel will often revegetate on their own within a year or two, provided there is an upslope or upstream source of seeds or plant material. Floodplain areas may take significantly longer and may warrant active revegetation to jump start the natural regeneration process.

Stream floodplain being grazed by livestock

In areas that are being grazed by livestock or are heavily impacted by other native grazing herbivores, exclusionary fencing can give the streambank enough protection to re-create healthy stands of native vegetation. Fencing may be temporary, maintained just long enough to allow native trees and shrubs to re-establish (ten years is often adequate).

Exclusionary fencing along stream headwaters

If fencing is used to allow for the regeneration of riparian habitat, it should be set back far enough to allow the stream to meander and create a diversity of habitat. Fences placed too close to the stream corridor may be damaged during high flows, wasting time and money.

Fencing design, including type of wire, gauge and spacing must be specific to the types of animals you are attempting to exclude. Many fencing supply stores have this information and can help you with construction specifics. Alternative water sources for livestock should be devloped to keep them out of the stream channel. If conditions require that livestock access the stream for pasturing or crossing between pastures, use specialized floating fences (which span the channel) to limit such access. When funding restoration projects, the Department of Fish and Game requires a riparian management plan to be developed and signed by the landowner. For more detailed information on exclusionary fencing, see Part VII.

Erosion Control

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. Structural approaches to stream bank erosion such as riprap tend to fix the stream in one place, exclude riparian vegetation, and prevent the natural movement that creates diverse habitats. Structural approaches are often more expensive, require permits, and may damage neighboring properties. Over the long term, structural approaches tend to fail or require excessive maintenance. If a structural approach is unavoidable, native vegetation should be incorporated into the structure. Bioengineering will increase the effectiveness of the erosion control method and provide some habitat value as well. See Part VII for descriptions of bioengineering.

Installation of erosion control

Planning and Implementing a Successful Revegetation Project

Revegetation using native plants is effective for enhancing habitat for numerous fish and wildlife species, as well as reducing upslope erosion and sedimentation to streams. Revegetation may include:

- broadcast seeding of native grass or forbs on hillslopes
- instream sprigging of dormant willow cuttings to increase cover and reduce bank erosion
- installation of plants propagated in a native plants nursery
- transplanting of emergent species such as rush, tule or sedge
- direct seeding of native species such as oaks or buckeyes.

The landowner, project personnel, or watershed organization should become acquainted with the stream processes and natural habitat of the area to create a plan that works within the local riparian ecosystem. While planning for any riparian vegetation project, contact the Department of Fish and Game or the Natural Resources Conservation Service for technical assistance. Depending on the project, permits may be required from several different local, state or federal agencies.

Creating and implementing a revegetation project can be a complex process, taking four to six months for design and approval, and several additional months for implementation. In some cases, involving a consultant or watershed group with expertise in the process can save time and be more cost effective. See Part VI for more information on permits.

Tree shelter installation

Riparian Revegetation Project Planning

A successful revegetation project will:

- establish a diversity of native plant types and plant species in the riparian area
- provide fish and wildlife habitat
- reduce erosion
- require minimal annual management.

Revegetation should attempt to replicate the natural system.
In the riparian zone, different species are adapted to distinct microsites, often based on elevation and proximity to the stream. Planning of a riparian revegetation project should take into account where each species occurs in the natural system. It can be helpful to draw a cross-sectional diagram of the riparian zone showing where different species occur. This can help determine planting sites based on elevation above the bankfull channel.

Diverse riparian and upland habitat

In general, container planting in the bankfull channel is not recommended.
If there is a severe bank erosion problem, or the system has lost all upstream sources of seed, some active channel revegetation may be warranted. Since the bankfull channel is subject to regular flooding, installed plants are likely to wash out prior to establishing a root system. Willows, whether as sprigs, a willow mattress or willow wall, are adapted to this flood prone environment, and can be an effective, relatively inexpensive way to stabilize a streambank or introduce cover to the stream. Plants installed in the bankfull channel should not have protective hardware, as it will likely be lost to flooding.

Seeds, cuttings or transplants should be collected as close as possible to the project site.
Local collection of plant material ensures that only genetically appropriate plants (i.e., those that are adapted to local conditions) will be used on site. Introduction of plant material from outside of the project watershed is not recommended. The use of local plant material usually results in higher survival rates.

