Phase II 2009 Garcia River Sediment Source Assessment

Garcia River Forest, Mendocino County, California

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1 PROJECT SUMMARY

At the request of The Conservation Fund (TCF), Pacific Watershed Associates (PWA) assessed approximately 141 mi of forest roads within the portion of the Garcia River Forest located in the Garcia River watershed. Methodologies for the assessment adhered to procedures approved by the California Department of Fish and Game (CDFG) and detailed in the *California Salmonid Stream Habitat Restoration Manual*. This report, entitled *2009 Garcia River Sediment Source Assessment*, summarizes the results of the assessment of roads located within seven California Watershed Assessment Areas (CALWAAs). The seven inventoried CALWAAs include North Fork Garcia River, Victoria Fork, North of Gualala Mountain, East of Eureka Hill, Little Penney, Larmour Creek, and Rolling Brook. The Phase II individual reports by CALWAA for the North Fork Garcia and Victoria Fork were provided to TCF in January 2009. This report includes the assessment results for the entire Phase II Garcia River project area (including all seven CALWAAs). Individual reports for the North of Gualala Mountain, East of Eureka Hill, Little Penney, Victoria Fork, and Larmour Creek CALWAAs were provided to TCF in August 2009. The Phase II sediment source assessment completes the assessment of the entire 24,000 acre Garcia River Forest Property. The Phase I Assessment submitted in March 2008 included the assessment of roads within the Garcia River Forest ownership in the Signal Creek and Inman Creek CALWAAs.

Results of the Phase II Garcia River Sediment Source Assessment show that a total of 723 individual sites and approximately 58 mi of rock surfaced and unsurfaced roads—and associated ditches and cutbanks—either are currently eroding and delivering sediment to streams in the project area, or show a potential to do so in the future. PWA recommends treating 680 sites and approximately 57 mi of roads for erosion control and erosion prevention. Recommended treatment sites include 510 stream crossings, 57 landslides, 33 springs, 26 road drainage discharge points, 26 gullies, 19 ditch relief culverts, 5 bank erosion sites, and 3 “other” sites. Our analyses indicate that implementing the recommended treatments could prevent delivery of approximately 150,645 yd^3 of sediment to streams in the project area, including an estimated 56,115 yd^3 of fine sediment during the next decade alone from the chronic erosion of road, ditch, and cutbank surfaces. The total estimated cost to implement all recommended erosion control and erosion prevention treatments is $8,014,945.

The expected benefit of remediating the erosion problems described in this report lies in the reduction of long-term sediment delivery to streams in the Garcia River watershed that are important for fisheries production in California. This assessment includes prioritized recommendations for cost-effective erosion prevention and erosion control which, when implemented and employed in combination with protective land use practices, can be expected to contribute to the long-term improvement of water quality and salmonid habitat in the Garcia River Forest and the greater Garcia River watershed.

2 CERTIFICATION AND LIMITATIONS

This report, entitled *Phase II 2009 Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California*, was prepared under the direction of a licensed professional geologist at Pacific Watershed Associates Inc. (PWA), and all information herein is based on data and information collected by PWA staff. Sediment-source inventory and analysis for the project, as well as erosion control treatment prescriptions, were similarly conducted by or under the responsible charge of a California licensed professional geologist at PWA.

The interpretations and conclusions presented in this report are based on a study of inherently limited scope. Observations are qualitative, or semi-quantitative, and confined to surface expressions of limited extent and artificial exposures of subsurface materials. Interpretations of problematic geologic and geomorphic features (such as unstable hillslopes) and erosion processes are based on the information available at the time of the study and on the nature and distribution of existing features.

The conclusions and recommendations contained in this report are professional opinions derived in accordance with current standards of professional practice, and are valid as of the submittal date. No other warranty, expressed or implied, is made. PWA is not responsible for changes in the conditions of the property with the passage of time, whether due to natural processes or to the works of man, or changing conditions on adjacent areas. Furthermore, to be consistent with existing conditions, information contained in the report should be reevaluated after a period of no more than three years, and it is the responsibility of the landowner to ensure that all recommendations in the report are reviewed and implemented according to the conditions existing at the time of construction. Finally, PWA is not responsible for changes in applicable or appropriate standards beyond our control, such as those arising from changes in legislation or the broadening of knowledge, which may invalidate any of our findings.

Certified by:

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3 INTRODUCTION

Sediment delivery to stream channels from roads and road networks has been extensively documented, and is recognized as a significant impediment to watershed health and salmonid habitat (Furniss et al., 1991; Higgins et al., 1992; Harr and Nichols, 1993; Flosi et al., 1998; NMFS, 2000, 2001). Unlike many watershed improvement and restoration activities, erosion prevention through "storm-proofing" rural, ranch, and forest roads provides immediate benefits to the streams and aquatic habitat of a watershed (Weaver and Hagans, 1994, 1999; Weaver et al., 2006). It measurably diminishes the impact of road related erosion on the biological productivity of the watershed's streams, and allows future storm runoff to cleanse the streams of accumulated coarse and fine sediment, rather than continuing to allow accelerated anthropogenic erosion and sediment delivery from managed areas.

The Garcia River Forest (GRF) is a 24,000 acre working forest owned and operated by The Conservation Fund (TCF) in conjuction in southwestern Mendocino County (Map 1). It is located in the middle portions of the Garcia River watershed, and is a prime example of coastal redwood forestland. The GRF encompasses approximately 90% of the land area for the watersheds of the North Fork Garcia River, Signal Creek, Inman Creek, and Olsen Gulch. In addition, the GRF includes approximately 65% of the Graphite Creek and Indian Springs Creek subwatersheds, 35% of the Blue Waterhole Creek subwatershed, and numerous small unnamed subwatersheds. In total the GRF includes approximately 35 mi of fish-bearing streams that will provide critical refugia for the recovery of coho and fall chinook salmon, as well as steelhead trout within the North Coast region.

In 1994, the U.S. Environmental Protection Agency (EPA) listed the Garcia River as impaired by excessive sediment. In 1997, the North Coast Regional Water Quality Control Board (NCRWQCB) undertook studies to determine the extent of the sedimentation impacts on aquatic habitat in the Garcia River watershed, the primary sediment production processes, how much sedimentation was caused by human activities, and how much of the total estimated sediment production was controllable. The results of these studies were used to develop numeric targets for reducing sediment production from the various land use practices occurring throughout the watershed. In 1998 and 1999, the NCRWQCB, in cooperation with the Environmental Protection Agency (EPA), developed a “Total Maximum Daily Load” (TMDL) plan for the Garcia River basin (EPA, 1998), as well as the “Action Plan for the Garcia River Watershed Sediment TMDL”, which is the TMDL implementation plan (NCRWQCB, 2001). The 2001 NCRWQCB Action Plan requires all landowners in the Garcia River watershed to develop either: (1) comprehensive ownership-wide erosion control plans, or (2) comprehensive site-specific erosion control plans, in order to begin the process of meeting the numeric targets established for sediment.

In 2005, TCF and PWA applied to the CDFG Fisheries Restoration Grant Program for funding to begin to assess road related erosion problems within the GRF, and develop a plan for compliance with TMDL requirements in the Garcia River basin. The project was funded under CDFG contract #PO530404. This report summarizes the final assessment results completed by PWA for the Garcia River including 7 of the 13 CALWAAs established by the State for planning purposes within the 114 mi^2 Garcia River watershed. The 7 CALWAAs include North Fork Garcia, Victoria Fork, North of Gualala Mountain, East of Eureka Hill, Little Penney, Larmour Creek, and Rolling Brook (Map 1). Specifically, the purpose of this project was to (1) identify and quantify all current and potential erosion problems associated with selected access roads and significant spur roads on the property, and (2) develop a prioritized plan for long-term erosion control and erosion prevention for these roads.

In this report we provide results of the road history aerial photo analysis, field assessment and data analysis, and a prioritized list of recommendations for implementing erosion control and erosion prevention treatments to reduce road related erosion in the Garcia River project area. The report is intended to provide TCF with a comprehensive prioritized and site-specific erosion control plan for the watershed in order to meet the TMDL submittal requirements for the NCRWQCB. All treatment prescriptions follow guidelines described in the *Handbook for Forest and Ranch Roads* (Weaver and Hagans, 1994), as well as *Parts IX* and *X* of the California Department of Fish and Game *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003; Weaver et al., 2006). Assessment data are summarized in Tables 1-5, Maps 1, 3, 4, and 5; and Appendix B. Results of the aerial photo analysis for road construction and landslide histories are shown in Figure 1 and Map 2. Projected requirements for heavy equipment and estimated project costs are provided in Tables 6 and 7. Construction and installation instructions for the recommended erosion control and erosion prevention treatments are provided in Appendix C.

4 FIELD DESCRIPTION OF THE ASSESSMENT AREA

4.1 Location and Travel Directions to the Field Area

The Phase II Garcia River project area is located in southwestern Mendocino County, east of the town of Point Arena (Map 1). The area is accessed from the west by taking Mountain View Road (off US Highway 1 near Manchester, California) to Graphite Road at Gate 28. Two other alternative access routes to the project area beginning from US Highway 128 to the east are: (1) from the northeast, take Fish Rock Road to Hollow Tree Road at Gate 32; and (2) from the southeast, take Fish Rock Road to Signal Creek Road at Gate 49. Access via Signal Creek Road is currently the best option for vehicle access to the project area east of the mainstem Garcia River.

4.2 Climate, Terrain, and Local Geology

The climate of north-coastal California in the area of the Garcia River is characterized by dry, warm summers and cool winters with periods of intense rainfall and minor snow accumulation during cold storms. Mean annual precipitation is approximately 41-47 in., based on California Department of Water Resources rain gauges in Point Arena and the surrounding area, with most of the rainfall occurring between November and April.[1] Forests within the Garcia River project area primarily consist of expanses of redwood and Douglas fir with lesser amounts of tanoak woodland.

[1] Rainfall data acquired from: http://www.krisweb.com/krisgarcia/krisdb/webbuilder/selecttopic_climate.htm

The Garcia River project area includes both moderately steep, mountainous terrain and gently sloping grassland hillslopes with elevations ranging from approximately 40 ft to 2,692 ft (USGS, 1978, 1991a, 1991b, 1998). Rock surface and unsurfaced native roads in the project area traverse a range of elevations from ridge tops to the inner gorges of the mainstem Garcia River and several unnamed tributaries. High annual rainfall amounts, intense winter storms, and steep bedrock channel gradients in the project area give these streams a high capacity to transport sediment (The Conservation Fund, 2006).

The geology of the Garcia River project area is primarily composed of sheared and potentially unstable rocks of the Central Belt and Coastal Belt Franciscan Complex (Davenport, 1984a, b; Wagner and Bortugno, 1982). Poorly consolidated sedimentary and sheared metamorphic rocks that are particularly susceptible to erosion and mass wasting during periods of sustained or heavy rainfall are exposed throughout the watershed. The Franciscan Central Belt (Cretaceous-Jurassic) sedimentary rocks consist of well consolidated sandstone, siltstone, and shale with minor amounts of conglomerate. The rocks are structurally deformed and usually highly sheared, and according to Carver et al. (1984) also include units mapped as Franciscan broken formation. Rocks of the Coastal Belt Franciscan consist of poorly consolidated sedimentary and sheared metamorphic rocks that are particularly susceptible to erosion and mass wasting during periods of sustained or heavy rainfall. Quaternary alluvium and alluvial river terrace deposits are found in the lowland settings of valley floors. Large-scale mass wasting is evident in the watershed, often characterized by rotational or translational debris sliding and earthflows (Davenport, 1984a,b). Similar to many Northcoast watersheds, other mass wasting features such as hillslope debris slides, slumps, cutbank slides, and road fill failures are evident throughout the Garcia River project area. In addition, as the area is tectonically active (for example, the lowermost 10 mi of the Garcia River follows the San Andreas fault), there is a potential for landslides in the Garcia River project area to be triggered by local earthquakes.

Of significance for salmonid habitat, the combination of high rainfall and erodible, potentially unstable geologic substrate results in high rates of erosion and sediment delivery from road networks to stream channels. Streams in the Garcia River project area alternately traverse gorges with steep and unstable slopes, and low gradient areas characterized by sediment deposition and accumulation. Whereas salmonid populations have evolved and flourished with the natural processes of rainfall and erosion in the area, the impact of anthropogenically induced erosion (e.g., from resource management and road construction) has resulted in accelerated sediment delivery to streams and a degradation of salmonid habitat in this important watershed.

4.3 The Phase II Garcia River Project Area Road Network

Roads assessed for this project were constructed to support land use, transportation, and resource management activities during the last 7 decades. All project roads are within the bounds of the GRF, which encompasses about 30% of the Garcia River watershed (Maps 2, 3). Travel along the mainline road network and many of the spur roads is possible by field vehicles (trucks and ATVs; Map 3).

PWA assessed approximately 170 mi of maintained, unmaintained, and previously decommissioned roads in the Phase II Garcia River project area between 2006 and 2008. This includes approximately 29 mi of road within designated THP areas within the Phase II Garcia River Project area, specifically within the North Fork Garcia River and Rolling Brook CALWAAs. The current conditions of the three year-round mainline access roads (Graphite Road, Hollow Tree Road, and Signal Creek Road) are generally maintained, rock surfaced, have culverts installed at most stream crossings, and are drained through the use of infrequent ditch relief culverts and rolling dips. Most of these roads show some evidence of recent maintenance (e.g. brushing, culvert cleaning, and recent rocking). PWA observed that along many of the maintained road segments, excessively long inboard ditches are currently draining directly into stream crossings and hydrologically connected[2] ditch relief culverts. As a result, fine sediment from road surface runoff, ditch incision, and cutbank ravel is being delivered directly to the stream system.

The remaining roads in the watershed are either unmaintained roads (with or without rock surfacing) or decommissioned roads. Unmaintained roads include a most of the spurs leading from the three mainline roads. The unmaintained roads are partially overgrown, and include sites where PWA staff documented erosion problems at stream crossings and on fillslopes. Road that have already received decommissioning treatments are dispersed throughout Garcia River project area. These roads are typically overgrown and have been partially decommissioned by removing culverts and placing shallow dips through road fill at stream crossings, and constructing waterbars on the road surface.

5 FIELD TECHNIQUES AND DATA COLLECTION

The Phase II Garcia River Sediment Source Assessment project consists of three distinct elements: (1) an analysis of historic aerial photographs and digital imagery from 1965 to 1995 to document the construction of road networks and the development of large-scale erosion and sediment delivery features in the field area; (2) a complete field inventory of all current and potential road related erosion sources along nearly 141 mi of road; and (3) the development of a prioritized plan of action for cost-effective erosion control and erosion prevention treatments in the project area.

For the first phase of the project, PWA staff analyzed sequential historic aerial photographs and a set of digital imagery to document the history of road construction and the occurrence of large landslides within the Garcia River watershed. Three sets of aerial photographs and one set of National Agricultural Imagery Program (NAIP) digital imagery were used in the analysis. The aerial photo years and scales were 1965 (1:20,000), 1978 (1:24,000), 1995 (1:13,000); and 2004 (1:12,000); the NAIP imagery was for 2005 (CaSIL, 2005). Mylar overlays were used to trace the image of roads and landslides observed on the photographs. This information was transferred to a base map (1:13,000) and spatially digitized into ArcMap. The road construction and

[2] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

landslide occurrence histories were documented based on the first occurrences of the road or landslide feature on the historic aerial photographs and imagery.

To facilitate the field inventory, roads identified on the historical aerial photos were digitized and combined with data layers provided by TCF to produce composite base maps. These maps were used to document the locations of inventoried sites, and to ground truth the location and configuration of mapped road segments in the field. Roads that were not identified on the aerial photos but were located in the field were also mapped, included in the field inventory, and added to the GIS roads layer to produce updated final project maps.

For the second phase of the project, PWA completed a field inventory of the roads on TCF property in the Garcia River watershed, and assessed all road related sites and road segments showing evidence for erosion and sediment delivery to the stream system. Because the purpose of the inventory was to evaluate and quantify road related erosion in terms of its impact on fish bearing streams in the Garcia River, we excluded any sites or road reaches showing evidence for erosion that did not also show evidence for sediment delivery to a stream.

Inventoried sites for this assessment include stream crossings, potential and existing landslides related to the road system, springs, ditch relief culverts, sites of bank erosion, and drainage discharge points (roadside gullies) for uncontrolled road surface and/or inboard ditch runoff. For each site identified as a potential sediment source, PWA staff plotted its location on a GIS-generated map with a 1:12,000 scale aerial photograph base, and recorded a series of field observations including (1) detailed site description, (2) nature and magnitude of existing and potential erosion problems, (3) likelihood of erosion or slope failure, (4) length of hydrologically connected road surface associated with the site, and (5) treatments needed for prevention or elimination of future sediment delivery. The data collected for each site also included an evaluation of treatment immediacy[3], based on the potential or likelihood of sediment delivery from the site to a stream channel, and the level of urgency for addressing erosion problems at that location. Stream crossing sites were additionally evaluated for potential fish barrier problems.

For each inventoried site that also showed evidence for current or potential sediment delivery, PWA field staff collected field measurements (length, width, and depth of the erosion source area) to derive volumetric estimates for sediment delivery from the site. For most stream crossings, PWA field crews used tape and clinometer surveys to develop longitudinal profiles and cross sections of the site. These data were used to calculate road fill and potential sediment delivery volumes with the STREAM computer program. This proprietary software, developed by PWA, provides accurate and reproducible estimates of: (1) the potential volume of erosion at a stream crossing, whether over time or during any possible catastrophic, storm-generated washouts; (2) excavation volumes associated with culvert installation, culvert replacement, or complete decommissioning of a stream crossing; and (3) backfill volumes associated with culvert installation or replacement.

[3] *Treatment immediacy* is described in further detail in Appendix A.

In addition, field crews measured the lengths of hydrologically connected road to derive estimates for chronic sediment delivery, on a decadal basis, using the empirical formula: (measured length) x (25 ft average width, including cutbanks and ditches) x (0.2 ft average lowering of the road per decade).

Where new or replacement stream crossing culverts are recommended for installation, culverts are sized to convey the 100-year peak storm flow[4] including expected sediment and organic debris in transport. PWA staff calculated the necessary culvert sizes using either (1) the Rational Method (Dunne and Leopold, 1978), for drainage areas less than 80 acres; or (2) the empirical equations of the USGS Magnitude and Frequency Method (Wannanan and Crippen, 1977) for drainage areas equal to or larger than 80 acres. These culvert sizing calculations were used for stream crossings where the field-estimated bankfull channel dimensions were greater than approximately 3 ft by 1 ft in cross sectional area.[5]

In the final phase of the project, PWA personnel analyzed the inventory results to develop cost-effective erosion control and erosion prevention prescriptions, as well as a prioritized plan of action for the project area. Using field observations, data analyses, and information from the landowner about realistic needs for future road use, PWA staff assigned a treatment designation of either "upgrade" or "decommission" for each treatment site.[6] These designations are intended to provide the landowner with prescriptions and estimated costs for storm-proofing treatment sites and hydrologically connected road segments, and are our best recommendations for the most efficient and cost-effective methods to accomplish this goal.

6 RESULTS

The purpose of the assessment, including the field inventory and aerial photographic analyses of road construction and landslide development, was to identify and quantify all locations that either are currently eroding and delivering sediment to streams in the project area, or show a strong potential to do so in the future. Any on-going or potential erosion sites identified in the field that did not show evidence for sediment delivery to a stream were not included in the inventory. Although such sites may impact road maintenance, they do not represent a threat to water quality or fish habitat, and therefore were not applicable to this project.

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[4] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.

[5] For stream channels with cross sectional areas of 3 ft^2 or smaller, PWA follows the recommendations outlined in the California Department Fish and Game *Salmonid Stream Habitat Restoration Manual* and defaults to a minimum culvert size of 24 in.

[6] An overview of road upgrading and decommissioning, and terminology regarding sediment sources, are provided in Appendix A.

6.1 Road Construction History Based on Aerial Photographic Analysis

Using aerial photographs and NAIP digital imagery, PWA developed a history of road construction in the project area for 4 time periods: pre-1965, 1966-1978, 1979-1995, 1996-2004 (Figure 1, Map 2). Our measurements show that a total of 175.8 mi of roads were constructed within the Phase II Garcia River project area as of 2004 (Figure 1). Approximately 14.2 mi of skid trails were constructed during the same time period (Map 3). Roads plus skid trails total approximately 190 mi.

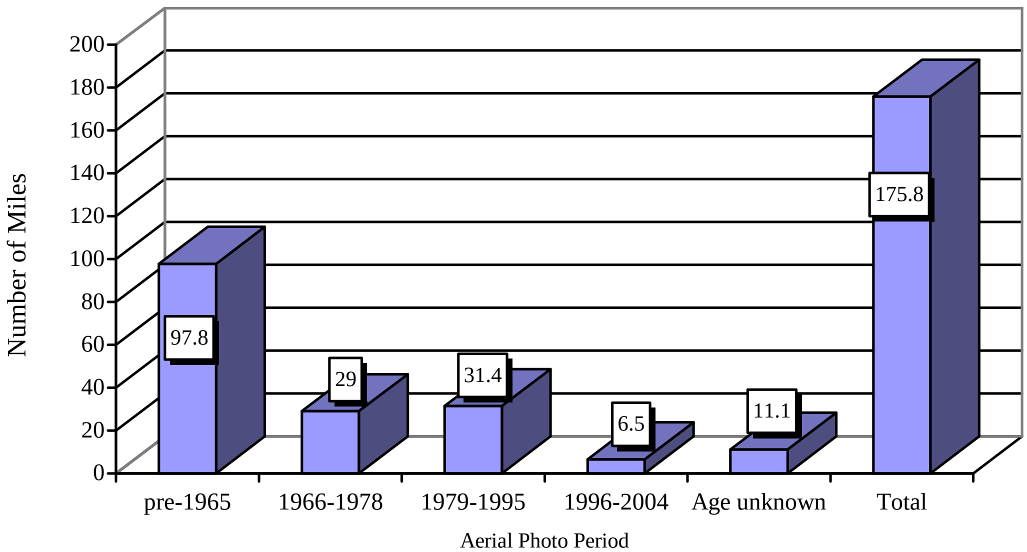

Figure 1. Road construction history for the area of the Garcia River Forest within the Phase II Assessment area (Mendocino County, California) based on analysis of historical aerial photographs and NAIP digital imagery.

By 1965 a total of 97.8 mi of road had been constructed in the Phase II Garcia River project area, which is 56% of the total road mileage (Figure 1). Roads constructed by 1965 include Hollow Tree Road, Graphite Road, , portions of the North Fork and Olsen Gulch Roads, and Signal Creek Road, and several associated spur roads (Map 2).

After 1965 but before 1978, an additional 29 mi of road were built in the Phase II project area, which is approximately 16% of the total road mileage (Figure 1). Roads constructed between 1965 and 1978 include the HT-4 Road, 41.3 Road, and portions of the Olsen Gulch and North Fork Roads, and spur roads used for timber harvesting in various upslope locations in the Garcia River project area (Map 2).

Approximately 31.4 mi of road were constructed between 1978 and 1995, which is approximately 18% of the total road mileage identified in the Phase II project area. Roads constructed during this time were primarily portions of the North Fork and 41.3 Roads, and numerous small road networks throughout the project area built for timber harvesting (Figure 1, Map 2).

Approximately 6.5 mi of roads were built after 1995 and before 2004 (Figure 1, Map 2), which is approximately 4% of the total road mileage for the Phase II project area. Finally, there are approximately 11.1 mi of roads of unknown age in the Phase II Garcia River project area that were not identified on the aerial photos but were documented during field work. We conclude that these roads were either overgrown and therefore obscured on the aerial photos, or were constructed after the last aerial photo year (2004).

6.2 Landslide History Based on Aerial Photographic Analysis

PWA used the same aerial photo sets and digital imagery as in the road construction study to document first occurrences of large mass wasting features (translational/rotational landslides, debris landslides, debris flows, and debris flow torrent tracks) in each of four time periods: pre-1965, 1966-1978, 1979-1995, and 1996-2004 (Figure 2, Maps 3). A total of 66 large landslides were identified within the Phase II project area during the entire time period studied including 21 landslides identified on the 1965 aerial photographs; 17 landslides identified on the 1978 aerial photographs; 28 landslides identified on the1995 aerial photographs, and no additional landslides identified on the 2004 photographs (Figure 2). As shown on Map 2, 76% of the observed landslides are located within the North Fork Garcia CALWAA.

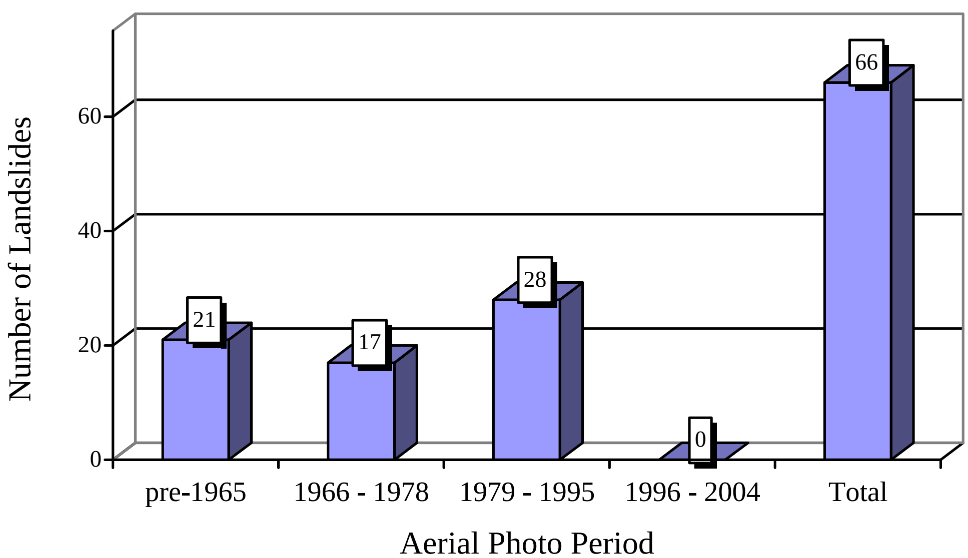

Figure 2. Landslide frequency distribution for the area of the Garcia River Forest within the Phase II Garcia River project area (occurrences of landslides during each of 4 time periods based on analysis of historical aerial photographs).

Numerous large storms capable of triggering mass wasting events have affected the Garcia River basin between 1956 and the present[7]. Examples of large storms in the Garcia River basin that are bracketed by the photography used in the aerial photo analysis occurred in 1956, 1965, 1966, 1974, 1986, and 1994. The relationship between large storms and landsliding is most evident when historic aerial photo years bracket the time of large storms. Twenty-eight (42%) of the landslides documented for the project area first appear on the 1995 photographs, which were taken just after the high peak discharge recorded in the Garcia River during the 1994 water year. In general for the project area, a large proportion of the landslides have occurred in areas where there has been extensive canopy reduction and ground disturbance from timber harvesting. The majority of the documented landslides appear to have been activated during large storm events in areas of steep topography that had been recently logged. A small number of the large landslides identified are deep seated features in the inner gorges of large channels, generated through landscape evolution processes. Our interpretation is that these deep-seated landslides are probably unrelated to land management practices

6.3 Summary of Field Data and Analyses

A total of 170 mi of road was inventoried as part of the Phase II 2009 Garcia River Sediment Source Assessment. As mentioned previously, approximately 29 mi was either assessed within designated THP areas or as appurtenant THP roads within the North Fork Garcia and Rolling Brook CALWAAs. PWA identified 117 sites along the 29 mi of THP-related roads, including 78 stream crossings, 15 landslides, 9 springs, 2 gullies, 1 road surface drainage point, and 1 “other” site. Treatment prescriptions for these THP-related sites were provided to The Conservation Fund for implementation during the 2007 equipment work season. Because the treatment prescriptions for the 117 THP-related sites have been implemented, they are no longer considered to be a sediment source risk and will not be discussed further in this report.

This following summary of the inventory field data and analyses only focuses on non THP-related sites inventoried along 141 mi of road within the Phase II 2009 Garcia River Sediment Source Assessment project area. From the 141 mi of inventoried non THP-related roads, PWA identified a total of 723 sites and 58.2 mi of hydrologically connected road surfaces as having the potential to deliver sediment to streams in the Phase II Garcia River project area (Maps 4, 5; Table 1a,b; Appendix B). We recommend that 680 of these sites and 57.4 mi of connected road segments be treated for erosion control and erosion prevention.

PWA recommends treatment for 510 stream crossings in the Phase II Garcia project area, which account for 75% of all treatment sites (Map 4, Table 1a, Appendix B). Inventoried stream crossing sites include: (1) 235 crossings with culverts, (2) 143 fill crossings, (3) 7 bridges, (4) 17 Humboldt crossings, (5) 33 armored fill crossing, and (6) 75 pulled crossings. We project that approximately 85,495 yd^3 of future road related sediment delivery will originate from stream crossings if they are left untreated, which is approximately 90% of total future site-specific sediment delivery for the Garcia River project area (Table 2). PWA identified 99 stream crossings on maintained and unmaintained roads that have drainage structures not sufficiently

[7] Flood and peak discharge data from: http://www.krisweb.com/krisgarcia/krisdb/webbuilder/selecttopic_climate.htm

designed for the 100-year peak storm flow (Table 3). A total of 237 stream crossings show a potential for stream diversion, and the stream is currently diverted at 31 crossings. Of the 235 existing culverts at stream crossings, 138 have a moderate or high potential to become plugged by sediment and debris (Table 3).

Field crews identified 61 potential road fill landslides in the Phase II Garcia River project area, and recommends 57 for treatment (Map 4; Table 1a, Appendix B). We project that approximately 7,345 yd^3 of future road related sediment delivery will originate from road fill landslides if they are left untreated (Table 2). This is approximately 8% of total episodic future sediment delivery for the project area.

PWA inventoried 36 springs contributing to sediment delivery in the project area, and recommends 33 for treatment (Table 1a). The total estimated potential episodic sediment delivery from spring sites is approximately 455 yd^3 (Table 2).

Table 1a. Inventory results for sediment delivery sites and hydrologically connected road segments, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Sources of sediment delivery	**Sediment delivery sites**		**Hydrologically connected roads adjacent to sites**		**Total length of roads surveyed for project (mi)**
	Inventoried (#)	**Recommended for treatment (#)**	**Inventoried (mi)**	**Recommended for treatment (mi)**	
Stream crossings	543	510	44.9	44.3	-
Landslides	61	57	2.2	2.1	-
Springs	36	33	3.0	3.0	-
Road drainage discharge points	27	26	3.5	3.4	-
Gullies	26	26	2.4	2.4	-
Ditch relief culverts	21	19	2.1	2.1	-
Bank Erosion	5	5	<0.1	<0.1	-
Other[a]	3	3	0.1	0.1	-
Total	**723**	**680**	**58.2**	**57.4**	**140.9**

Note: Definitions for sediment delivery sources are provided in Appendix A.
[a]*Other* sources of sediment delivery are specified in Table 1b, and include: 4 discharge points at the road surface low point; 3 sites of bank erosion; and 1 non-road related upslope gully.

Table 1b. Sediment delivery sites included in the "Other" category in Table 1 and Maps 4 and 5, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Site #	"Other" sediment delivery sites	Recommended for treatment (Y/N)
1120	Swale	Y
1337	Swale	Y
1378	Non-road related upslope gully	Y

Table 2. Estimated future sediment delivery for sites and road surfaces recommended for treatment, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Sources of sediment delivery	Estimated future sediment delivery (yd^3)	Percent of total
1. Episodic sediment delivery from road related erosion sites (indeterminate time period)		
Stream crossings	85,495	90%
Landslides	7,345	8%
Springs	455	<0.1%
Road drainage discharge points	205	<0.1%
Gullies	210	<0.1%
Ditch relief culverts	95	<0.1%
Bank Erosion	725	0.7%
Other	0	0%
Total episodic sediment delivery	**94,530**	**100%**
2. Chronic sediment delivery from road surface erosion (estimated for a 10 yr period)[a]		
Total chronic sediment delivery	**56,115**	
Total estimated future sediment delivery for the project area	**150,645**	

[a]Sediment delivery from treatment sites for unsurfaced roads is calculated for a 10 yr period. It assumes a combined width of 25 ft for the road, ditch, and cutbank contributing area, and an empirical value of 0.2 ft/10 yr for road surface lowering and cutbank retreat.

Table 3. Erosion problems at stream crossings, Garcia River Sediment Source Assessment, Phase II Garcia River Forest, Mendocino County, California.

Stream crossing problem	# Inventoried	% of total[a]
Stream crossings with diversion potential	237	44%
Stream crossings currently diverted	31	6%
Crossings with culverts likely to plug[b]	138	25%
Crossings with culverts that are currently undersized[c]	99	18%

[a]From table 1, total stream crossings inventoried = 543.
[b]Culvert plug potential is moderate to high.
[c]Culverts in stream channels larger than 3 ft x 1 ft that are too small to convey the calculated 100-year peak storm flow.

PWA identified 27 discharge points for road surface drainage that require treatment (Map 4, Table 1a). A drainage discharge point is a location where concentrated road surface runoff is able to exit the road and reach the stream system. It may simply be a low spot in the road, and therefore have no site-specific sediment delivery, or involve gully formation, in which the projected amount of sediment delivered from the site will be based on estimated amounts of gully enlargement. The total estimated potential episodic sediment delivery from spring sites is approximately 205 yd^3 (Table 2). Some of the discharge points for road surface identified in the Phase II Garcia River field area do not have associated gully formation, and therefore there is no projected site-specific sediment delivery at these sites. However, each of these sites is currently serving as a conduit for sediment delivery from adjacent hydrologically connected road surfaces and inboard ditches, and therefore should be carefully considered for erosion control treatments.

Ditch relief culverts are designated as sites if they show evidence for site-specific future erosion potential, are functioning as conduits for delivery of road surface sediment, or both. PWA identified 21 ditch relief culverts in the Phase II Garcia River project area, and recommends 19 for treatment (Map 4, Table 1a, Appendix B). Ditch relief culverts represent 3% of all treatment sites, with a projected potential site-specific sediment delivery of approximately 95 yd^3 (Table 2).

PWA recommends treatment for 26 inventoried road-related gullies (Map 4; Tables 1a, 2; Appendix B). Road-related gullies represent 4% of the treatment sites. If left untreated, we project that the future sediment delivery from these sites will be approximately 210 yd^3.

Five bank erosion sites were identified by PWA crews in the Phase II Garcia River project area (Map 4, Table 1a, Appendix B). These sites are located on the outboard edge of full bench roads constructed parallel to the stream channel, and either adjacent to or on the streambank. Bank erosion sites represent nearly 1% of all treatment sites, with a projected potential site-specific sediment delivery of approximately 725 yd^3 (Table 2).

Finally, 3 “other” sites were identified in the Phase II project area (Map 4, Table 1a, Appendix B). “Other” sites include 2 swales and 1 non-road related upslope gully (Table 1b). The 3 “other” sites do not have associated gully formation, and therefore there is no projected site-specific sediment delivery at these sites. However, these sites do act as conduits for sediment delivery from adjacent hydrologically connected road surfaces and inboard ditches, and therefore have been recommended for erosion control treatments.

Of the nearly 141 mi surveyed, PWA field crews measured approximately 58.2 mi of road surfaces and/or ditches currently draining to stream channels either directly or via gullies, of which 57.4 mi are recommended for treatment (Map 4; Table 1a). From these hydrologically connected road segments, we estimate that approximately 56,115 yd^3 of sediment could be delivered to stream channels in the project area during the next decade if no efforts are made to change road drainage patterns (Table 2). This volume represents about 37% of the total estimated potential sediment delivery volume for the project area based on current data for the project (150,645 yd^3; Table 2). We emphasize, however, that the estimate for chronic sediment delivery from road surfaces is calculated for a 10 yr period, and over longer time periods (for example, in comparison to the typical multi-decadal lifespan of a culvert) the potential amount of sediment delivery from untreated road/ditch surfaces in the project area could be much greater.

Of the 680 inventoried sites recommended for treatment, we designate 125 with priority ratings of high or high-moderate (Map 5; Tables 4a, 4b; Appendix B). The potential episodic sediment delivery (over an indeterminate time period) for the 125 sites is approximately 31,030 yd^3, which is about 33% of the projected episodic sediment delivery for the project area. There are a total of 11.8 mi of hydrologically connected road segments associated with these sites, which, we project, could deliver an additional 11,470 yd^3 of sediment to streams in the project area during the next decade.

We assign moderate or moderate-low priorities to 425 sites, which include a total of 39.2 mi of associated hydrologically connected road reaches. Estimated future sediment delivery for the 425 sites is approximately 56,735 yd^3. We project that the hydrologically connected road segments adjacent to these sites could deliver approximately 38,420 yd^3 of sediment to the stream system during the next 10 years. We assign a low priority to 130 sites, which have a total of 6.4 mi of associated hydrologically connected road segments. Estimated potential sediment delivery for the sites is approximately 6,765 yd^3, with an additional 6,225 yd^3 of sediment projected to be delivered from the road reaches during the coming decade (Map 5; Tables 4a, 4b).