Valley oak (Quercus lobata) an important native seed

Sources for Native Plant Material

Appropriate, site specific native plants are one of the most important aspects of a successful riparian restoration project. Project planning may need to begin up to 18 months in advance to obtain those species that must be grown in containers. For example, a particular species may have seed that ripens in July. After treatment of the seed and propagation in the nursery, the plant may not be ready for outplanting until the following fall/winter. This is often the most important phase of planning a successful restoration project. If you are not in a position to grow the plants yourself, it is a good idea to order plants from a local native plants nursery as soon as you have selected a restoration site.

Bare-root stock can also be used instead of container stock. However, bare-root stock is often difficult to locate because few nurseries produce it. Spacing of plants depends on the species, the goals of the project, desired densities, and many other factors. General spacing recommendations are included in Table XI-1, page XI-26.

Nurseries specializing in California native plants do things differently than typical landscape nurseries. California native plant nurseries usually custom collect site specific material for particular restoration projects, or at minimum, they track where the plant material was collected. This ensures that you can purchase plant material suitable for your project site.

The California Native Plant Society website, *http://www.cnps.org/links/grow links.htm* includes a variety of resources about California flora, including a list of native plant nurseries.

Common container sizes found in native plants nurseries are listed below:

Container Name	Size	Uses
6” and 8” supercell	1 1/8” x 6” 1 1/8” x 8”	Best for plants with fibrous root systems
deepots	2 1/2” x 10”	Good for trees and shrubs
treepot	4” x 14”	Generally used for trees
treebands	2 1/2” x 5”	Good for trees and shrubs

Native plants nurseries also use unique containers like treepots, deepots or supercells (shown to the left) to develop an optimum root-to-shoot ratio (see example photo, above right). This approach provides plants with a well established root system prior to outplanting at the revegetation site.

Emergent Transplant Installation

Plants such as rushes, sedges and tules are commonly called emergent plants, because they are often associated with creeks, wetlands and lakes, where they emerge from the water. They may reproduce from seed or from the spreading of underground rhizomes. This vegetative form of reproduction makes emergent species ideal candidates for transplantation into revegetation sites. These species are widely adapted to a range of environments, including high velocity bankfull channels, slow moving backwaters, seeps on hillslopes, and stable, relatively dry floodplains. It is important to identify the species to use and transplant them in an appropriate location. There are also some non-native species of emergents that should not be transplanted into riparian zones. Care should be taken to sensitively harvest these plants so the existing population is not seriously degraded. It is a good idea to take several small clumps from a variety of larger clumps, leaving the majority of each population intact to ensure genetic diversity.

Collecting emergent vegetation

Emergent vegetation, rhizomes exposed

Steps required to transplant emergent species:

- In the winter or early spring, carefully harvest rhizomes and the above-ground portions of the plant with a mattox, sharp trowel or shovel. Make sure one to several intact rhizomes remain for each transplant.
- Store the collected plant in a cool moist location until time for transplanting. Ideally, plants should be stored in moist soil, and should be transplanted as soon as feasible after collection.
- Dig a hole for the transplant that is large enough to accommodate the extended rhizome without bending or breaking it. Place dirt around the rhizome, pack it down, and water it in thoroughly to close any air holes around the rhizome.
- Trim back the above ground portions of the plant in order to stimulate rhizome growth.

Installation of emergent vegetation

Dormant Willow or Cottonwood Sprig Installation

Willows and cottonwoods are in the willow family (*Salicaceae*) and are generally adapted to bankfull channel environments. Species in this family form specialized roots along their stems, allowing for vegetative reproduction in riparian corridors. This feature makes them good candidates for installation as sprigs or dormant cuttings. In general, willows need significant amounts of light and a year-round source of moisture. They are good candidates for revegetation as long as their root zone remains moist during the summer. Because of their ability to withstand flood flows, they are often a good choice for bank stabilization projects in bankfull channel areas. There are many varieties of willow and cottonwood in California. Some (such as the curly willow and Lombardy poplar) are not native and should never be planted in riparian areas. They may not supply the same habitat values as the native plants, and may hybridize with them. Cuttings should be harvested from a variety of parent plants in order to avoid out-planting genetically identical material. These techniques result in a more successful project, will ensure genetic diversity, and do the least damage to the collection site.