6.4 Problematic or Complex Sites

6.4.1 Sites with high treatment immediacy and erosion potential

Our field data show that 28 sites particularly show evidence for imminent erosion and sediment delivery, and require immediate attention: #801, 803, 804, 808, 1117, 1329, 1331, 1265, 1267, 1280, 1495, 1521, 1524, 1526, 1581, 1602, 1648, 1650, 1652, 1665, 1744, 1745, 1749, 1770, 1819, 1829, 1839, and 1866 (Map 5; Appendix B).

Table 4a. Treatment immediacy ratings for sediment delivery sites and associated lengths of hydrologically connected road, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Treatment immediacy	Treatment sites				Estimated future sediment delivery from inventoried erosion sites[d]		Estimated future sediment delivery from road, ditch, and cutbank surfaces[e]	
	Upgrade sites[a] [site #]	Road length[c] (mi)[a]	Decommission sites[b] [site #]	Road length[c] (mi)[a]	(yd^3)	%	(yd^3)	%
High	15 Stream crossings 2 Landslides 1 Spring 1 Ditch relief culvert 1 Gully	1.4	2 Stream crossings 2 Landslides	0.2	5,605	6%	1,525	3%
High-moderate	77 Stream crossings 7 Landslides 1 Spring 3 Gullies 1 Bank erosion	9.7	4 Stream crossings 5 Landslides 1 Gully 2 Bank erosion	0.5	25,425	27%	9,945	18%
Subtotal	*109 sites*	*11.1*	*16 sites*	*0.7*	*31,030*	*33%*	*11,470*	*21%*
Moderate	150 Stream crossings 11 Landslides 3 Springs 8 Ditch relief culverts 8 Road drainage discharge points 6 Gullies 1 Bank erosion	20.2	24 Stream crossings 8 Landslides 1 Spring 2 Bank erosion	2.2	39,100	41%	21,930	39%
Moderate-Low	127 Stream crossings 9 Landslides 13 Springs 4 Ditch relief culverts 8 Road drainage discharge points 8 Gullies	14.6	22 Stream crossings 3 Landslides 4 Springs 2 Road drainage discharge points 3 Gullies	2.2	17,635	19%	16,490	29%
Subtotal	*356 sites*	*34.8*	*69 sites*	*4.4*	*56,735*	*60%*	*38,420*	*68%*

Table 4a. Treatment immediacy ratings for sediment delivery sites and associated lengths of hydrologically connected road, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Treatment immediacy	Treatment sites				Estimated future sediment delivery from inventoried erosion sites[d]		Estimated future sediment delivery from road, ditch, and cutbank surfaces[e]	
	Upgrade sites[a] [site #]	Road length[c] (mi)[a]	Decommission sites[b] [site #]	Road length[c] (mi)[a]	(yd^3)	%	(yd^3)	%
Low	67 Stream crossings 10 Landslides 9 Springs 6 Ditch relief culverts 5 Road drainage discharge points 4 Gullies 2 Other	4.9	22 Stream crossings 1 Spring 3 Road drainage discharge points 1 Other	1.5	6,765	7%	6,225	11%
Total	**568 upgrade sites**	**50.8**	**112 decommission sites**	**6.6**	**94,530**	**100%**	**56,115**	**100%**

[a]Upgrade sites: 436 stream crossings, 39 landslides, 19 ditch relief culverts, 27 springs, 21 road drainage discharge points,.22 gullies, 2 bank erosion, and 2 other sites(568 upgrade sites total).
[b]Decommission sites: 74 stream crossings, 18 landslides, 6 springs, 5 road drainage discharge points, 4 gullies, 4 bank erosion, and 1 other site (112 decommission sites total).
[c]*Road length* refers to hydrologically connected road reaches adjacent to recommended treatment sites.
[d]Episodic sediment delivery for road related sites (indeterminate time period).
[e]Chronic sediment delivery from adjacent hydrologically connected roads and cutbanks (estimated for a 10 yr period).

Table 4b. Individual upgrade and decommission sites listed by treatment immediacy, Phase II Garcia River Sediment Source Assessment, Mendocino County, California.

Site type	Upgrade site ID #	Decommission site ID #
High treatment immediacy		
Stream crossing	#1117, 1208, 1225, 1265, 1267, 1274, 1280, 1581, 1648, 1650, 1652, 1658, 1659, 1700, 1770	#116.1, 1495
Landslide	#1329, 1331	#1602, 1665
Spring	#1660	-
Ditch relief culvert	#1699.1	-
Gully	#1630	-
High-moderate treatment immediacy		
Stream crossing	#801, 803, 804, 806, 808, 1041, 1043, 1047, 1073, 1076, 1139, 1166, 1168, 1209, 1211, 1212, 1219, 1224, 1251, 1262, 1266, 1268, 1276, 1278, 1288, 1289, 1290, 1291, 1295, 1390, 1401, 1413, 1417, 1422, 1425, 1431, 1443, 1447, 1469, 1470, 1470.1, 1471, 1472, 1473, 1477.2, 1479, 1509, 1521, 1524, 1526, 1529, 1577, 1580, 1583, 1594, 1608, 1617, 1628, 1634, 1682, 1683, 1698, 1705, 1713, 1714, 1724, 1744, 1745, 1749, 1752, 1763, 1769, 1824, 1829, 1832, 1846, 1866	#1498, 1641, 1701.1, 1839
Landslide	#1118, 1300, 1333, 1341, 1475, 1681, 1685	#1277, 1304, 1402, 1586, 1662
Spring	#1050	-
Gully	#1269, 1582, 1819	#1409
Bank Erosion	#1392	#1368, 1585
Moderate treatment immediacy		
Stream crossing	# 802, 807, 811, 1036, 1037, 1045, 1046, 1056, 1057, 1058, 1072, 1080, 1110, 1112, 1113, 1114, 1125, 1126, 1132, 1137, 1138, 1140, 1160, 1161, 1163, 1163.1, 1163.2, 1165, 1170, 1200, 1203, 1204, 1205, 1206, 1221, 1222, 1223, 1241, 1250, 1253, 1259, 1263, 1264, 1270, 1272, 1273, 1282, 1283, 1284, 1286, 1293, 1294, 1297, 1299, 1299.1, 1299.2, 1301, 1327, 1330, 1332, 1339, 1386, 1388, 1399, 1414, 1415, 1423, 1424, 1429, 1430, 1441, 1448, 1449, 1455, 1466, 1477, 1482, 1505, 1512, 1517, 1523, 1525, 1537, 1546, 1561, 1565, 1575, 1576, 1587, 1588, 1589, 1590, 1592, 1605, 1609, 1610, 1618, 1620, 1626, 1633, 1635, 1644, 1644.1, 1644.2, 1644.4, 1645, 1649, 1653, 1657, 1688, 1699, 1701, 1706, 1711, 1715, 1720, 1723.1, 1727, 1728, 1730, 1731, 1732, 1734, 1739, 1742, 1743, 1748, 1751, 1753, 1754, 1757, 1759, 1760, 1765, 1767, 1804, 1817, 1823, 1825, 1831, 1845, 1849, 1850, 1853, 1856, 1861, 1865, 1870, 1874	#1101.1, 1121.1, 1167, 1248, 1326, 1328, 1340, 1359, 1361, 1369, 1379, 1381, 1403, 1458, 1493, 1545, 1549, 1552, 1560, 1593, 1838, 1840, 1841, 1851
Landslide	#1042.2, 1104, 1119.2, 1258, 1400, 1419, 1468, 1520, 1607, 1639, 1647	#1307, 1380, 1418, 1420, 1536, 1544, 1600, 1664
Spring	#1051, 1061, 1115	#1812
Ditch relief culvert	#1393, 1477.1, 1481, 1516, 1519, 1702, 1719, 1762	-
Gully	#1133, 1478, 1513, 1814, 1867, 1871	-
Road surface drainage points	#1071, 1219.1, 1446, 1456, 1522, 1532, 1554, 1591	-
Bank Erosion	#1570	#1136, 1564
Moderate-low treatment immediacy		

Table 4b. Individual upgrade and decommission sites listed by treatment immediacy, Phase II Garcia River Sediment Source Assessment, Mendocino County, California.

Stream crossing	#804.1, 805, 809, 1042, 1053, 1063, 1070, 1081, 1100, 1101, 1108, 1119, 1121, 1131, 1171, 1202, 1210, 1213, 1215, 1217, 1218, 1243, 1245, 1246, 1257, 1281, 1285, 1287, 1298, 1335, 1336, 1357, 1382, 1385, 1387, 1389, 1391, 1395, 1427, 1428, 1433, 1434, 1436, 1440, 1462, 1463, 1474, 1485, 1500, 1504, 1507, 1508, 1510, 1511, 1515, 1528, 1530, 1538, 1555, 1562, 1566, 1568, 1569, 1571, 1574, 1584, 1611, 1616, 1623, 1627, 1631, 1636, 1643, 1644.3, 1646, 1654, 1655, 1656, 1678, 1679, 1680, 1684, 1686, 1689, 1690, 1691, 1696, 1697, 1703, 1709, 1722, 1725.1, 1726, 1733, 1735, 1736, 1738, 1740, 1741, 1746, 1750, 1753.1, 1755, 1756, 1758, 1760.1, 1800, 1801, 1805, 1807, 1809, 1815, 1818, 1826, 1828, 1833, 1834, 1842, 1843, 1844, 1852, 1854, 1855, 1858, 1860, 1868, 1873	#1247, 1356, 1362, 1363, 1373, 1375, 1377, 1404, 1407, 1408, 1411, 1453, 1460, 1496, 1499, 1543, 1550, 1551, 1564.1, 1604, 1640, 1820
Landslide	#1044, 1052, 1059, 1060, 1128, 1130, 1255.1, 1270.1, 1710	#1169, 1374, 1701.2
Spring	#1039, 1068, 1111, 1207, 1254, 1334, 1467, 1527, 1567, 1606, 1619, 1806, 1848	#1067, 1305, 1802, 1813
Ditch relief culvert	#1480, 1708, 1712, 1768	
Gully	#1275, 1292, 1397, 1464, 1465, 1514, 1869, 1872	#1461, 1497, 1603
Road surface drainage points	#1035, 1042.1, 1055, 1164, 1501, 1531, 1558, 1847	#1366, 1535
Low treatment immediacy		
Stream crossing	#800, 1038, 1040, 1054, 1064, 1069, 1102, 1103, 1105, 1107, 1122, 1129, 1162, 1201, 1220, 1240, 1242, 1244, 1249, 1252, 1255, 1279, 1382.1, 1396, 1421, 1426, 1439, 1442, 1445, 1451, 1454, 1483, 1484, 1502, 1503, 1556, 1572, 1573, 1579, 1622, 1624, 1625, 1629, 1637, 1644.5, 1651, 1661, 1663, 1687, 1704, 1718, 1721, 1723, 1725, 1729, 1737, 1752.1, 1761, 1764, 1808, 1830, 1836, 1857, 1859, 1862, 1863, 1875	#1122.1, 1306, 1358, 1360, 1364, 1367, 1370, 1405, 1406, 1410, 1459, 1540, 1541, 1601, 1642, 1675, 1810, 1821, 1822, 1827, 1835, 1837
Landslide	#1048, 1062, 1065, 1127, 1138.1, 1216, 1432, 1557, 1578, 1615	-
Spring	#1066, 1120.1, 1256, 1435, 1452, 1563, 1632, 1638, 1766	#1811
Ditch relief culvert	#1106, 1109, 1296, 1383, 1716, 1717	-
Gully	#1214, 1437, 1438, 1864	-
Road surface drainage points	#1049, 1134, 1518, 1553, 1621	#1131.1, 1135, 1376
Other	#1120, 1337	#1378

Sites #801, 803, 804, and 808 are stream crossings that drain to the same Class II tributary stream on the south side of the mainstem Garcia River within the North of Gualala Mountain CALWAA (Maps 4, 5). Each site possesses a high-moderate treatment immediacy rating, as well as an erosion potential rating of high or high-moderate (Map 5; Tables 4a, 5b; Appendix B). Site #808 is a culverted crossing with a high erosion potential. The culvert inlet is crushed and 90% plugged, which is causing the stream to divert down the road during high flows. This site also has nearly 1,200 ft of hydrologically connected road surface draining directly to the stream crossing. Stream crossing sites #801 and 803 (fill crossings) and 804 (a culverted crossing) exhibit high-moderate erosion potentials. The road fill is actively being eroded at these sites, and the stream is either already being diverted or shows a clear potential to divert in future during large storm events. PWA recommends upgrading these sites with properly installed culverts designed and sized for the 100-year peak storm flow. In addition to the site specific treatments, adequate road drainage structures and road surface treatments should be applied along hydrologically connected road surfaces.

Site #1117 is a stream crossing located within the North Fork Garcia CALWAA on Road OG-1 (an unmaintained, native surface road). The site is a crossing of a Class II stream with an approximately 2ft wide by 1 ft deep channel (Maps 4, 5; Appendixes A, B). The crossing currently includes a 24in diameter culvert with a past and potential fill failure along the entire outboard edge of the crossing. We strongly recommend that site #1117 be treated immediately to prevent further erosion and sediment delivery to Olsen Gulch, which we estimate could total 590 yd^3 from this location. Treatment should include installing a new culvert properly sized for the drainage area and an engineered retaining structure to stabilize outboard fill (Maps 4, 5; Appendixes A, B).

Sites #1329 and 1331 are landslides located within the North Fork Garcia CALWAA on Road NF-6 (an unmaintained and native surface road). Each landslide site has a high rating for treatment immediacy and erosion potential. Site # 1329 is a road fill landslide located directly above a Class II stream. The site has failed in the past, and field data suggest it has the potential to reactivate. We strongly recommend that site #1329 be treated immediately to prevent further erosion and sediment delivery of approximately 280 yd^3 to the North Fork Garcia River (Appendix B). Treatment should include the excavation of potentially unstable road fill along the outboard fill edge (Maps 4, 5; Appendixes A, B).

Site #1331 is a past and potential hillslope debris slide that delivered directly to a Class II tributary to the North Fork Garcia River. The entire road prism has failed for approximately 95 ft of the road alignment and lateral landslide scarps extend upslope through a steep 100% gradient cutbank. Approximately 265 yd^3 of sediment is expected to fail from remaining native hillslope material perched in the center of the landslide feature. If this road is intended for future use, treatment should include the full reconstruction of the road alignment including the excavation of any remaining unstable native hillslope materials.

Sites #1265, 1267, and 1280 are stream crossings on Road BW-1 within the Victoria Fork CALWAA. Each has high ratings for treatment immediacy and erosion potential, and is actively eroding during the winter months. Site #1265 is on a Class II stream, and delivers year-round. It is an actively collapsing Humboldt crossing, and field measurements indicate that more than 165 yd^3 of unconsolidated sediments could erode into the stream system from this site if no actions are taken. Site #1267 crosses a 3 ft x 1 ft stream, and there is currently a 6 ft deep headcut that has eroded to the middle of the roadbed through the fill crossing. Problems at Site #1280 include a rusty, inadequately placed culvert, erosion gullies that have formed on the fillslope, and a 4 ft high eroding headcut above the culvert inlet. PWA recommends upgrading these 3 sites with adequately installed and sized culvert drainage structures for 100 year storm events (Maps 4, 5; Appendixes A, B).

Sites #1495 and 1602 are on Road BW-3 within the Victoria Fork CALWAA, which has been inadequately decommissioned. Site #1495 is crossing at a 4 ft x 1 ft Class II stream. It is nearly

40% pulled, with remaining vertical fillslopes calving continually into the stream. Site #1602 is a potential road fill failure threatening to deliver directly to a Class II (possibly Class I) stream. This stretch of road is located approximately 20 ft above a year-round stream and has experienced several small failures in the past. PWA strongly recommends appropriately decommissioning this portion of Road BW-3 and treating these 2 high priority sites.

Sites #1521, 1524, and 1526 are culverted stream crossings on the H2-T Road (the main seasonal access road) on the north side of the mainstem Garcia River within the North of Gualala Mountain CALWAA. The erosion potential at site #1524 is high because of an undersized and improperly installed culvert. The gradient for the Class II stream is approximately 36%, but the culvert – which is undersized for the drainage area—was installed at a gradient of only 3%. As a result, the culvert outlet is perched ("shotgunned") 25 ft above the outboard road fill, resulting in high-energy discharge from the culvert that is actively eroding the outboard fillslope. Treating this site will require installing a new culvert properly sized for the 100-yr storm flow at the base of the fill and in line with the natural stream grade. This will require a steep and deep excavation in order to properly position the new culvert to prevent future erosion problems. Stream crossing sites #1521 and 1526 exhibit high-moderate erosion potential ratings and are both located on large Class II streams. These sites have culverts that are too small to convey the 100-yr storm flow, and show evidence for the streams having overtopped the crossing fills in the past. Currently at site #1521 there is a 6 ft wide gully cutting through the road surface and the bare outboard fillslope which will continue to enlarge if left untreated. PWA recommends upgrading these sites with properly installed culverts designed and sized for the 100-year peak storm flow. In addition to the site specific treatments, adequate road drainage structures and road surface treatments should be applied along hydrologically connected road surfaces.

Site #1581 is located on the 41 Road (an abandoned road) within the East of Eureka Hill CALWAA, and is a crossing of a Class II stream with an approximately 6ft wide by 1 ft deep channel (Maps 4, 5; Appendixes A, B). The crossing currently includes a 30in diameter culvert with a 100% plugged inlet, which allows the stream to overtop the road during high flows. As a result, a large gulley (100 ft long × 50ft wide ×15ft deep) has cut through the road fill and adjacent hillslope. Flow from subsurface piping also enters the gully at several locations, further decreasing the stability of the crossing. We strongly recommend that site #1581 be treated immediately to prevent further erosion and sediment delivery to the Garcia River, which we estimate could total 590 yd^3 from this location. Treatment should include installing a new culvert properly sized for the drainage area.

Sites # 1648, 1650, and 1652 are stream crossings on the 41.3.2 Road within the East of Eureka Hill CALWAA, each of which is assigned high ratings for treatment immediacy and erosion potential (Maps 4, 5; Table 4a, 4b; Appendixes A, B). Site #1648 is an actively eroding fill crossing on a Class II stream. The crossing has nearly vertical banks, and sediment delivery occurs year-round and is accelerated during winter months. If left untreated, field data show that approximately 110 yd^3 of unconsolidated sediment could be delivered directly into the stream system at this site. Site #1650 is an actively eroding fill crossing on a Class III stream. Currently, a 10 ft deep headcut has eroded into the middle of the roadbed through the fill crossing. If left untreated, this site has the potential to deliver approximately 150 yd^3 of sediment to the stream system. Site #1652 is an actively eroding Humboldt crossing on a Class III stream with near vertical stream banks. Field measurements at this site indicate that nearly 200 yd^3 of sediment could be delivered to streams if no actions are taken. PWA recommends properly decommissioning these 3 sites by removing all unstable road fill and laying back the sideslopes to stable (~2:1) angles

Site #1665 is a potential landing fill landslide located on the 41.3.2.1 Spur 1 Road within the East of Eureka Hill CALWAA. This landslide has failed in the past, and field data suggest it has the potential to reactivate. There are 3 major gullies on the landslide scar surface as well as numerous rills, and spring flow is actively emerging at the base of the landslide head scarp. Field measurements indicate a potential for a at least 300 yd^3 of erosion and sediment delivery from this site, with possible delivery of approximately 1,000 yd^3 of sediment should catastrophic failure occur under saturated conditions on the steep slope.

Sites #1744 and #1745 are stream crossings located within the Little Penney CALWAA on the Hollow Tree Road, a maintained year-round use road (Maps 4, 5; Appendixes A, B). Site #1744 is a crossing of a Class II stream that is approximately 5 ft wide by 1.5 ft deep. The crossing currently includes an undersized 18 in. diameter culvert with a crushed inlet. The stream overtops the road during high flows, and as a result a gully has cut through the road fill and adjacent hillslope. We strongly recommend that site #1744 be treated immediately to prevent further erosion and sediment delivery of approximately 265 yd^3 from the crossing and adjacent road reaches to the Garcia River (Appendix B). Treatment should include installing a new culvert properly sized for the drainage area.

Site #1745 is a complicated stream crossing that conveys flow from 3 moderately sized Class II streams through an undersized 30 in. diameter culvert. The streams converge about 300 ft above the crossing on Hollow Tree Road, and are each about 1 ft deep and range from 4 to 6 ft wide. The stream channel between the confluence and the culvert inlet is heavily aggraded and braided. At the crossing, the culvert is placed far to the left of the natural stream alignment and as a result culvert discharge has caused erosion along the left stream bank. Field measurements show that erosion and sediment delivery from the site to the Garcia River could be as great as 350 yd^3 with an additional 130 yd^3 from chronic erosion of 700 ft of hydrologically connected road leading to the site (Appendix B). PWA strongly recommends that site #1745 be treated immediately by installing a new culvert that is properly sized for the drainage area and aligned with the natural stream channel.

Sites #1749 and #1770 are stream crossings located within the Larmour Creek CALWAA on the Hollow Tree Road, a maintained year-round use road (Maps 4, 5; Appendix B). Site #1749 is a crossing of a Class II stream that is approximately 5 ft wide by 1.5 ft deep. The crossing currently includes a culvert that is undersized (24 in. diameter) and plugged at the inlet. Further, the culvert was installed approximately 70 ft down the road from the natural stream alignment. As a result of the poor culvert placement, a gully has formed and cut through the road fill and adjacent hillslope. We strongly recommend that site #1749 be treated immediately to prevent further erosion and sediment delivery Garcia River, which we estimate at 505 yd^3 from erosion at the crossing and from adjacent road reaches (Appendix B). Treatment should include

installing a new culvert properly sized for the drainage area and aligned with the natural stream channel.
Site #1770 is a crossing of a Class III stream that is approximately 2 ft wide by 0.5 ft deep. The crossing currently has no drainage structure and therefore the stream overtops the road during high flows. As a result, a gully has formed that cuts through the road fill and adjacent hillslope. Treatment at this site should include: (1) installing a culvert properly sized for the drainage area and aligned with the natural stream channel; and (2) constructing a critical dip to prevent future stream diversions.

Site # 1819 is a roadside gully located on the HT-9 Road within the Little Penney CALWAA, which is a maintained seasonal use road (Maps 4, 5; Table 4a, 4b; Appendix B). The gully acts as a conduit to deliver concentrated flow from long sections of the HT-8 and HT-9 Roads (approximately 830 ft and 150 ft, respectively) to the headwaters of a Class III stream. Field measurements indicate a potential for 185 yd^3 of sediment delivery via this gully over the next decade if no efforts are made to treat the problem. Treatment should include installing rolling dips to disperse surface runoff along the 980 ft of hydrologically connected road currently delivering concentrated flow to the site.

Site #1829 is located within the Larmour Creek CALWAA on the HT-14-2 Road (a decommissioned road). It is a crossing of a Class III stream with a channel approximately 3 ft wide by 1 ft deep (Maps 4, 5; Appendix B). The crossing currently includes a partially decommissioned armored fill. A large sink hole is developing on the outboard edge of the remaining road fill and a large gully is actively eroding the downstream fillslope. We strongly recommend that site #1829 be treated immediately to prevent further erosion and sediment delivery of approximately 480 yd^3, from the crossing and adjacent road reaches, to the Garcia River (Appendix B). Since the road is intended for future use, the treatment at this site should include: (1) installing a new culvert properly sized for the drainage area and aligned with the natural stream channel; and (2) outsloping the adjacent hydrologically connected road reaches for a total of approximately 630 ft.

Site # 1839 is a stream crossing located within the Larmour Creek CALWAA on the HT-11 spur, downstream from Site #1838 on the HT-11 Road (Maps 4, 5; Appendix B). It is a crossing of a Class II stream that is approximately 4 ft wide by 1 ft deep. A large active gully with steep and bare sideslopes is currently eroding through the entire fill prism; field measurements indicate past sediment delivery of approximately 320 yd^3. We strongly recommend that site #1839 be treated immediately to prevent further erosion and sediment delivery of approximately 230 yd^3 from the crossing and adjacent road reaches to the Garcia River (Appendix B). Treatment should include fully decommissioning the stream crossing by excavating the fill down to the natural channel, and laying sideslopes back to a 2:1 configuration.

Site #1866 is located within the Little Penney CALWAA on the HT-7-2 Road (a maintained seasonal use road), and is a crossing of a Class III stream with a channel approximately 2 ft wide by 1 ft deep (Maps 4, 5; Appendix B). The crossing currently includes an 18 in. diameter culvert that was installed high in the fill and outside of the natural stream channel alignment. During high flows, the stream crossing overtops the crossing and diverts down the road, as evidenced by the formation of a large gully (50 ft long × 5 ft wide × 3 ft deep) that has cut through the road fill and adjacent hillslope. PWA strongly recommends that site #1866 be treated immediately to prevent the current gully from enlarging as well as to prevent additional gully formation from continued diverted stream flow. Treatment at this site should include: (1) installing a new culvert properly sized for the drainage area and in alignment with the natural stream channel; and (2) constructing a critical dip to prevent future stream diversions.

6.4.2 Sites with restricted access

A large landslide (site #1420) is currently restricting vehicle access to 24 sites and more than 5 mi of Road GR-8 within the North Fork Garcia CALWAA (Maps 4, 5). Currently the road is intact past site #1420, but has a high potential to erode and will be a continual maintenance concern for nearly 0.40 mi (as far as stream crossing site #1417) because of year-round saturation from springs. Our surveys indicate that it will not be possible to adequately rebuild the road prism at site 1420 and control future sediment delivery along the 0.40 mi road segment. Therefore, we recommend decommissioning sites #1417, 1418, 1419, and1420 and rerouting traffic through Road GR-8-1, which is an upper midslope road (Maps 3-5).

6.4.3 Sites with increased treatment complexity because of a buried fiber optic cable

The presence of a fiber optic cable buried in the road fill increases the complexity of treating the majority of sites along Hollow Tree Road and several sites on Graphite Road: #1500, 1501, 1508, 1513-1515, 1696-1699.1, and 1703-1770 (Appendix B). Where the cable is present, additional equipment and labor hours will be necessary to ensure that earthwork proceeds with sufficient caution at treatment locations where the road prism will be excavated, including stream crossings, rolling dips, and ditch relief culverts.

6.4.4 Sites that are possible barriers to fish passage

Our field data show that 3 sites particularly show evidence as potential barriers to fish passage: #1447, 1517, 1538, (Map 5; Appendix B).

Site #1447 is a culverted stream crossing of a possible Class I stream on Road BW-2 within the Victoria Fork CALWAA. This low gradient, approximately 10 ft by 2 ft stream has a culvert that was recently installed, but installed askew to the natural channel, and with a 4 ft drop from the culvert outlet when the stream is at its estimated maximum (bankfull) depth. The site is located approximately 650 ft above mainstem Blue Waterhole Creek, a salmonid bearing stream. The list of problems for this site include: (1) probable fish barrier, (2) inadequately installed culvert, (3) inadequately sized culvert (culvert diameter too small), (4) potential to divert, and (5) availability of a large volume of unconsolidated material to deliver into the stream system. The treatment recommendations prepared by PWA for this site will meet necessary stormproofing standards (Maps 4, 5; Appendixes A, B)

Stream crossing site #1517 is a bridge crossing located within the North of Gualala Mountain CALWAA on the HT-2 Road over a 12 ft wide by 2 ft deep Class I stream (Maps 4, 5; Appendix B). The bridge is not currently recommended for truck use because the decking is rotten with large holes on the inboard tread and the stringer logs are failing. The location and width of the bridge confines the width of the stream channel and deflects stream flow towards the stream bank, which is causing the bank and bridge footings to erode. This bridge should be replaced with an adequately sized bridge that is properly installed (Maps 4, 5; Appendixes A, B).

Site #1538 is a crossing of a possible Class I stream on the HT-2-1 Road within the North of Gualala Mountain CALWAA (Maps 4, 5; Appendix B). The stream is low gradient, with an approximately 12 ft wide by 1.5 ft deep channel at the crossing. The current culvert is adequately sized for the drainage area, but was not properly installed relative to the stream gradient, and as a result there is a 5 ft drop from the culvert outlet to a 2 ft deep eroded pool below. Although the culvert is able to adequately convey stream flow and debris, the perched culvert may be a barrier to fish migration. This stream crossing site is located on a tributary approximately 900 ft above its confluence with mainstem Garcia River. We recommend that the tributary reach below site #1538 be surveyed to determine if fish are present. If so, we recommend that the culvert be replaced with a bridge as soon as possible to facilitate fish migration and increase the range of accessible habitat along the stream (Maps 4, 5; Appendixes A, B).

7 RECOMMENDED TREATMENTS

PWA recommends 24 different types of erosion control and erosion prevention treatments for the Phase II Garcia River project area, which we generally subdivide into 2 categories: site-specific treatments and road surface treatments (Table 5). These prescriptions include both upgrading and decommissioning measures.

Stream crossing treatments are primarily implemented to reduce the risk of catastrophic failure and sediment delivery resulting from culvert capacity being exceeded, road fill becoming saturated and weakened, or streams being diverted along road surfaces. Recommended treatments for stream crossings include: (1) constructing a total of 196 critical dips to prevent diversions at streams with diversion potential; (2) installing 91 culverts at currently unculverted stream crossings; (3) replacing 180 undersized or damaged culverts; (4) constructing 104 armored fill crossings, and (5) replacing 6 bridges on Class I streams. Approximately 1,890 yd^3 of clean fill will need to be imported to reconstruct stream crossings after stream crossing culvert installations and replacements. We recommend installing downspouts on 20 stream crossing culverts to prevent erosion at the culvert outlets. In addition, trash racks are required for 76 stream crossing culverts, a flared inlet is required at 2 stream crossing culvert inlets, and 14 stream crossing culvert inlets requires cleaning or repairing.

Road treatments are designed to control road drainage by reshaping the roadbed, which redirects concentrated flow to stable slopes and prevents delivery to streams. Upgrading treatments to redirect flow include outsloping the road, installing rolling dips, cutting ditches, and removing berms. Road surface erosion is curtailed by adding road rock, which fortifies the surface and reduces production of fine sediment. For road decommissioning, cross-road drains are constructed to direct water off road surfaces.

Table 5. Recommended treatments for all inventoried sites and road surfaces, Phase II Garcia River, Garcia River Forest, Mendocino County, California.

Treatment type			No.	Comments
Site specific treatments	Stream crossing treatments	Culvert (install)	91	Install a culvert at an unculverted fill.
		Culvert (replace)	180	Replace an undersized, poorly installed, or worn out culvert.
		Clean culvert inlet	11	Clean culvert inlet to prevent plugging.
		Repair culvert inlet	3	Repair culvert inlet to prevent plugging
		Flared Inlet	2	Install flared inlet to increase culvert capacity
		Downspout	20	Install to prevent erosion at stream crossing culvert outlets.
		Trash rack	76	Install at culvert inlets to prevent plugging
		Wet crossing	104	Install 103 armored fill crossings and 1 ford using 2,085 yd^3 of rock armor.
		Install bridge	6	Install or replace 6 bridges at undersized drainage structure or for fish passage.
		Critical dip	196	Install to prevent stream diversions.
	Other	Rock (armor)	247	At 247 sites, add a total of 6,125 yd^3 of rock armor on inboard and outboard stream crossing fillslopes, ditches, and headcuts.
		Soil excavation	449	At 449 sites, excavate and remove a total of 59,428 yd^3 of sediment, primarily at fillslopes and stream crossings.
		Engineered fill	2	At 2 sites, road treatment requires an engineer design.
		Miscellaneous treatments	18	Miscellaneous treatments at 18 site-specific locations
Road surface treatments	Road drainage structures	Ditch relief culvert (install or replace)	71	Install or replace ditch relief culverts to improve road surface drainage.
		Ditch relief culvert downspout	9	Install to prevent erosion at ditch relief culvert outlets.
		Rolling dip	1,453	Install to improve road drainage.
		Cross road drain	657	Install to improve drainage on decommission roads.
	Road shaping treatments	Outslope road and remove ditch	290	At 290 locations, outslope road and remove ditch for a total of 148,613 ft of road to improve road surface drainage.
		Outslope road and retain ditch	33	At 33 locations, outslope road and retain ditch for a total of 9,615 ft of road to improve road surface drainage.
		Berm (remove)	59	At 59 locations, remove a total of 10,599 ft of berm to improve road surface drainage.
		Clean or cut ditch	39	At 39 locations, clean or cut ditch for a total of 3,780 ft.
		Remove ditch	1	At 1 location, remove ditch for a total of 3 ft.
	Other	Road rock (for road surfaces)	447	At 447 locations, use a total of 8,052 yd^3 of road rock to rock the road surface at 63 stream culvert installations, 8 critical dips, 7 armored fill crossing, 58 DRC installations, 271 rolling dips, 17,690 ft of outslope, and 34 other site-specific location.

Road treatments in the project area include: (1) removing a total of approximately 10,599 ft of outboard road berm, (2) cutting 3,780 ft of ditch, (3) outsloping a total of 158,228 ft of road, (4) installing 1,453 rolling dips, and (5) installing or replacing 80 ditch relief culverts. In addition, we recommend installing 657 cross-road drains as decommissioning treatments.

Once the road shaping and road drainage structures have been constructed, most road sections will be graded, watered, and recompacted as a final road treatment. Bare soil areas will be seeded with native grasses appropriate for the area, and where necessary, bare soil areas will also be mulched with weed-free straw to prevent sediment delivery to nearby gullies or streams.

8 HEAVY EQUIPMENT AND LABOR REQUIREMENTS

Equipment needs for erosion control treatments in the assessment area are detailed in the project database and summarized, based on immediacy, in Table 6. Most treatments require the use of heavy equipment, e.g., excavator, bulldozer, grader, and water truck. Some hand labor is required at sites needing downspouts, new culverts or culvert repairs, or for applying seed and mulch to ground disturbed during construction. Equipment needs are reported as equipment times, in hours, to treat all sites and road segments. These estimates only include the time needed for the actual treatment work, and do not include additional construction activities such as opening roads, staging materials at work sites, traveling between sites, final grading, or spreading road rock, straw, and mulch. Equipment and labor hours in addition to those listed in Table 6 are further explained in Section 9. The equipment and labor hours listed in Table 6 include additional time that will be required to treat sites along Hollow Tree Road and Graphite Road without damaging the fiber optic cable buried in the road fill (see Section 6.4.2).

Table 6. Estimated heavy equipment and labor requirements based on treatment immediacy, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Treatment immediacy	# of sites	Excavated volume[a] (yd^3)	Excavator (hr)	Bulldozer (hr)	Dump truck (hr)	Water truck (hr)	Labor (hr)
High or high-moderate	125	43,630	1,980	2,567	409	469	595
Moderate or moderate-low	425	72,180	3,805	5,556	745	1,140	1,365
Low	130	9,775	636	773	128	168	236
Total	**680**	**125,585**	**6,421**	**8,896**	**1,282**	**1,777**	**2,196**

Note: Equipment and labor times do not include hours necessary for opening roads, traveling between sites, transporting culverts, spreading road rock, and spreading straw and mulch.

[a]Excavated volume includes material permanently removed and stored as well as material excavated and reused for backfilling upgraded stream crossings.

PWA estimates that erosion control and erosion prevention remediation in the Phase II Garcia River project area will require 6,421 hr of excavator time and 8,896 hr of bulldozer time (Table 6). An excavator and bulldozer will not be needed at all treatment sites, and some treatment sites will require one but not the other. Dump truck operators will require 1,282 hr to transport excavated spoil material to disposal sites. Approximately 1,777 hr of water truck time will be needed for applying water to dry soils during road-drainage treatment implementation, and for backfilling excavations at stream crossings and ditch relief culverts. Finally, approximately 2,196 hours of labor time will be required for various tasks, including culvert installation or replacement.

9 ESTIMATED COSTS

The estimated total cost to implement the recommended erosion control and erosion prevention treatments for the Phase II Garcia River project is $8,014,945 (Table 7). Approximately $2,078,850, or 26% of the total, is for the purchase of rock, culvert, and bridge materials. A total of $1,143,525 is projected for detailed project planning, on-site equipment operator instruction and supervision, establishing effectiveness monitoring measures, and post-project analysis and reporting. Costs detailed in Table 7 also include labor time for spreading straw mulch and seed (footnote “i”); truck/trailer time for delivering straw mulch and culverts to work sites (footnote “g”); and time required by a motor grader and water truck to create a “finished” grade to banks, ditches, and road surfaces following rough construction by other equipment (footnote “h”). There will also be necessary expenses for the use of lowboy trucks to haul construction equipment to and from the work area (footnote "f").