Sharp, clean loppers produce high quality sprigs and cuttings

Typical dimensions for willow and cottonwood sprigs

Steps required to install dormant willow and cottonwood cuttings:

- Harvest cuttings during the winter months when plants are dormant (usually December-January). Although willows and cottonwoods will grow from cuttings at other times of the year, dormant cuttings are more resistant to disease, have higher survival rates, and do not require irrigation if planted in the appropriate location. Sprigs may be harvested using sharp, clean loppers, hand shears, or a chainsaw. The cuttings

Store cuttings in a moist environment

may be collected at a range of sizes (i.e., ½ inch to 4 inches diameter and up to 8 feet long). It is important to select material that has not become too woody, and that has several viable buds along the stem.

- Cuttings may be used immediately, stored on-site in the stream, or stored off-site in a bucket of cool water. Ideally, material should be harvested and installed the same day.

- Sprigs should be installed with buds pointing up, with approximately ¾ of the cutting in the soil, and ¼ exposed. Holes may be dug with a pick, with a piece of rebar, with an auger, or a backhoe (for large material). In areas with soft soil, you may avoid digging a hole by cutting the bottom at an angle and pounding it into the ground with a small sledge hammer. If the top is damaged by the hammer, cut off the top of the sprig to allow for clean healing or place a driving shield over the top to drive in the sprig.

Auger used for planting holes

Small sledge hammer for installing sprig

Clean, sharp loppers cut off damaged top of sprig

Container Plant Installation with Shelters
Container plants need to be ordered or propagated months in advance and may be grown by a native plants nursery or an individual practitioner (see page XI-16). Although the installation of container plant material requires more up-front planning than sprigging, emergent transplants and direct seeding, it also allows for the installation of a more diverse plant palette. Some projects use a two-phased approach, with cuttings, emergents and direct seeded species installed the first year, followed by installation of container plants the second year.

Steps required for installing container plants with shelters:

- Plants should be installed during the winter. Plants that will not be irrigated should be planted from December through February, after rains have thoroughly saturated the ground. Plants that will be drip irrigated can be installed at other times during the year. Because of the dangers of planting on the bank of a stream during high flow periods, when stream banks are slippery and the current swift, it may be best to delay some projects until conditions are safe.

- When installing plants, dig holes to twice the depth of the root-ball of the plant to be installed, crumbling any large soil clumps. Partially refill the hole, firmly tamping the soil to create a firm base for the new plant. Place the plant so the top of the root-ball is slightly above finish grade, to allow for future settling. Fill the hole and tamp firmly to remove any air pockets. Irrigate immediately, ensuring the water soaks deeply, unless the ground is already saturated.

Remove weeds from the planting area

Dig the planting hole twice the depth of the root ball

Water the plant immediately, ensuring that the water soaks deeply. If planting in low moisture conditions, plants should be watered during the planting process and therafter until rains begin.

- Where damage from domestic animals and wildlife is a concern, consider protecting plants with shelters (except those that will be in flood-scoured areas). Shelters should be firmly staked and tied so they will remain upright. There are a variety of shelters available, ranging from chicken wire enclosures (screen and collar, shown in photo at bottom) to plastic tubes (a.k.a., *supertubes*, shown in photo at right). All of these methods have proven successful, if they are maintained and weeds are controlled. Shelters should be removed as soon as the plants begin to outgrow them (3-5 years is typical for riparian plants).

- Weeds should be carefully controlled in revegetation areas before and after installation. Plants can become lost in the weeds, increasing maintenance costs and reducing project success. Mow tall weeds before installation, and consider using weed mats (3-foot-diameter sheets of specially designed woven or perforated plastic) around each new plant.

Installation of supertube on newly planted native seedling

Installation of weed mat

Installation of screen and collar protective hardware

Direct Seed Installation

Several riparian species are good candidates for direct seeding. These include large seeded species such as buckeye, native California black walnut, California bay laurel and the native oaks. Large seeds provide these species with a reserve of nutrients that can sustain them during the early phases of seedling development. Although some other seed producing species can be direct seeded under ideal conditions (including weed free environments with good soil moisture), it is generally not a successful technique. Additionally, many seeds are adapted to very specific conditions prior to germination, and may require treatment such as cold stratification or seed coat scarification. In order to ensure genetic diversity and maximize project success, seeds should be collected from several source plants.

Buckeye seed with developing root

Steps required for direct seeding:

- Collect the buckeye, bay, walnut or oak seeds when ripe (fall or winter, depending on the species). Ideally, seeds should be collected from the trees, rather than the ground in order to reduce damage from insects and bacteria. Seeds should come off easily. Check each seed for large numbers of insect holes or mechanical damage, and discard those that appear diseased or feel lighter than the others.
- Store seeds in a cool place until ready for out-planting. If seeds will be stored for more than a few days, they should be placed in plastic bags with perlite and refrigerated.
- Plant seeds in the winter, when soil moisture has reached a depth of 10 inches or more. Dig a shallow hole at each planting location, and cover seeds with one to two inches of soil. If seeds have begun to germinate, care should be taken to protect the tender new root. For buckeye, only one seed should be required, whereas for the other species you will want to install three to five seeds per planting spot. Once they have germinated, you can select the strongest seedling and clip the others with shears.
- If you choose to protect seedlings from deer browse, the techniques described on the following pages may be used.

Careful placement of buckeye seed

Cover seed with 1-2 inches of soil

Project Maintenance

Maintenance of native plant revegetation projects is critical to project success, and often requires an equal or greater expenditure of labor and resources than the installation phase. Maintenance usually includes weeding, watering and general monitoring.

Important maintenance tasks include:

- Regular hand weeding around individual plants during the height of growing season in spring and early summer, as well as one final weeding in the fall. In some cases, where tall weedy species like mustard, hemlock or fennel are present, the whole site may require mowing or mechanical weeding in order to ensure site access and reduce excess shading.

- Soil moisture should be checked on a regular basis during the first two to three growing seasons and plants evaluated for drought stress. The watering regime (whether hand irrigation or a drip system) should be scheduled according to plant needs, rather than an arbitrary schedule. Irrigation should include the minimum amount necessary to keep the plants healthy so they do not become dependent upon additional water. If the plants are appropriate to the location, and installed correctly at the right time of year, they should not require irrigation past year three. Watering should taper off as the plants mature.

- General monitoring should take place at each maintenance visit. Each plant should be checked for signs of disease, rodent or insect browse, and drought stress. Damaged plants should be replaced when possible. Encroachment by invasive species should also be monitored, and these species controlled before they take over the revegetation site.

Mechanical weeding of project site

Hand watering of individual plant

REGULATORY AGENCIES AND REQUIREMENTS

(excerpted from The Pierce's Disease/Riparian Habitat Workgroup, 2000
Riparian Vegetation Management for Pierce's Disease in North Coast California Vineyards)

Several federal, state, and local agencies have regulatory authority over work done in the riparian corridor and may need to be contacted for a revegetation project. It is the landowner's responsibility to be familiar with these agencies and notify them when a project is planned.

Different agencies may have jurisdiction over a project, depending on the character or extent of the project. Most revegetation projects will involve only the removal of specific non-native plants, and replanting of native plants. Such simple revegetation projects will require the least regulatory agency input. The one agency that will certainly require notification, even for a simple revegetation project, is the California Department of Fish and Game. In addition, the Regional Water Quality Control Board may need notification if the project would result in soil erosion, and/or runoff of pesticides into the stream (due to removal of a vegetative buffer).

Some revegetation projects may have a streambank stabilization component. If the stabilization involves re-contouring of the streambed and banks, the United States Army Corps of Engineers and NOAA Fisheries may need notification, in addition to the two agencies mentioned above. Streambank stabilization projects that use bio-technical approaches, such as live vegetation baffles and revetments, will have fewer negative impacts to natural resources and may need less regulatory agency involvement than projects with standard engineering and riprap. The use of standard engineering and riprap is generally discouraged in areas that contain threatened and endangered species, such as salmon and steelhead, because of the negative effects on habitat.