Most of the treatments listed in this plan are not complex or difficult for equipment operators with experience in road upgrading and decommissioning operations on forestlands. The costs in Table 7 are assumed reasonable if work is performed by experienced outside contractors, and there is no added overhead for contract administration and pre- and post-project surveying. The use of inexperienced operators or the wrong combination of heavy equipment could require additional technical oversight and supervision in the field, as well as an escalation of the costs to implement the work. To help insure success of the project, it is imperative that only the most experienced and reliable heavy equipment operators be employed, and that the project coordinator is on-site full time at the beginning of the project and intermittently after equipment operations have begun.

Table 7. Estimated equipment times and costs to implement erosion control and erosion prevention treatments, Phase II Garcia River Sediment Source Assessment, Garcia River Forest, Mendocino County, California.

Cost category[a]		Cost rate[b] ($/hr)	Estimated Project Times: Treatment[c] (hr)	Estimated Project Times: Logistics[d] (hr)	Estimated Project Times: Total (hr)	Total estimated costs[e] ($)
Move in, move out[f]	Excavator	110	148	-	148	16,280
	Bulldozer	110	148	-	148	16,280
	Grader	110	148	-	148	16,280
	Water Truck	110	132	-	132	14,520
	Truck/trailer	80	132	-	132	10,560
Road opening	Excavator	185	747	-	747	138,195
	Bulldozer	165	747	-	747	123,255
Heavy equipment for site-specific treatments[g]	Excavator	185	6,260	1,878	8,138	1,505,530
	Bulldozer	165	4,979	1,494	6,473	1,068,045
	Dump truck	110	1,329	399	1,728	190,080
	Water truck	110	820	246	1,066	117,260
	Truck/trailer	80	244	73	317	25,360
Heavy equipment for road drainage treatments[h]	Excavator	185	320	96	416	76,960
	Bulldozer	165	3,917	1,175	5,092	840,180
	Grader	185	741	222	963	178,155
	Water truck	110	1,698	509	2,207	242,770
Laborers[i]		50	2,761	828	3,589	179,450
Rock costs (includes trucking for 8,052 yd3 of road rock and 8,210 yd^3 of riprap)						1,051,753
Culvert materials costs (2,960’ of 18”, 11,010’ of 24”, 1,490’ of 30”, 2,020’ of 36”, 1,740’ of 42”, 2,010’ of 48”, 850’ of 54”, 550’ of 60”, and 210’ of 72”, including costs for couplers, elbows, and trash racks)						907,097
Bridge costs (6 bridges @$20,000 ea.)						$120,000
Permitting						4,000
Mulch, seed, and planting materials for approximately 27.1 acres of disturbed ground[j]						18,695
Miscellaneous costs (pumps, compactors, etc.)						10,715
Supervision, coordination, layout, and reporting[k]						1,143,525
Total Estimated Costs: $8,014,945						
Potential sediment savings: 150,645 yd^3						

(Continued on next page.)

Table 7—continued.

[a]Costs excluded from the list are for (1) tools and miscellaneous materials, and (2) variable administration and contracting expenses.

[b]Heavy equipment costs include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.

[c]Treatment times refer to equipment hours expended explicitly for erosion control and erosion prevention work at all project sites and roads.

[d]Logistics 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 to convey treatment prescriptions and strategies. Logistic times for laborers (30%) include estimated daily travel time to project area.

[e]Total estimated project costs for equipment rental and labor are based on private sector rates at prevailing wage. Materials costs are subject to change.

[f]Lowboy hauling costs area based on 4 hauls each (1 to move in and 1 to move out per season) at 6 hr/trip, for excavator, bulldozer, grader, and water truck. An additional 2 hours per round trip is added for unloading and loading the excavator, dozer, and grader.

[g]An additional 132 hr of truck and trailer are added for delivering straw to sites. A total of 112 hr of excavator and truck and trailer time are added for delivering culverts. An additional 47 hr of excavator and dump truck time are added for the import of 1,890 yd^3 of fill to rebuild stream crossings.

[h]An additional 741 hr of water truck time and grader time are added during the project and post treatment.

[i]An additional 565 hr of labor time are added for spreading straw mulch and seeding. This includes 132 hr of labor for initial delivery of straw to sites.

[j]Seed costs are based on 35 lb of erosion control seed per acre at $9.75/lb. Straw needs are 50 bales per acre at $6.95/bale. Labor time for straw mulching and seeding is based on 16 hr/acre.

[k]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.

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Appendix A

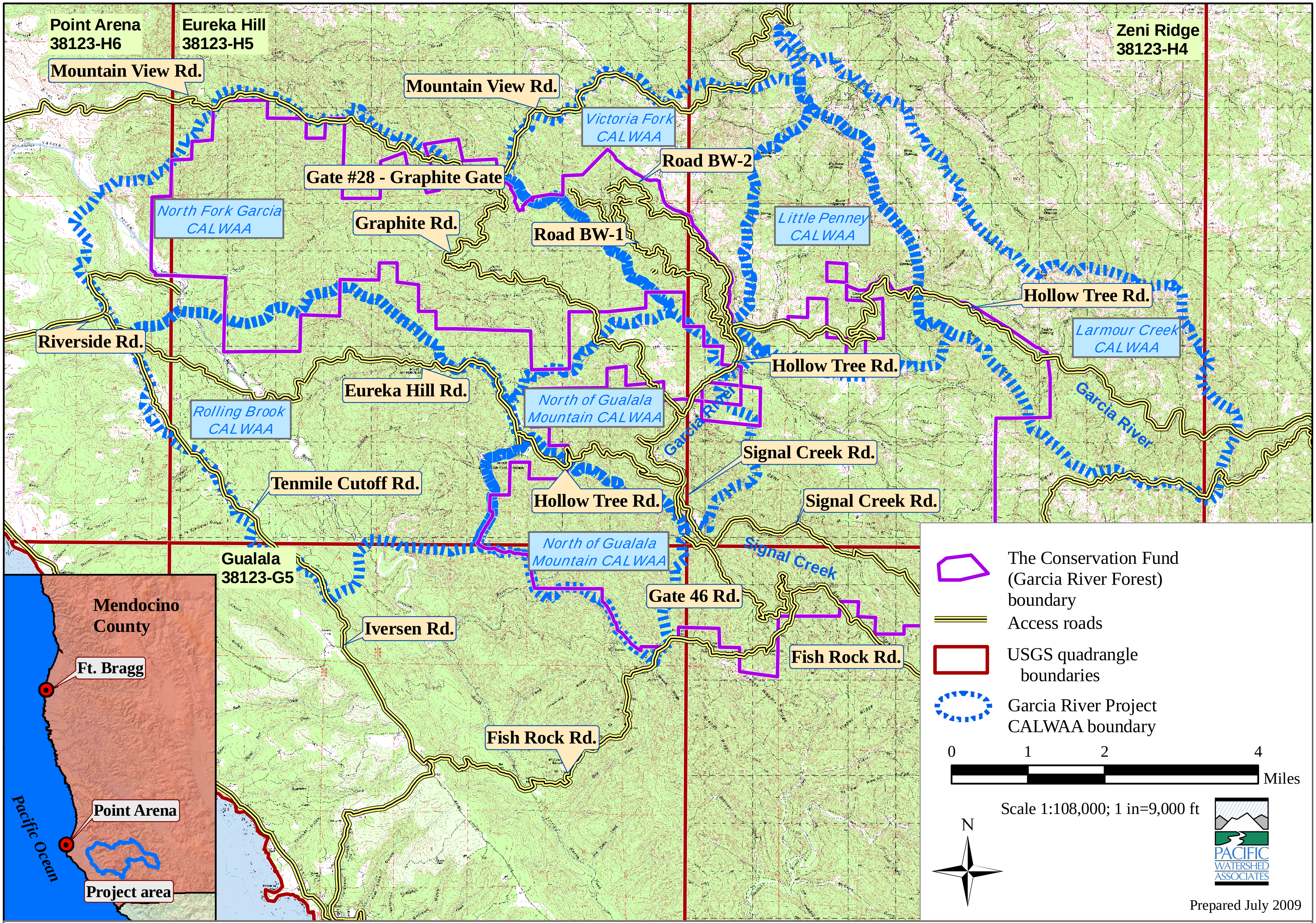
Project maps for the Phase II 2009 Garcia River Sediment Source Assessment,

Garcia River Watershed, Mendocino County, CA.

(CDFG Contract# P0530404)

Map 1. Location map
Map 2. Road construction history and landslide development
Map 3. Drivability of roads
Map 4. Inventoried sites by problem type
Map 5. Inventoried sites by treatment priority

[Maps 2 – 5 are located in sleeve in back of report]



Map 1. Location of the Phase II 2009 Garcia River Sediment Source Assessment Project, Garcia River Forest, Mendocino County, California (Point Arena, Eureka Hill, Gualala, and Zeni Ridge 7.5' quadrangles; USGS 1978; 1991 a,b; 1998).

Map 2. Road construction history and landslide development based on aerial photo analysis, Phase II 2009 Garcia River Sediment Source Assessment Project, Garcia River Forest, Mendocino County, California.

Map 3. Drivability of roads in the project area, Phase II 2009 Garcia River Sediment Source Assessment Project, Garcia River Forest, Mendocino County, California.

Map 4. Inventoried sites by problem type, Phase II 2009 Garcia Sediment Source Assessment Project, Garcia River Forest, Mendocino County, California.

Map 5. Inventoried sites by treatment priority, Phase II 2009 Garcia Sediment Source Assessment Project, Garcia River Forest, Mendocino County, California.

APPENDIX B

Supplementary information regarding terminology and techniques used in road related erosion assessments

A-1 SOURCES OF ROAD RELATED EROSION

Sources for erosion and sediment delivery are divided into two categories: (1) sediment from specific treatment sites, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks and inboard ditches—that are hydrologically connected[8] to streams.

Site-specific erosion is termed *episodic*, as it is projected to occur at a point in time, usually triggered by a storm or flood event, typically at some indeterminate time in the future. Some sites may show evidence for imminent failure, erosion, and sediment delivery, such as unstable fillslope landslides on steep hillslopes. Other sites may show a more subtle potential for erosion and sediment delivery, but these sites might not erode and deliver sediment to the stream until a threshold event occurs and a combination of site factors lead to failure (for example, peak flood flow events occurring at a stream crossing that contains an undersized culvert with a high plug potential and/or diversion potential).

In contrast to site-specific episodic erosion, erosion from road surfaces is termed *chronic* because it occurs on an on-going basis, during every rainfall event that results in surface runoff. Chronic road surface erosion is primarily dependent on the level of road usage, the erodibility of the road surface, the steepness of the road, and the amount of surface runoff that is collected, concentrated, and discharged from the road. PWA typically estimates chronic erosion for a 10-year period, based on empirical calculations for fine sediment generation from hydrologically connected road surfaces and associated bare cutbanks and ditches. The amount of fine sediment delivered to stream channels from these eroding road surfaces can be substantial when evaluated on timescales similar to those applied to episodic erosion sites (multi-decades), and in many watersheds may represent the greater detriment to water quality, fish habitat and the aquatic ecosystem.

A-1.1 Site-Specific Erosion Sources

A-1.1.1 Stream crossings

A stream crossing is the location where a road crosses a stream channel (Weaver and Hagans, 1994). Drainage structures used in stream crossings include bridges, fords, armored fills, culverts, and a variety of temporary crossing structures. When they erode, sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded from the crossing site is delivered directly to the stream (Furniss et al., 1997; Weaver et al., 2006). The size of the stream affects the rate of sediment mobilization and movement, but any sediment delivered to small ephemeral streams will eventually be transported to downstream fish-bearing stream channels. Because of this, it is important to identify all stream crossings and evaluate the potential for erosion and sediment delivery from the site.

[8] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

Common features of stream crossings that lead to erosion problems include (1) fill crossings without culverts, (2) crossings with undersized culverts, (3) crossings with culverts susceptible to being plugged, (4) crossings with culvert outlet erosion, (5) crossings with logs or debris buried in the fill intended to convey streamflow (i.e., *Humboldt crossings*), (5) crossings with a potential for stream diversion, and (6) crossings that have currently diverted streams.

A *fill crossing* is a stream crossing without a culvert or other drainage structure to carry the flow through the road prism. At such sites, stream flow either crosses the road and flows over the fillslope, or is diverted down the road via the inboard ditch. Most fill crossings are located at small Class II or III streams[9] that only have flow during larger runoff events. *Armored fill crossings* and *ford crossings* are designed to be functional, unculverted stream crossings. A properly constructed armored fill crossing is based on a site-specific design, using a mix of riprap-sized rock to minimize erosion while allowing the stream to flow across the road prism (Weaver et al., 2006). A ford crossing may use rock armor to stabilize the roadway, but the road is built essentially on the natural stream channel, and fill is not used.

Humboldt crossings are constructed from logs or woody debris, usually laid parallel to flow, which are then covered with fill. Humboldt crossings are susceptible to plugging, gullying, and washout during storm flows (Weaver et al., 2006). Older Humboldt log crossing structures beneath more recently installed culverts are often found in rural northern California road networks.

Large volumes of erosion may occur at stream crossings when culverts are too small for the drainage area and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will spill across the road, allowing erosion of the stream crossing fill and development of a *washout crossing*. Washout crossings will remain highly problematic as the stream banks continue to erode to a natural grade.

Serious erosion problems may also occur as a result of a stream crossing that has a *diversion potential*. Stream diversions occur at stream crossings that are unculverted, or have culverts that plug during a flood event, which allows water to spill out onto the road surface or into the ditch, and flow down the road and onto adjacent hillslopes or into nearby stream channels. When this occurs, the roadbed, hillslope, and/or stream channel that receives the diverted flow may become deeply gullied or destabilized. Road and hillslope gullies can develop and enlarge quickly and deliver large quantities of sediment to stream channels (Hagans et al., 1986; Furniss et al., 1997). Streamflow that is diverted onto steep or unstable slopes may also trigger hillslope landslides and large debris flows.

[9] In general, Class I streams are waterways containing viable fish habitat; Class II streams are perennial or intermittent waterways capable of supporting non-fish aquatic vertebrate habitat; Class III streams are defined but ephemeral channels not capable of supporting vertebrate aquatic habitat; Class IV streams are man-made watercourses.

To be considered adequately sized, culverts at stream crossings must have the capacity to convey a 100-year peak storm flow[10] with sediment and organic debris in transport (USDA Forest Service, 2000; Weaver et al., 2006). In areas where large woody debris may lodge against the culvert, trash racks should be installed slightly upstream from culvert inlets as an additional precaution against plugging. Substandard stream crossing culverts include those that are not large enough to convey a 100-year flow, or are installed at too low of a gradient through the stream crossing fill. Installing a culvert at a shallower grade than the natural upstream channel will cause sediment and debris to be deposited at and immediately upstream of the culvert inlet, which promotes plugging and decreases the culvert's capacity to carry streamflow. Improper, low-gradient culvert installations were once common because they required shorter lengths of pipe to convey flow through the road, and were therefore used to minimize construction costs. However, in the long run these cost-cutting measures prove detrimental to erosion control and maintenance efforts because the culvert discharges water onto unconsolidated road fill, rather than into the preexisting stream channel, which can result in pronounced erosion of the outboard, downstream fill face.

A-1.1.2 Landslides

Landslides with the potential to fail during periods of high and prolonged rainfall events are identified in the field by tension cracks, scarps showing vertical displacement, corrective regrowth on trees (i.e., pistol butt trees) and perched, hummocky fill indicating surface instability. As a standard practice, PWA maps all landslides observed in the field, but only Inventories those that are associated with roads and show a potential to deliver sediment to a watercourse. Types of landslides in a road related erosion assessment typically include (1) road fill failures, (2) landing fill failures, (3) hillslope debris slides, and (4) deep-seated, slow landslides. The majority of treatable landslides in an assessment area are often the result of failure of unstable fill and sidecast material from earlier road construction. Preemptive excavation of small, current or potential landslides is an effective technique for erosion control, achieved by removing the eroding material and redepositing it in a stable, designated location either at or near the treatment site. Conversely, large, deep-seated landslides are usually technically infeasible to treat.

A-1.1.3 Ditch relief culverts

A *ditch relief culvert* (DRC) is a plastic, metal, or concrete pipe installed beneath the road surface to convey flow from an inside road ditch to an area beyond the outer edge of the road fill. When properly spaced, DRCs limit the quantity of water available to cause erosion at any single location, allowing flow to disperse and reducing the likelihood of gullies forming at their outlets. It is sometimes necessary to install downspouts or rock armor at DRC outlets to further disperse energy and prevent erosion.

[10] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.

A-1.1.4 Discharge points for road surface, cutbank, and ditch erosion

Unpaved road surfaces, and their associated cutbanks and inboard ditches, are major sources for erosion and delivery of fine sediment to stream channels. For paved roads, ditches, cutbanks, and unpaved turnouts may still represent active sediment sources. Road surface, cutbank, and ditch erosion is termed "chronic" because it occurs throughout the year, and may include one or more of the following processes: (1) mechanical pulverizing and wearing down of road surfaces by vehicular traffic; (2) erosion of unpaved road surfaces by rainsplash and runoff during periods of wet weather; (3) erosion of inboard ditches by runoff during wet weather; and (4) erosion of cutbanks by dry ravel, rainfall, slope failures, and brushing/grading practices. *Discharge points for road surface, cutbank, and ditch erosion* are locations where sediment-laden flow from poorly drained road/cutbank/ditch segments exits the roadway to be delivered into the stream system. Discharge points are often in the form of roadside gullies or water bars, but on some low gradient or streamside roads may simply be low spots where concentrated flow exits the road and is delivered directly into a stream without gully formation.

A-1.1.5 Additional site-specific sediment sources

Additional, less frequent sources of sediment delivery that may be found in an assessment area include:

Point source springs. Point source springs refer to sites where spring flow is entering the roadbed and causing erosion. Flow from multiple springs may become concentrated along a road with inadequate drainage structures, creating roadside gullies or fillslope failures.

Sites of bank erosion. Bank erosion sites refer to locations of streambank erosion caused or exacerbated by emplacement of a nearby road.

Swales. Swales are channel-like depressions that only carry minor flow during periods of extreme rainfall.

Channel scour. Channel scour refers to the widening or deepening of stream channels as a result of increased flow levels.

Non-road related upslope gullies. These are sites of focused runoff that form upslope from a roadway, and may exacerbate erosion at the roadway or contribute sediment to the system during high discharge.