Formal agency notification typically involves completing a form that describes the project, often with a project design map and written description, and paying a fee. Talking to agency representatives about the project before this formal notification can save a significant amount of time. Most agencies encourage informal consultation in the early stages of project planning. The concerns of each party can be addressed, and potential roadblocks eliminated or reduced. In some cases, one agency may pass your project on for review by other agencies, but do not assume this will happen. The landowner and project manager is always responsible for informing all agencies. Many of these agencies charge fees to process the applications and permits. Call each agency for information and a current fee schedule.

Riparian revegetation project, Russian River watershed

Become familiar with the regulatory agencies described below. Even better, get to know the agency staff that work in your area and find out what their interests are, before designing your project (refer to Part VI, Project Planning and Organization).

Activity	**Agency to Contact**
Native plant revegetation	California Department of Fish and Game
Native plant bio-engineering	California Department of Fish and Game
Streambank stabilization (riprap, other structures)	United States Army Corps of Engineers California Department of Fish and Game
Earth moving & placement of fill	United State Army Corps of Engineers California Department of Fish and Game Regional Water Quality Control Board County Permit and Resource Management Dept. County Planning Department Natural Resources Conservation Service
Herbicide application	Agricultural Commissioners Office Regional Water Quality Control Board
Vegetation removal (native or non-native)	California Department of Fish and Game

Riparian corridor expansion project

Herbicide application

Table XI-1. Native Plants for Revegetation: Planting Location, Container Type and Spacing

The following plants are common in central and north coast watersheds and are recommended for use in riparian revegetation projects. Before choosing plants for a revegetation project, survey your area to determine the appropriate species, or consult with a native plant specialist. This table provides information about the typical location of riparian species, the revegetation approach (e.g., container, direct seed, dormant sprig or transplant) and general spacing suggestions.

COMMON NAME	LATIN NAME	PLANTING LOCATION	REVEGETATION APPROACH	SPACING feet-on-center	PAGE
BROADLEAF TREES					
Big Leaf Maple	*Acer macrophyllum*	floodplain	container	8 – 10’	A-1
Black Cottonwood	*Populus balsamifera* ssp. *trichocarpa*	channel	container, sprig	8 – 10’ 2 – 6’	A-2
Box Elder	*Acer negundo* var. *californicum*	floodplain	container	8 – 10’	A-3
California Bay Laurel	*Umbellularia californica*	floodplain	container	8 – 10’	A-4
California Buckeye	*Aesculus californica*	floodplain	container, direct seed	8 – 10’	A-5
Coast Live Oak	*Quercus agrifolia*	floodplain	container, direct seed	8 – 10’	A-6
Fremont Cottonwood	*Populus fremontii* ssp. *fremontii*	floodplain, channel	container, sprig	8 – 10’ 2 – 6’	A-7
Mountain Dogwood	*Cornus nuttallii*	channel	container	8 – 10’	A-8
No. CA Black Walnut	*Juglans californica* var. *hindsii*	floodplain	container	8 – 10’	A-9
Oregon Ash	*Fraxinus latifolia*	floodplain, channel	container	8 – 10’	A-10
Oregon Oak	*Quercus garryana* var. *garryana*	floodplain	container, direct seed	8 – 10’	A-11
Red Alder	*Alnus rubra*	floodplain, channel	container	8 – 10’	A-12
Sycamore	*Platanus racemosa*	floodplain	container	8 – 10’	A-13
Valley Oak	*Quercus lobata*	floodplain	container, direct seed	8 – 10’	A-14
Water Birch	*Betula occidentalis*	channel	container	8 – 10’	A-15
White Alder	*Alnus rhombifolia*	channel	container	8 – 10’	A-16
Willow	*Salix* spp.	channel, floodplain	container, sprig	8 – 10’ 2 – 6’	A-17
CONIFEROUS TREES					
California Nutmeg	*Torreya californica*	floodplain	container	8 – 10’	A-18
Coast Redwood	*Sequoia sempervirens*	floodplain	container	8 – 10’	A-19
Douglas Fir	*Pseudotsuga menzieii*	floodplain	container	8 – 10’	A-20
Pacific Yew	*Taxus brevifolia*	floodplain	container	8 – 10’	A-21
Western Hemlock	*Tsuga heterophylla*	floodplain	container	8 – 10’	A-22
SHRUBS AND SMALL TREES					
Blue Elderberry	*Sambucus mexicana*	floodplain	container	8 – 10’	A-23
California Blackberry	*Rubus ursinus*	floodplain	container	4 – 6’	A-24
California Hazelnut	*Corylus cornuta* var. *californica*	floodplain	container	4 – 6’	A-25
California Wild Rose	*Rosa californica*	floodplain	container	4 – 6’	A-26
Cascara	*Rhamnus purshiana*	floodplain	container	4 – 6’	A-27
Coffeeberry	*Rhamnus californica*	floodplain	container	4 – 6’	A-28