A-1.2 Evaluation of Hydrologically Connected Road Segments

PWA measures the lengths of hydrologically connected road segments adjacent to sediment delivery sites, such as on either side of a stream crossing, ditch relief culvert, or discharge point, to derive an estimate for total potential sediment delivery from connected road surfaces in the project area. In addition, because the adjacent hydrologically connected road segments contribute to the overall erosion and sediment delivery problem at a site, PWA considers the treatment site and adjacent road segments as a unit when estimating future sediment delivery and developing treatment prescriptions for that location.

A-2 OVERVIEW OF STORM-PROOFING ROADS (ROAD UPGRADING AND DECOMMISSIONING)

Forest and rural roads may be storm-proofed by one of two methods: upgrading or decommissioning (Weaver and Hagans, 1994, 1999; Weaver et al., 2006). Upgraded roads are kept open, and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate the 100-year peak storm flow[11]. Conversely, properly decommissioned roads are closed and no longer require maintenance. Whether through upgrading or decommissioning, the goal of storm-proofing is to make the road as “hydrologically invisible” as possible, that is, to reduce or prevent future sediment delivery to the local stream system. A well-designed storm-proofed road includes specific characteristics (Table A1), all proven to contribute to long-term improvement and preservation of watershed hydrology and aquatic habitat.

A-2.1 Road upgrading

Road upgrading involves a variety of treatments used to make a road more resilient to large storms and flood flows. The most important of these include upgrading stream crossings (especially culvert upsizing to accommodate the 100-year peak storm flow and debris in transport, and correct or prevent stream diversion); removing unstable sidecast and fill materials from steep slopes; and applying road drainage techniques (e.g., installing ditch relief culverts, removing berms, constructing rolling dips, insloping or outsloping the road) to improve dispersion of surface runoff. Road upgrading often also includes adding road rock or riprap as needed to fortify roads and crossings.

A-2.1.1 Installing rolling dips

Rolling dips are installed on low- to moderate-gradient hydrologically connected[12] roads to disperse surface runoff and discharge it onto native hillslope below the road. Rolling dips extend from the inboard edge to the outboard edge of a road, and are constructed at intervals as needed to control erosion (typically 100, 150, or 200 ft). They are effective in reducing year-round (“chronic”) sediment delivery from road surfaces, and are designed to be easily drivable and not impede vehicular traffic.

A-2.1.2 Road shaping

Road shaping changes the existing geometry or orientation of the road surface, and is accomplished through insloping (sloping the road toward the cutbank), outsloping (sloping the road toward the outside edge), or crowning (creating a high point down the center axis of the road so that it slopes equally inward and outward). Like rolling dips, road shaping is used to prevent uncontrolled delivery of road surface runoff by dispersing it into the inside ditch or onto the hillslope below the road. This is also effective in preventing the formation of gullies at the edge of the road, and localized slope instability below the road.

[11] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.
[12] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

Table A1. Characteristics of storm-proofed roads (*from* Weaver et al., 2006).

Storm-proofed stream crossings • All stream crossings have a drainage structure designed for the 100-year peak storm flow (with debris). • Stream crossings have no diversion potential (functional critical dips are in place). • Stream crossing inlets have low plug potential (trash barriers installed). • Stream crossing outlets are protected from erosion (extended beyond the base of fill; dissipated with rock armor). • 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 “hydrologically disconnected” from streams and stream crossing culverts. • Class I stream crossings meet CDFG and NMFS fish passage criteria (Taylor and Love, 2003).
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 “hydrologically 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 implementing a variety of surface drainage techniques including berm removal, road surface shaping (outsloping, insloping, or crowning), road surface decompaction, and installing rolling dips, ditch relief culverts, waterbars, and/or cross-road drains to disperse road surface runoff and reduce or eliminate sediment delivery to the stream.

A-2.1.3 Installing ditch relief culverts

A ditch relief culvert is a drainage structure (usually an 18 in. pipe) installed across a road prism to move water and sediment from the inboard ditch so that it can be dispersed on native hillslope beneath the road. Ditch relief culverts are used to drain ditch flow on roads that are too steep for rolling dips or outsloping, as well as at sites with excessive flow from springs or seepage from cutbanks.

A-2.1.4 Excavating unstable fillslope

The fillslope, the sloping part of the road between its outboard edge and the natural ground surface below, may fail or show signs of potential failure. As a preventative measure, unstable fillslope sediment is excavated and relocated to a permanent, stable spoil depository site.

A-2.1.5 Upgrading stream crossings

Techniques used to remediate road related erosion at a stream crossing are dependent on the size of the stream channel, and specific physical characteristics at the crossing site. Class I and large stream crossings may require a bridge, or, if their banks are small or low gradient, a ford crossing may be suitable, particularly if seasonal use is anticipated. A common approach to upgrading moderate sized Class II and III crossings is to construct a culverted fill crossing capable of withstanding the 100-year flood flow. Techniques for upgrading small stream crossings include:

Installing or replacing culverts. A culvert capable of withstanding the 100-year storm flow, including expected sediment and debris, is installed or replaced in the fill crossing. Culverts on non fish-bearing streams are placed at the base of fill, in line and on grade with the natural stream channel upstream and downstream of the crossing site. Backfill material, free of woody debris, is compacted in 0.5-1.0 ft thick lifts until 1/3 of the diameter of the culvert has been covered. At sites where fillslopes are steeper than 2:1, or where eddying currents might erode fill on either side of the inlet, rock armor is applied as needed.

Installing an armored fill. Armored fills are installed on smaller stream crossings with relatively small fill volume, but where debris torrents are common, channel gradients are steep, or inspection and maintenance of a culverted crossing is impossible. The roadbed is heavily rocked, and a keyway in the outboard fillslope is excavated and backfilled with interlocking rock armor of sufficient size to resist transport by stream flow. Armored fill crossings are constructed with a dip in the axis of the crossing to prevent diversion of the stream flow, and focus the flow over the part of the fill that is most densely armored.

Installing secondary structures. A variety of secondary structures may be used to increase the function of small stream crossings by allowing uninterrupted stream flow, decreasing flooding, and controlling erosion. Where a culvert has been improperly installed too high in the fill, a *downspout* may be added to its outlet to release the flow close to the ground surface, rather than letting it cascade from the height of the culvert. *Rock armor* may be used to buttress steep fillslopes, as well as to prevent erosion of inboard or outboard fillslopes by eddying currents. A *trash rack* placed in the channel above a culvert inlet will trap debris and reduce plugging. To prevent stream diversion should the culvert become plugged or its capacity exceeded, a *critical dip* (essentially a rolling dip constructed in line with the stream channel) may be installed to ensure that stream flow will be directed across the road and back into the natural channel. Finally, an *overflow culvert* may be a necessary addition at a culverted crossing where, because of site conditions, plugging or capacity exceedence of the primary culvert is anticipated.

A-2.2 Road decommissioning

In essence, decommissioning is “reverse road construction”, although complete topographic obliteration of the roadbed is not usually required to achieve cost-effective erosion prevention. In most cases, serious erosion problems are confined to a few, isolated locations along a road (perhaps 10% to 20% of the full road network to be decommissioned) where stream crossings need to be excavated, unstable sidecast on the downslope side of a road or landing needs to be removed before failure, or the road crosses unstable terrain and the entire road prism must be removed. But typically, lengths of road beyond the extent of individual treatment sites usually require simpler, permanent improvements to surface drainage, such as surface decompaction, additional road drains, and/or partial outsloping. As with road upgrading, the heavy equipment techniques used in road decommissioning have been extensively field tested, and are widely accepted (Weaver and Sonnevil, 1984; Weaver and others, 1987, 2006; Harr and Nichols, 1993; Pacific Watershed Associates, 1994).

A-2.2.1 Road ripping or decompaction

Road ripping is a technique in which the surface of a road or landing is disaggregated or "decompacted" to a depth of at least 18 in.using mechanical rippers. This action reduces or eliminates surface runoff and usually enhances revegetation.

A-2.2.2 Installing cross-road drain

Cross-road drains (also called “deep waterbars”) are large ditches or trenches excavated across a road or landing surface to provide drainage and prevent runoff from traveling along, or pooling on, the former road bed. They are typically installed at 50, 75, 100 or 200 ft intervals, or as necessary at springs and seeps. In some locations (e.g., streamside zones), partial outsloping may be used instead of cross-road drain construction.

A-2.2.3 In-place stream crossing excavation (IPRX)

IPRX is a decommissioning treatment used for roads or landings that are built across stream channels. The fill (including the culvert or Humboldt log crossing) is completely excavated and the original streambed and side slopes are exhumed. Excavated spoil is stored at nearby, stable locations where it will not erode. In some cases, this may necessarily be as far as several hundred feet from the crossing. An IPRX typically involves more than simply removing a culvert, as the underlying and adjacent fill material must also be removed and stabilized. As a final measure, the sides of the channel may be cut back to slopes of 2:1, and mulched and seeded for erosion control.

A-2.2.4 Exported stream crossing excavation (ERX)

ERX is a decommissioning treatment in which stream crossing fill material is excavated and the spoil is hauled off-site for storage (the act of moving spoil material off-site is called “endhauling”). This procedure is necessary when large, stable storage areas are not available at or near the excavation site. It is most efficient to use dump trucks to endhaul the spoil material.

A-2.2.5 In-place outsloping (IPOS)

IPOS (also called "pulling the sidecast") calls for excavation of unstable or potentially unstable sidecast material along the outside edge of a road prism or landing, and placement of the spoil on the roadbed against the corresponding, adjacent cutbank or within several hundred feet of the site. As a further decommissioning measure, the spoil material is placed against the cutbank to block access to the road.

A-2.2.6 Export outsloping (EOS)

EOS is a technique comparable to IPOS, except that spoil material is moved off-site to a permanent, stable storage location. EOS is required when it is not possible to place spoil material against the cutbank, e.g., where the road prism is narrow or where there are springs along the cutbank. EOS usually requires dump trucks to endhaul the spoil material. This technique is used for both decommissioning and upgrading roads, but as the roadbed is partially or completely removed, EOS is more commonly used for decommissioning.

A-3 DETERMINING TREATMENT IMMEDIACY AND COST-EFFECTIVENESS

Identifying *treatment immediacy* is an integral part of an assessment used to prioritize sites prior to implementation. Treatment immediacy is a professional evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is defined as “high,” “moderate,” or “low,” and represents the urgency of treating the site before it erodes or fails. An evaluation of treatment immediacy is based on the following criteria: (1) *erosion potential*, or whether there is a low, moderate, or high likelihood for future erosion at a site; (2) *sediment delivery*, which is an estimate of the sediment volume projected to be eroded from a site and delivered to a nearby stream; and (3) the value or sensitivity of downstream resources being protected. Generally, sites that are likely to erode or fail in a normal winter, and are expected to deliver significant quantities of sediment to a stream channel, are rated as having high treatment immediacy.

The *erosion potential* of a site is a professional evaluation of the likelihood that erosion will occur during a future storm, based on local site conditions and field observations. It is a subjective probability estimate, expressed as “low,” “moderate,” or “high,” and not an estimate of how much erosion is likely to occur. The volume of sediment projected to erode and reach stream channels is described by *sediment delivery*, which plays a significant role in determining the treatment immediacy for a site. The larger the volume of potential future sediment delivery to a stream, the more important it becomes to closely evaluate the need for treatment.

From this assessment, treatment immediacy and *cost-effectiveness* may be analyzed, along with the client’s transportation needs, to prioritize treatment sites or locations for implementation. *Cost-effectiveness* is not only a necessary consideration for environmental protection and restoration projects for which funding may be limited, but is also an accepted and well-documented tool for prioritizing potential treatment sites in an area (Weaver and Sonnevil, 1984; Weaver and Hagans, 1999). A quantitative estimate for cost-effectiveness is determined by dividing the cost of accessing and treating a site by the volume of sediment prevented from being delivered to local stream channels. The resulting value, or *sediment savings*, provides a comparison of cost-effectiveness among sites, and an average for the entire project area. For example, if the cost to develop access and treat an eroding stream crossing is projected to be \$5,000, and the treatment will potentially prevent 500 yd^3 of sediment from reaching the stream channel, the predicted cost-effectiveness for that site would be \$5,000/500yd^3, or \$10/yd^3.

PWA further evaluates cost-effectiveness for an entire assessment area by organizing sites into logistical groups based on similar requirements for heavy equipment and materials, and addressing these as a unit to minimize expenses. Furthermore, although sites and road segments with the lowest immediacy ratings are placed last on the list for treatment, it is sometimes possible to treat these sites once the project is underway, as opportunities to cost-effectively treat low-immediacy sites often arise when heavy equipment is already located nearby to perform maintenance or restoration at higher-immediacy sites.

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APPENDIX C

List of 723 inventoried sites showing field data and analyses, including treatment immediacy and estimates of potential sediment delivery for the site-specific problem

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
800	North of Gualala Mountain	46.1	Stream crossing	Upgrade	L	ML	55	0	0
801	North of Gualala Mountain	46.2	Stream crossing	Upgrade	HM	HM	41	405	0
802	North of Gualala Mountain	46.2	Stream crossing	Upgrade	M	M	22	0	0
803	North of Gualala Mountain	46.2	Stream crossing	Upgrade	HM	HM	13	150	0
804	North of Gualala Mountain	46.2	Stream crossing	Upgrade	HM	HM	207	216	0
804.1	North of Gualala Mountain	46.1	Stream crossing	Upgrade	ML	ML	24	0	1602
805	North of Gualala Mountain	46.1	Stream crossing	Upgrade	ML	L	23	0	170
806	North of Gualala Mountain	46.1	Stream crossing	Upgrade	HM	M	462	0	50
807	North of Gualala Mountain	46.1	Stream crossing	Upgrade	M	ML	1337	80	227
808	North of Gualala Mountain	46.2	Stream crossing	Upgrade	HM	H	122	1187	0
809	North of Gualala Mountain	46.2	Stream crossing	Upgrade	ML	M	910	260	70
811	East of Eureka Hill	Signal Creek Road	Stream crossing	Upgrade	M	M	255	371	0
1035	North Fork Garcia	GR-1	Road drainage discharge point	Upgrade	ML	L	0	380	0
1036	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	L	226	1005	25
1037	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	ML	67	60	45
1038	North Fork Garcia	GR-1	Stream crossing	Upgrade	L	L	17	25	60
1039	North Fork Garcia	GR-1	Spring	Upgrade	ML	ML	15	140	0
1040	North Fork Garcia	GR-1	Stream crossing	Upgrade	L	L	179	45	195
1041	North Fork Garcia	GR-1	Stream crossing	Upgrade	HM	ML	268	90	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1042	North Fork Garcia	GR-1	Stream crossing	Upgrade	ML	L	73	0	240
1042.1	North Fork Garcia	GR-1-6	Road drainage discharge point	Upgrade	ML	L	0	900	100
1042.2	North Fork Garcia	GR-1	Landslide	Upgrade	M	H	244	0	10
1043	North Fork Garcia	GR-1	Stream crossing	Upgrade	HM	HM	320	760	1269
1044	North Fork Garcia	GR-1	Landslide	Upgrade	ML	M	45		
1045	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	ML	164	309	1075
1046	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	H	515	0	402
1047	North Fork Garcia	GR-1	Stream crossing	Upgrade	HM	ML	282	0	85
1048	North Fork Garcia	GR-1	Landslide	Upgrade	L	M	80		
1049	North Fork Garcia	GR-1	Road drainage discharge point	Upgrade	L	L	8	150	130
1050	North Fork Garcia	GR-1	Spring	Upgrade	HM	HM	40	0	0
1051	North Fork Garcia	GR-1	Spring	Upgrade	M	M	0	3112	20
1052	North Fork Garcia	GR-1	Landslide	Upgrade	ML	ML	1	888	314
1053	North Fork Garcia	GR-1	Stream crossing	Upgrade	ML	ML	151	240	0
1054	North Fork Garcia	GR-1	Stream crossing	Upgrade	L	ML	181	0	253
1055	North Fork Garcia	GR-1	Road drainage discharge point	Upgrade	ML	ML	68	678	253
1056	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	HM	112	30	10
1057	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	M	107	890	0
1058	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	M	250	72	70
1059	North Fork Garcia	GR-1	Landslide	Upgrade	ML	M	43	40	0
1060	North Fork Garcia	GR-1-4-1	Landslide	Upgrade	ML	ML	46		
1061	North Fork Garcia	GR-1-3	Spring	Upgrade	M	M	67	300	0
1062	North Fork Garcia	GR-1-3	Landslide	Upgrade	L	L	25	55	0
1063	North Fork Garcia	GR-1-3	Stream crossing	Upgrade	ML	ML	15	750	0
1064	North Fork Garcia	GR-1-3	Stream crossing	Upgrade	L	M	92	25	10
1065	North Fork Garcia	GR-1-3	Landslide	Upgrade	L	L	9		
1066	North Fork Garcia	GR-1-3	Spring	Upgrade	L	L	4	0	195

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1067	North Fork Garcia	GR-1-3-1	Spring	Decommission	ML	M	9	200	25
1068	North Fork Garcia	GR-1-2	Spring	Upgrade	ML	ML	16	20	1215
1069	North Fork Garcia	GR-1-2	Stream crossing	Upgrade	L	L	5	60	865
1070	North Fork Garcia	GR-1-2-1	Stream crossing	Upgrade	ML	ML	30	785	35
1071	North Fork Garcia	GR-1	Road drainage discharge point	Upgrade	M	M	20	400	0
1072	North Fork Garcia	GR-1	Stream crossing	Upgrade	M	M	37	250	35
1073	North Fork Garcia	GR-1	Stream crossing	Upgrade	HM	HM	234	1145	40
1076	North Fork Garcia	GR-3	Stream crossing	Upgrade	HM	H	33	240	20
1080	North Fork Garcia	MV-1	Stream crossing	Upgrade	M	L	56	20	1230
1081	North Fork Garcia	MV-1	Stream crossing	Upgrade	ML	ML	360	750	55
1100	North Fork Garcia	OG-1	Stream crossing	Upgrade	ML	ML	122	0	80
1101	North Fork Garcia	OG-1	Stream crossing	Upgrade	ML	L	168	0	466
1101.1	North Fork Garcia	OG-1	Stream crossing	Decommission	M	ML	17	165	0
1102	North Fork Garcia	OG-1	Stream crossing	Upgrade	L	L	85	315	45
1103	North Fork Garcia	OG-1	Stream crossing	Upgrade	L	L	171	0	367
1104	North Fork Garcia	OG-1	Landslide	Upgrade	M	L	3	0	0
1105	North Fork Garcia	OG-1	Stream crossing	Upgrade	L	L	125	0	525
1106	North Fork Garcia	OG-1	Ditch relief culvert	Upgrade	L	L	2	155	216
1107	North Fork Garcia	OG-1	Stream crossing	Upgrade	L	L	93	100	242
1108	North Fork Garcia	OG-1	Stream crossing	Upgrade	ML	ML	111	0	1116
1109	North Fork Garcia	OG-1	Ditch relief culvert	Upgrade	L	L		0	247
1110	North Fork Garcia	OG-1	Stream crossing	Upgrade	M	HM	172	50	0
1111	North Fork Garcia	OG-1	Spring	Upgrade	ML	L	13	95	140
1112	North Fork Garcia	OG-1	Stream crossing	Upgrade	M	M	134	110	0
1113	North Fork Garcia	OG-1	Stream crossing	Upgrade	M	L	159	215	35
1114	North Fork Garcia	OG-1	Stream crossing	Upgrade	M	M	155	0	150
1115	North Fork Garcia	OG-1	Spring	Upgrade	M	L	50	0	145