COMMON NAME	LATIN NAME	PLANTING LOCATION	REVEGETATION APPROACH	SPACING feet-on-center	PAGE
SHRUBS AND SMALL TREES					
Coltsfoot	*Petasites frigidus*	floodplain	container	4 – 6’	A-29
Creambush	*Holodiscus discolor*	floodplain	container	4 – 6’	A-30
Elk Clover	*Aralia californica*	floodplain	container	4 – 6’	A-31
Hawthorn	*Crataegus douglasii*	floodplain	container	4 – 6’	A-32
Mulefat	*Baccharis salicifolia*	floodplain	container	4 – 6’	A-33
Ninebark	*Physocarpus capitatus*	floodplain	container	4 – 6’	A-34
Osoberry	*Oemleria cerasiformis*	channel	container	4 – 6’	A-35
Pacific Wax Myrtle	*Myrica californica*	floodplain	container	4 – 6’	A-36
Red Elderberry	*Sambucus racemosa*	floodplain	container	8 – 10’	A-37
Red Flowering Currant	*Ribes sanguineum*	floodplain	container	4 – 6’	A-38
Red Twig Dogwood	*Cornus glabrata*	floodplain	container	4 – 6’	A-39
Salmonberry	*Rubus spectabilis*	floodplain	container	4 – 6’	A-40
Snowberry	*Symphoricarpos albus*	floodplain	container	4 – 6’	A-41
Spiraea	*Spiraea douglasii*	floodplain	container	4 – 6’	A-42
Stink Currant	*Ribes bracteosum*	floodplain	container	4 – 6’	A-43
Stream Dogwood	*Cornus sericea*	channel	container	4 – 6’	A-44
Thimbleberry	*Rubus parviflorus*	channel	container	4 – 6’	A-45
Toyon	*Heteromeles arbutifolia*	floodplain	container	4 – 6’	A-46
Twinberry	*Lonicera involucrata*	floodplain	container	4 – 6’	A-47
Vine Maple	*Acer circinatum*	floodplain	container	4 – 6’	A-48
Western Azalea	*Rhododendron occidentale*	floodplain	container	4 – 6’	A-49
Western Spicebush	*Calycanthus occidentalis*	floodplain	container	4 – 6’	A-50
Wild Mock Orange	*Philadelphus lewisii*	floodplain	container	4 – 6’	A-51
VINES					
California Wild Grape	*Vitis californica*	floodplain	container	4 – 6’	A-52
Dutchman's Pipevine	*Aristolochia californica*	floodplain	container	4 – 6’	A-53
Honeysuckle	*Lonicera hispidula* var. *vacillans*	floodplain	container	4 – 6’	A-54
Manroot	*Marah fabaceus*	floodplain	container	4 – 6’	A-55
Poison Oak	*Toxicodendron diversilobum*	floodplain	container	4 – 6’	A-56
Virgin’s Bower	*Clematis lasiantha*	floodplain	container	4 – 6’	A-57
EMERGENT AND HERBACEOUS PLANTS					
Bulrush	*Scirpus acutus* var. *occidentalis*	channel	container, transplant	1 – 2’	A-58
Cattail	*Typha latifolia*	channel	container, transplant	1 – 2’	A-59
Creeping Wild Rye	*Leymus triticoides*	floodplain	container, transplant	1 – 2’	A-60
Horsetail	*Equisetum* spp.	floodplain, channel	container, transplant	1 – 2’	A-61
Indian Rhubarb	*Darmera peltata*	channel	container, transplant	1 – 2’	A-62
Mugwort	*Artemesia douglasii*	floodplain, channel	container, transplant	1 – 2’	A-63
Rush	*Juncus* spp.	floodplain, channel	container, transplant	1 – 2’	A-64
Sedge	*Carex* spp.	floodplain, channel	container, transplant	1 – 2’	A-65
Spike rush	*Eleocharis* spp.	channel	container, transplant	1 – 2’	A-66
Stinging Nettle	*Urtica dioica*	floodplain, channel	container, transplant	1 – 2’	A-67