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1116	North Fork Garcia	OG-1	Spring	NT	NT	H	1	0	0
1117	North Fork Garcia	OG-1	Stream crossing	Upgrade	H	H	586	0	165
1118	North Fork Garcia	OG-1	Landslide	Upgrade	HM	M	68	20	50
1119	North Fork Garcia	OG-1	Stream crossing	Upgrade	ML	M	538	985	95
1119.2	North Fork Garcia	OG-1	Landslide	Upgrade	M	ML	3		
1120	North Fork Garcia	OG-1	Other	Upgrade	L	L	0	125	0
1120.1	North Fork Garcia	OG-1	Spring	Upgrade	L	L	1	0	0
1121	North Fork Garcia	OG-1	Stream crossing	Upgrade	ML	L	129	335	330
1121.1	North Fork Garcia	OG-1	Stream crossing	Decommission	M	ML	117	245	0
1122	North Fork Garcia	OG-1	Stream crossing	Upgrade	L	L	64	50	235
1122.1	North Fork Garcia	OG-1-7	Stream crossing	Decommission	L	L	24	250	0
1125	North Fork Garcia	Olson Gulch Road Spur B	Stream crossing	Upgrade	M	ML	162	220	325
1126	North Fork Garcia	OG-8	Stream crossing	Upgrade	M	M	184	2025	15
1127	North Fork Garcia	OG-8	Landslide	Upgrade	L	L	25	550	135
1128	North Fork Garcia	OG-8	Landslide	Upgrade	ML	ML	44	0	1460
1129	North Fork Garcia	OG-8	Stream crossing	Upgrade	L	L	144	0	480
1130	North Fork Garcia	OG-8	Landslide	Upgrade	ML	ML	18	0	0
1131	North Fork Garcia	OG-8	Stream crossing	Upgrade	ML	ML	64	0	1730
1131.1	North Fork Garcia	OG-8-2-2	Road drainage discharge point	Decommission	L	L	0	0	650
1132	North Fork Garcia	OG-8	Stream crossing	Upgrade	M	ML	42	560	0
1133	North Fork Garcia	OG-7	Gully	Upgrade	M	M	12	700	650
1134	North Fork Garcia	OG-7	Road drainage discharge point	Upgrade	L	L	0	200	300
1135	North Fork Garcia	OG-7	Road drainage discharge point	Decommission	L	L	0	0	300
1136	North Fork Garcia	OG-7	Bank erosion	Decommission	M	M	12	0	0
1137	North Fork Garcia	OG-0.5	Stream crossing	Upgrade	M	HM	125	50	0
1138	North Fork Garcia	OG-0.5	Stream crossing	Upgrade	M	HM	82	250	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1138.1	North Fork Garcia	OG-0.5	Landslide	Upgrade	L	L	3	50	0
1139	North Fork Garcia	OG-0.5	Stream crossing	Upgrade	HM	HM	495	50	30
1140	North Fork Garcia	OG-0.5	Stream crossing	Upgrade	M	ML	94	0	85
1160	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	ML	60	0	165
1161	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	ML	81	1217	120
1162	North Fork Garcia	OG-9	Stream crossing	Upgrade	L	L	229	587	187
1163	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	M	489	15	2350
1163.1	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	ML	811	15	10
1163.2	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	ML	679	375	20
1164	North Fork Garcia	OG-9	Road drainage discharge point	Upgrade	ML	ML	0	35	142
1165	North Fork Garcia	OG-9	Stream crossing	Upgrade	M	M	49	375	2022
1166	North Fork Garcia	OG-9	Stream crossing	Upgrade	HM	HM	172	26	300
1166.1	North Fork Garcia	OG-9 skid	Stream crossing	Decommission	H	HM	648	470	15
1167	North Fork Garcia	OG-9	Stream crossing	Decommission	M	ML	53	20	300
1168	North Fork Garcia	OG-9-1-2	Stream crossing	Upgrade	HM	M	42	14	1200
1169	North Fork Garcia	OG-9-1-2	Landslide	Decommission	ML	ML	11	0	100
1170	North Fork Garcia	OG-12.5	Stream crossing	Upgrade	M	HM	264	150	135
1171	North Fork Garcia	OG-12.5	Stream crossing	Upgrade	ML	ML	167	475	30
1200	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	M	65	20	3139
1201	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	L	L	59	0	437
1202	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	ML	28	1083	0
1203	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	M	168	595	0
1204	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	ML	169	289	0
1205	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	HM	119	130	5
1206	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	M	250	0	2087
1207	North Fork Garcia	Olson Gulch Road	Spring	Upgrade	ML	L	18	607	469
1208	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	H	HM	887	673	358
1209	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	HM	M	562	203	433
1210	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	ML	528	355	922

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1211	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	HM	HM	303	0	650
1212	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	HM	HM	149	0	55
1213	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	ML	6	112	893
1214	North Fork Garcia	Olson Gulch Road	Gully	Upgrade	L	M	32	30	0
1215	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	M	36	890	0
1216	North Fork Garcia	Olson Gulch Road	Landslide	Upgrade	L	ML	112		
1217	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	ML	5	50	583
1218	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	ML	ML	75	200	0
1219	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	HM	M	98	415	0
1219.1	North Fork Garcia	Olson Gulch Road	Road drainage discharge point	Upgrade	M	M	0	3120	130
1220	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	L	L	233	35	100
1221	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	ML	233	20	550
1222	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	HM	30	0	722
1223	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	M	HM	538	0	1042
1224	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	HM	M	60	164	800
1225	North Fork Garcia	Olson Gulch Road	Stream crossing	Upgrade	H	ML	12	0	174
1240	North Fork Garcia	OG-3-4	Stream crossing	Upgrade	L	L	24	10	65
1241	North Fork Garcia	OG-3-4	Stream crossing	Upgrade	M	M	58	65	0
1242	North Fork Garcia	OG-3	Stream crossing	Upgrade	L	L	30	15	500
1243	North Fork Garcia	OG-3_6	Stream crossing	Upgrade	ML	M	72	95	40
1244	North Fork Garcia	OG-3	Stream crossing	Upgrade	L	L	2	250	80
1245	North Fork Garcia	OG-3	Stream crossing	Upgrade	ML	ML	23	15	15
1246	North Fork Garcia	OG-3	Stream crossing	Upgrade	ML	M	3	200	50
1247	North Fork Garcia	OG-17	Stream crossing	Decommission	ML	ML	20	1130	0
1248	North Fork Garcia	OG-17	Stream crossing	Decommission	M	M	13	120	0
1249	North Fork Garcia	OG-17	Stream crossing	Upgrade	L	L	20	60	85
1250	North Fork Garcia	OG-14	Stream crossing	Upgrade	M	M	58	300	25
1251	North Fork Garcia	OG-14	Stream crossing	Upgrade	HM	L	95	1000	25
1252	North Fork Garcia	OG-5-3	Stream crossing	Upgrade	L	L	13	25	990

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1253	North Fork Garcia	OG-5-3	Stream crossing	Upgrade	M	ML	12	110	45
1254	North Fork Garcia	OG-5-3	Spring	Upgrade	ML	ML	0	1100	0
1255	North Fork Garcia	OG-9-1	Stream crossing	Upgrade	L	M	36	50	0
1255.1	North Fork Garcia	OG-9-1	Landslide	Upgrade	ML	ML	23		
1256	North Fork Garcia	OG-9-1	Spring	Upgrade	L	L	0	100	0
1257	North Fork Garcia	OG-9-1	Stream crossing	Upgrade	ML	ML	53	310	10
1258	North Fork Garcia	OG-9-1	Landslide	Upgrade	M	HM	46		
1259	North Fork Garcia	OG-9-1	Stream crossing	Upgrade	M	M	84	440	20
1260	North Fork Garcia	OG-11	Landslide	NT	NT	ML	56	0	0
1260.6	North Fork Garcia	OG-11	Stream crossing	NT	NT	M	10	0	0
1260.7	North Fork Garcia	OG-11	Stream crossing	NT	NT	L		0	0
1260.8	North Fork Garcia	OG-11	Stream crossing	NT	NT	ML		50	0
1260.9	North Fork Garcia	OG-11	Stream crossing	NT	NT	L		60	25
1261	North Fork Garcia	OG-11	Stream crossing	NT	NT	ML	75	30	0
1262	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	169	0	400
1263	Victoria Fork	BW-1	Stream crossing	Upgrade	M	ML	62	0	525
1264	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	69	0	180
1265	Victoria Fork	BW-1	Stream crossing	Upgrade	H	H	167	0	300
1266	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	49	0	175
1267	Victoria Fork	BW-1	Stream crossing	Upgrade	H	H	310	30	220
1268	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	414	50	193
1269	Victoria Fork	BW-1	Gully	Upgrade	HM	L	2	30	1646
1270	Victoria Fork	BW-1	Stream crossing	Upgrade	M	L	222	204	219
1270.1	Victoria Fork	BW-1	Landslide	Upgrade	ML	M	896	0	0
1271	Victoria Fork	BW-1	Stream crossing	NT	NT	L		30	30
1272	Victoria Fork	BW-1	Stream crossing	Upgrade	M	ML	265	200	400
1273	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	85	1025	280
1274	Victoria Fork	BW-1	Stream crossing	Upgrade	H	M	243	1250	0
1275	Victoria Fork	BW-1	Gully	Upgrade	ML	M	19	290	10
1276	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	ML	395	265	740

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1277	Victoria Fork	BW-1 skid	Landslide	Decommission	HM	HM	230	100	0
1278	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	M	217	590	40
1279	Victoria Fork	BW-1	Stream crossing	Upgrade	L	L	1	320	10
1280	Victoria Fork	BW-1	Stream crossing	Upgrade	H	H	175	439	100
1281	Victoria Fork	BW-1	Stream crossing	Upgrade	ML	M	2	100	15
1282	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	24	450	0
1283	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	110	380	0
1284	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	170	421	0
1285	Victoria Fork	BW-1	Stream crossing	Upgrade	ML	ML	225	395	0
1286	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	95	555	0
1287	Victoria Fork	BW-1	Stream crossing	Upgrade	ML	ML	168	363	0
1288	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	H	169	393	0
1289	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	64	195	0
1290	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	460	325	0
1291	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	M	83	50	0
1292	Victoria Fork	BW-1	Gully	Upgrade	ML	ML	10	53	0
1293	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	191	207	0
1294	Victoria Fork	BW-1	Stream crossing	Upgrade	M	ML	100	905	0
1295	Victoria Fork	BW-1	Stream crossing	Upgrade	HM	HM	108	162	0
1296	Victoria Fork	BW-1	Ditch relief culvert	Upgrade	L	L		138	0
1297	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	120	385	0
1298	Victoria Fork	BW-1	Stream crossing	Upgrade	ML	L	71	311	0
1299	Victoria Fork	BW-1	Stream crossing	Upgrade	M	L	110	370	0
1299.1	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	1069	110	40
1299.2	Victoria Fork	BW-1	Stream crossing	Upgrade	M	M	69	190	0
1300	North Fork Garcia	OG-5-3-2	Landslide	Upgrade	HM	HM	312	0	0
1301	North Fork Garcia	OG-5-3-2	Stream crossing	Upgrade	M	ML	397	1760	40
1302	North Fork Garcia	OG-5-3-2	Spring	NT	NT	ML	0	80	0
1303	North Fork Garcia	OG-5-3-2	Stream crossing	NT	NT	L		155	185

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1304	North Fork Garcia	GR-9	Landslide	Decommission	HM	H	54	0	0
1305	North Fork Garcia	GR-9	Spring	Decommission	ML	ML	0	250	50
1306	North Fork Garcia	GR-9	Stream crossing	Decommission	L	L	19	100	10
1307	North Fork Garcia	GR-9	Landslide	Decommission	M	HM	30	0	0
1326	Victoria Fork	BW-1-1	Stream crossing	Decommission	M	ML	12	2050	50
1327	Victoria Fork	BW-1-2-1	Stream crossing	Upgrade	M	M	173	1334	40
1328	Victoria Fork	BW-1-2-2	Stream crossing	Decommission	M	HM	44	55	65
1329	North Fork Garcia	NF-6	Landslide	Upgrade	H	H	280	0	0
1330	North Fork Garcia	NF-6	Stream crossing	Upgrade	M	HM	201	110	50
1331	North Fork Garcia	NF-6	Landslide	Upgrade	H	H	263	0	0
1332	North Fork Garcia	NF-6	Stream crossing	Upgrade	M	M	25	120	110
1333	North Fork Garcia	NF-6	Landslide	Upgrade	HM	HM	85		
1334	North Fork Garcia	NF-6	Spring	Upgrade	ML	L	0	0	130
1335	North Fork Garcia	NF-6	Stream crossing	Upgrade	ML	ML	34	60	20
1336	North Fork Garcia	NF-6	Stream crossing	Upgrade	ML	ML	224	450	0
1337	North Fork Garcia	NF-6	Other	Upgrade	L	L	0	0	240
1338	North Fork Garcia	NF-6	Stream crossing	Upgrade	M	M	51	0	240
1339	North Fork Garcia	NF-6	Stream crossing	Upgrade	M	HM	85	275	50
1340	North Fork Garcia	NF-6 Skid-1	Stream crossing	Decommission	M	M	17	110	180
1341	North Fork Garcia	NF-7	Landslide	Upgrade	HM	HM	419	90	0
1342	North Fork Garcia	NF-8-1	Road drainage discharge point	NT	NT	L	0	400	0
1356	North Fork Garcia	GR-5	Stream crossing	Decommission	ML	ML	19	725	0
1357	North Fork Garcia	NF-6-1	Stream crossing	Upgrade	ML	ML	19	210	380
1358	North Fork Garcia	GR-7-1	Stream crossing	Decommission	L	L	14	220	20
1359	North Fork Garcia	GR-7-1	Stream crossing	Decommission	M	HM	165	0	100
1360	North Fork Garcia	GR-7-1	Stream crossing	Decommission	L	L	68	270	0
1361	North Fork Garcia	GR-7-1	Stream crossing	Decommission	M	M	152	460	0
1362	North Fork Garcia	GR-7-1	Stream crossing	Decommission	ML	ML	12	140	460
1363	North Fork Garcia	GR-7-1	Stream crossing	Decommission	ML	ML	24	50	165