GLOSSARY

Achene: Dry, one-seeded fruit that often looks like a seed. Produced in a one-chambered ovary. Does not open to release the seed.

Allelopathic: Plant produces and releases a toxic substance that results in suppressed growth in other plant species.

Alternate: Describes growth pattern in which new structures develop singularly along axis. For leaves, only one leaf is produced per node so leaves appear to have "alternated" the side of the stem from which they grew (see opposite).

Annual: Plant completes entire life cycle, from germination to seed production and death, in one year or growing cycle (see biannual, perennial).

Asexual: Reproduction by a single individual using a process that is not sexual and does not involve the union of individual cells and the reassortment of genetic characteristics.

Biennial: Plant completes entire life cycle, from germination to seed production and death, in two years or growing cycles. Usually flowers are produced only during the second cycle (see annual, perennial).

Bisexual: Flowers have both female and male fertile reproductive structures (see unisexual, dioecious, monoecious).

Bract: A leaf-like or scale-like structure associated with and usually directly under a flower or cone.

Capsule: Dry, pod-like fruit with fused or partially fused chambers. When ripe, the fruit splits to release multiple seeds.

Catkin: An unbranched inflorescence of closely attached flowers. Flower petals and sepals are inconspicuous or absent but bracts can be showy. Flowers are all the same sex on each catkin.

Compound: Composed of two or more parts or repeating a structural pattern.

Deciduous: Leaves fall off naturally at the end of each growing season and re-grow after a period of leaf-less dormancy (see evergreen).

Dioecious: Male and female flowers produced on separate plants. Each plant produces either male or female unisexual flowers (see monoecious and bisexual).

Elliptic (al): Shaped like a flattened circle, widest at center and tapering almost equally at both ends.

Evergreen: Leaves remain green and on the plant throughout the year, and do not shed en-mass at the end of the growing season (see deciduous).

Gall: An abnormal outgrowth in plant tissue caused by certain parasitic insects, fungi, bacteria, or mechanical injury.

Inflorescence: A cluster of flowers and associated structures such as bracts, petioles and stems (does not include full sized foliage leaves).

Lanceolate: Lance shaped, width widest along lower half and tapers to a point at the tip.

Monoecious: Plant produces both male and female unisexual flowers (see dioecious and bisexual).

Oblong: Longer than wide, with almost parallel sides and rounded corners at each end.

Opposite: Describes a growth pattern in which new structures develop directly across from one another. In leaves, two leaves will grow per node on opposite sides of the stem (see alternate).

Ovate: Egg shaped, widest below middle, tip round or pointed.

Palmate: Radiating from a common point, similar to fingers from the palm of a hand.

Perennial: Plants live more than two years or growing cycles. For this text, description applies to plants that are non-woody above ground and also describes species that lose all above ground structures during dormancy and re-grow from roots (see annual, biannual).

Petiole: Slender stem that supports the leaf, i.e. the leaf stalk.

Pistil: Female reproductive structure of the flower. At the base is the ovary with one or more ascending stalk-like structures (styles) supporting the pollen receiving structure, the stigma (see stamen).

Sepal: Outer most structure of the flower. Similar to petals but usually green.

Stamen: Male reproductive structure of the flower. A stalk like structure (filament) with a pollen-producing anther at the tip (see pistil).

Stigma: Pollen receiving structure of the pistil. Usually located near the flower center, elevated above the ovary. The stigma is often sticky or hairy and sometimes lobed.

Terminal: At the end or tip of a structure.

Unisexual: Flowers that have either male or female fertile reproductive structures but not both (see bisexual, dioecious, monoecious).

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