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1364	North Fork Garcia	GR-7-1	Stream crossing	Decommission	L	L	13	0	250
1365	North Fork Garcia	GR-7-2	Stream crossing	NT	NT	ML	148	0	0
1366	North Fork Garcia	GR-7-2	Road drainage discharge point	Decommission	ML	ML	0	0	250
1367	North Fork Garcia	GR-7-2-1-1	Stream crossing	Decommission	L	ML	21	0	0
1368	North Fork Garcia	GR-7-2-1-1	Bank erosion	Decommission	HM	HM	196	0	0
1369	North Fork Garcia	GR-7-2-1-1	Stream crossing	Decommission	M	M	401	0	450
1370	North Fork Garcia	GR-7-2-1-1	Stream crossing	Decommission	L	L		25	290
1372	North Fork Garcia	GR-5-1	Stream crossing	NT	NT	L		0	0
1373	North Fork Garcia	GR-5-1	Stream crossing	Decommission	ML	L	95	220	20
1374	North Fork Garcia	GR-5-1	Landslide	Decommission	ML	L	125	0	0
1375	North Fork Garcia	GR-5-1	Stream crossing	Decommission	ML	ML	213	295	260
1376	North Fork Garcia	GR-7	Road drainage discharge point	Decommission	L	M	1	180	0
1377	North Fork Garcia	GR-7	Stream crossing	Decommission	ML	L	56	180	0
1378	North Fork Garcia	GR-7	Other	Decommission	L	M		25	0
1379	North Fork Garcia	GR-7	Stream crossing	Decommission	M	M	45	600	0
1380	North Fork Garcia	GR-7	Landslide	Decommission	M	M	106	0	0
1381	North Fork Garcia	GR-7	Stream crossing	Decommission	M	ML	13	100	475
1382	North Fork Garcia	GR-8-1	Stream crossing	Upgrade	ML	M	11	1555	0
1382.1	North Fork Garcia	MV-3	Stream crossing	Upgrade	L	L	27	150	160
1383	North Fork Garcia	GR-8	Ditch relief culvert	Upgrade	L	L		490	0
1384	North Fork Garcia	GR-8	Stream crossing	NT	NT	L	14	20	25
1385	North Fork Garcia	GR-8	Stream crossing	Upgrade	ML	L	55	30	0
1386	North Fork Garcia	GR-8	Stream crossing	Upgrade	M	M	241	110	290
1387	North Fork Garcia	GR-8	Stream crossing	Upgrade	ML	ML	171	75	50
1388	North Fork Garcia	GR-8	Stream crossing	Upgrade	M	M	49	125	700
1389	North Fork Garcia	GR-8	Stream crossing	Upgrade	ML	M	255	130	50
1390	North Fork Garcia	GR-8	Stream crossing	Upgrade	HM	M	78	1600	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1391	North Fork Garcia	GR-8	Stream crossing	Upgrade	ML	L	78	100	0
1392	North Fork Garcia	GR-8	Bank erosion	Upgrade	HM	HM	48	60	60
1393	North Fork Garcia	GR-8	Ditch relief culvert	Upgrade	M	M	11	0	1900
1394	North Fork Garcia	GR-8	Ditch relief culvert	NT	NT	L		80	0
1395	North Fork Garcia	GR-8	Stream crossing	Upgrade	ML	L	133	350	0
1396	North Fork Garcia	GR-8	Stream crossing	Upgrade	L	L	54	490	40
1397	North Fork Garcia	GR-8	Gully	Upgrade	ML	HM		225	0
1398	North Fork Garcia	GR-8	Stream crossing	NT	NT	L	7	190	0
1399	North Fork Garcia	GR-8	Stream crossing	Upgrade	M	M	211	415	0
1400	North Fork Garcia	GR-8	Landslide	Upgrade	M	M	45	0	0
1401	North Fork Garcia	GR-8	Stream crossing	Upgrade	HM	HM	221	110	65
1402	North Fork Garcia	GR-7	Landslide	Decommission	HM	H	167	0	200
1403	North Fork Garcia	GR-7	Stream crossing	Decommission	M	HM	54	45	20
1404	North Fork Garcia	GR-7	Stream crossing	Decommission	ML	M	21	0	30
1405	North Fork Garcia	GR-7	Stream crossing	Decommission	L	L	5	0	10
1406	North Fork Garcia	GR-7	Stream crossing	Decommission	L	L	11	0	60
1407	North Fork Garcia	GR-7	Stream crossing	Decommission	ML	M	18	50	0
1408	North Fork Garcia	GR-7	Stream crossing	Decommission	ML	HM	43	80	60
1409	North Fork Garcia	GR-7	Gully	Decommission	HM	H	23	150	0
1410	North Fork Garcia	GR-7	Stream crossing	Decommission	L	HM	207	400	80
1411	North Fork Garcia	GR-7	Stream crossing	Decommission	ML	ML	20	30	0
1412	North Fork Garcia	GR-7	Stream crossing	NT	NT	L	0	0	0
1413	North Fork Garcia	GR-8	Stream crossing	Upgrade	HM	M	176	0	600
1414	North Fork Garcia	GR-8-2	Stream crossing	Upgrade	M	M	14	218	20
1415	North Fork Garcia	GR-8-2	Stream crossing	Upgrade	M	ML	30	1450	100
1416	North Fork Garcia	GR-8-2	Stream crossing	NT	NT	M		95	25
1417	North Fork Garcia	GR-8	Stream crossing	Upgrade	HM	HM	75	0	430
1418	North Fork Garcia	GR-8	Landslide	Decommission	M	HM	34	300	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1419	North Fork Garcia	GR-8	Landslide	Upgrade	M	ML	15	120	0
1420	North Fork Garcia	GR-8	Landslide	Decommission	M	H	250	1000	0
1421	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	L	L	3	0	80
1422	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	HM	H	79	30	30
1423	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	M	L	3	20	800
1424	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	M	HM	12	10	30
1425	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	HM	ML	117	380	800
1426	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	L	L	24	0	60
1427	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	ML	L	31	0	110
1428	Victoria Fork	BW-1-3-1	Stream crossing	Upgrade	ML	ML	4	500	140
1429	Victoria Fork	BW-1 skid	Stream crossing	Upgrade	M	M	37	30	410
1430	Victoria Fork	BW-1 skid	Stream crossing	Upgrade	M	L	2	0	600
1431	Victoria Fork	BW-1 skid	Stream crossing	Upgrade	HM	HM	7	0	325
1432	Victoria Fork	BW-1 skid	Landslide	Upgrade	L	M	11	0	500
1433	Victoria Fork	BW-2	Stream crossing	Upgrade	ML	M	43	375	20
1434	Victoria Fork	BW-2	Stream crossing	Upgrade	ML	L	16	220	0
1435	Victoria Fork	BW-2	Spring	Upgrade	L	M	7	250	10
1436	Victoria Fork	BW-2	Stream crossing	Upgrade	ML	ML	217	176	22
1437	Victoria Fork	BW-2	Gully	Upgrade	L	M	2	160	10
1438	Victoria Fork	BW-2	Gully	Upgrade	L	ML	3	40	10
1439	Victoria Fork	BW-2	Stream crossing	Upgrade	L	L	48	0	120
1440	Victoria Fork	BW-2	Stream crossing	Upgrade	ML	ML	68	90	150
1441	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	11	100	140
1442	Victoria Fork	BW-2	Stream crossing	Upgrade	L	ML	75	0	110
1443	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	HM	102	600	245
1444	Victoria Fork	BW-2	Stream crossing	NT	NT	L	12	223	180
1445	Victoria Fork	BW-2	Stream crossing	Upgrade	L	L	50	200	0
1446	Victoria Fork	BW-2	Road drainage discharge point	Upgrade	M	ML	15	240	0
1447	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	HM	519	0	420

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1448	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	96	90	255
1449	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	111	120	0
1450	North Fork Garcia	GR-8-2-3	Stream crossing	NT	NT	L		0	80
1451	North Fork Garcia	GR-8-2-1	Stream crossing	Upgrade	L	L		120	30
1452	North Fork Garcia	GR-8-1	Spring	Upgrade	L	M	89	85	25
1453	Victoria Fork	BW-2-2 skid	Stream crossing	Decommission	ML	ML	22	15	80
1454	Victoria Fork	BW-2-2	Stream crossing	Upgrade	L	L	3	40	50
1455	Victoria Fork	BW-2-2	Stream crossing	Upgrade	M	HM	4	55	0
1456	Victoria Fork	BW-2-4	Road drainage discharge point	Upgrade	M	M	42	0	940
1457	Victoria Fork	BW-2-4	Stream crossing	NT	NT	L	2	0	105
1458	North Fork Garcia	GR-7-2-1-1	Stream crossing	Decommission	M	M	54	20	25
1459	North Fork Garcia	GR-7-2-1	Stream crossing	Decommission	L	L	2	240	25
1460	North Fork Garcia	GR-7-2-1	Stream crossing	Decommission	ML	ML	8	10	30
1461	North Fork Garcia	GR-7-2-1	Gully	Decommission	ML	ML	2	10	450
1462	Victoria Fork	BW-2-1	Stream crossing	Upgrade	ML	ML	15	400	700
1463	Victoria Fork	BW-2-1	Stream crossing	Upgrade	ML	M	9	0	700
1464	Victoria Fork	BW-2-1	Gully	Upgrade	ML	HM	7	0	30
1465	Victoria Fork	BW-2-1	Gully	Upgrade	ML	ML		0	865
1466	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	187	438	0
1467	Victoria Fork	BW-2	Spring	Upgrade	ML	M	6	30	778
1468	Victoria Fork	BW-2	Landslide	Upgrade	M	M	77	0	205
1469	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	M	213	0	550
1470	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	M	807	35	820
1470.1	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	M	1405	115	0
1471	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	HM	170	250	0
1472	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	ML	3	1300	20
1473	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	M	113	200	0
1474	Victoria Fork	BW-2	Stream crossing	Upgrade	ML	ML	229	196	220
1475	Victoria Fork	BW-2	Landslide	Upgrade	HM	H	42	0	150

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1476	Victoria Fork	BW-2-4	Stream crossing	NT	NT	L	2	20	50
1477	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	89	380	30
1477.1	Victoria Fork	BW-2	Ditch relief culvert	Upgrade	M	M	14	350	10
1477.2	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	HM	774	369	0
1478	Victoria Fork	BW-2	Gully	Upgrade	M	ML	12	113	370
1479	Victoria Fork	BW-2	Stream crossing	Upgrade	HM	HM	971	140	80
1480	Victoria Fork	BW-2	Ditch relief culvert	Upgrade	ML	L		100	0
1481	Victoria Fork	BW-2	Ditch relief culvert	Upgrade	M	M		285	0
1482	Victoria Fork	BW-2	Stream crossing	Upgrade	M	M	65	53	0
1483	Victoria Fork	BW-2	Stream crossing	Upgrade	L	L	40	240	0
1484	Victoria Fork	BW-2-3	Stream crossing	Upgrade	L	ML	16	0	420
1485	Victoria Fork	BW-2-3	Stream crossing	Upgrade	ML	ML	12	75	30
1490	Victoria Fork	BW-3	Stream crossing	NT	NT	L	0	30	10
1491	Victoria Fork	BW-3	Stream crossing	NT	NT	L	0	20	250
1492	Victoria Fork	BW-3	Stream crossing	NT	NT	L	0	30	150
1493	Victoria Fork	BW-3	Stream crossing	Decommission	M	ML	158	40	20
1494	Victoria Fork	BW-3	Stream crossing	NT	NT	L	0	30	180
1495	Victoria Fork	BW-3	Stream crossing	Decommission	H	H	223	600	0
1496	Victoria Fork	BW-3	Stream crossing	Decommission	ML	HM	79	230	0
1497	Victoria Fork	BW-3	Gully	Decommission	ML	ML	6	500	0
1498	Victoria Fork	BW-3	Stream crossing	Decommission	HM	H	108	600	0
1499	Victoria Fork	BW-3	Stream crossing	Decommission	ML	M	18	60	0
1500	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	49	330	0
1501	East of Eureka Hill	Hollow Tree Road	Road drainage discharge point	Upgrade	ML	L		500	0
1502	East of Eureka Hill	HT-1-2	Stream crossing	Upgrade	L	L		400	150
1503	East of Eureka Hill	HT-1-2	Stream crossing	Upgrade	L	L		100	50

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1504	East of Eureka Hill	HT-1-2	Stream crossing	Upgrade	ML	ML	3	500	20
1505	East of Eureka Hill	HT-1-2	Stream crossing	Upgrade	M	M	92	70	0
1506	East of Eureka Hill	HT-1-2	Stream crossing	NT	NT	L	7	95	0
1507	East of Eureka Hill	HT-1-2	Stream crossing	Upgrade	ML	ML	137	60	1065
1508	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	341	200	0
1509	East of Eureka Hill	HT-1-3	Stream crossing	Upgrade	HM	ML	133	3500	100
1510	East of Eureka Hill	HT-1-3	Stream crossing	Upgrade	ML	M	27	0	740
1511	East of Eureka Hill	HT-1-3	Stream crossing	Upgrade	ML	ML	19	10	50
1512	East of Eureka Hill	HT-1-3	Stream crossing	Upgrade	M	M	22	110	450
1513	East of Eureka Hill	Hollow Tree Road	Gully	Upgrade	M	M	6	0	715
1514	East of Eureka Hill	Hollow Tree Road	Gully	Upgrade	ML	ML	3	0	915
1515	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	32	75	400
1516	East of Eureka Hill	Signal Creek Road	Ditch relief culvert	Upgrade	M	M		820	400
1517	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	M	M	64	130	365
1518	North of Gualala Mountain	HT-2	Road drainage discharge point	Upgrade	L	L		75	130
1519	North of Gualala Mountain	HT-2	Ditch relief culvert	Upgrade	M	HM	8	275	0
1520	North of Gualala Mountain	HT-2	Landslide	Upgrade	M	M	3	1450	0
1521	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	HM	HM	347	450	150
1522	North of Gualala Mountain	HT-2	Road drainage discharge point	Upgrade	M	M	28	743	65
1523	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	M	HM	334	840	110
1524	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	HM	H	589	300	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1525	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	M	ML	245	1520	0
1526	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	HM	HM	149	450	40
1527	North of Gualala Mountain	HT-2	Spring	Upgrade	ML	L		600	40
1528	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	ML	ML	202	570	0
1529	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	HM	M	98	30	1335
1530	North of Gualala Mountain	HT-2	Stream crossing	Upgrade	ML	ML	283	0	95
1531	North of Gualala Mountain	HT-2	Road drainage discharge point	Upgrade	ML	M		30	600
1532	East of Eureka Hill	HT-2	Road drainage discharge point	Upgrade	M	M		0	1120
1533	North of Gualala Mountain	HT-2-1	Landslide	NT	NT	L	190	140	310
1534	North of Gualala Mountain	HT-2-1	Stream crossing	NT	NT	L	3	50	0
1535	North of Gualala Mountain	HT-2-1	Road drainage discharge point	Decommission	ML	ML	2	725	0
1536	North of Gualala Mountain	HT-2-1	Landslide	Decommission	M	M	53	330	0
1537	North of Gualala Mountain	HT-2-1	Stream crossing	Upgrade	M	HM	62	0	525
1538	North of Gualala Mountain	HT-2-1	Stream crossing	Upgrade	ML	ML	345	1200	100
1539	North of Gualala Mountain	HT-2-2-2	Stream crossing	NT	NT	L	2	150	18

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1540	North of Gualala Mountain	HT-2-3	Stream crossing	Decommission	L	ML	44	0	205
1541	North of Gualala Mountain	HT-2-3	Stream crossing	Decommission	L	ML	16	55	390
1542	North of Gualala Mountain	HT-2-3	Landslide	NT	NT	M	28	0	35
1543	North of Gualala Mountain	HT-2-4	Stream crossing	Decommission	ML	L		25	350
1544	North of Gualala Mountain	HT-2-4	Landslide	Decommission	M	M	311	0	670
1545	North of Gualala Mountain	HT-2-5	Stream crossing	Decommission	M	M	13	170	360
1546	North of Gualala Mountain	HT-2-5	Stream crossing	Upgrade	M	M	26	80	290
1547	North of Gualala Mountain	HT-2-2	Stream crossing	NT	NT	L	10	0	20
1548	North of Gualala Mountain	HT-2-2	Stream crossing	NT	NT	L	10	0	80
1549	North of Gualala Mountain	HT-2-2	Stream crossing	Decommission	M	M	168	750	160
1550	North of Gualala Mountain	HT-2-2	Stream crossing	Decommission	ML	ML	100	10	10
1551	North of Gualala Mountain	HT-2-2-3	Stream crossing	Decommission	ML	HM	72	0	110
1552	North of Gualala Mountain	HT-2-2-3	Stream crossing	Decommission	M	M	427	0	0
1553	North of Gualala Mountain	HT-2-6	Road drainage discharge point	Upgrade	L	L	7	0	405
1554	North of Gualala Mountain	HT-2-6	Road drainage discharge point	Upgrade	M	ML	11	0	2273

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[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1555	North of Gualala Mountain	HT-2-6	Stream crossing	Upgrade	ML	M	187	0	1045
1556	North of Gualala Mountain	HT-2-6	Stream crossing	Upgrade	L	L	439	25	152
1557	North of Gualala Mountain	HT-2-6	Landslide	Upgrade	L	L	3		
1558	North of Gualala Mountain	HT-2-6	Road drainage discharge point	Upgrade	ML	L		0	790
1560	North of Gualala Mountain	HT-2-8	Stream crossing	Decommission	M	HM	1124	50	420
1561	North of Gualala Mountain	HT-1-Spur	Stream crossing	Upgrade	M	ML	507	365	0
1562	North of Gualala Mountain	HT-1-Spur	Stream crossing	Upgrade	ML	L	113	1200	30
1563	North of Gualala Mountain	HT-1-spur	Spring	Upgrade	L	L	4	450	15
1564	North of Gualala Mountain	HT-2-2	Bank erosion	Decommission	M	M	66	0	0
1564.1	North of Gualala Mountain	HT-2-2	Stream crossing	Decommission	ML	L	0	0	300
1565	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	M	HM	113	950	90
1566	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	ML	L	59	50	0
1567	East of Eureka Hill	41.3.1	Spring	Upgrade	ML	ML	2	1100	200
1568	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	ML	L	235	1000	0
1569	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	ML	HM	66	90	0
1570	East of Eureka Hill	41.3.1	Bank erosion	Upgrade	M	HM	200	20	0
1571	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	ML	ML	4	1180	3
1572	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	L	L	36	480	60
1573	East of Eureka Hill	41.3	Stream crossing	Upgrade	L	L	281		
1574	East of Eureka Hill	41.3	Stream crossing	Upgrade	ML	L	37	0	1000
1575	East of Eureka Hill	41.3	Stream crossing	Upgrade	M	ML	239	0	25

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1576	East of Eureka Hill	41.3.1	Stream crossing	Upgrade	M	M	8	10	500
1577	East of Eureka Hill	41	Stream crossing	Upgrade	HM	HM	810	110	250
1578	East of Eureka Hill	41	Landslide	Upgrade	L	L	139	200	0
1579	East of Eureka Hill	41	Stream crossing	Upgrade	L	L	13	160	0
1580	East of Eureka Hill	41	Stream crossing	Upgrade	HM	M	72	300	0
1581	East of Eureka Hill	41	Stream crossing	Upgrade	H	H	588	300	0
1582	East of Eureka Hill	41	Gully	Upgrade	HM	M		950	0
1583	East of Eureka Hill	41	Stream crossing	Upgrade	HM	HM	854	90	0
1584	East of Eureka Hill	41	Stream crossing	Upgrade	ML	ML	10	320	380
1585	East of Eureka Hill	41.2	Bank erosion	Decommission	HM	HM	204	0	0
1586	East of Eureka Hill	41.2	Landslide	Decommission	HM	H	360	1000	0
1587	East of Eureka Hill	41	Stream crossing	Upgrade	M	M	335	100	1700
1588	East of Eureka Hill	41.3	Stream crossing	Upgrade	M	HM	54	0	1400
1589	East of Eureka Hill	41.3	Stream crossing	Upgrade	M	ML	91	90	980
1590	East of Eureka Hill	41.3	Stream crossing	Upgrade	M	M	24	0	600
1591	East of Eureka Hill	41.3	Road drainage discharge point	Upgrade	M	ML		130	600
1592	East of Eureka Hill	41.3	Stream crossing	Upgrade	M	M	40	8	320
1593	East of Eureka Hill	41.1	Stream crossing	Decommission	M	M	26	170	0
1594	East of Eureka Hill	41	Stream crossing	Upgrade	HM	HM	95	0	1000
1600	Victoria Fork	BW-3	Landslide	Decommission	M	HM	67	0	150
1601	Victoria Fork	BW-3	Stream crossing	Decommission	L	ML	5	0	20
1602	Victoria Fork	BW-3	Landslide	Decommission	H	H	610	0	0
1603	Victoria Fork	BW-3	Gully	Decommission	ML	ML		0	1200
1604	Victoria Fork	BW-3	Stream crossing	Decommission	ML	M	40	0	1000
1605	North of Gualala Mountain	HT-2-6	Stream crossing	Upgrade	M	ML	313	500	250
1606	North of Gualala Mountain	HT-2-6	Spring	Upgrade	ML	ML	3	300	50

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1607	North of Gualala Mountain	HT-2-6	Landslide	Upgrade	M	ML	24	0	0
1608	North of Gualala Mountain	HT-2-6	Stream crossing	Upgrade	HM	M	68	350	0
1609	North of Gualala Mountain	HT-2-6-1	Stream crossing	Upgrade	M	M	626	0	40
1610	North of Gualala Mountain	HT-2-6-1	Stream crossing	Upgrade	M	M	13	0	135
1611	North of Gualala Mountain	HT-2-6-1	Stream crossing	Upgrade	ML	ML	9	0	480
1612	North of Gualala Mountain	HT-2-5-1	Stream crossing	NT	NT	L	2	90	0
1613	North of Gualala Mountain	HT-2-5-1	Stream crossing	NT	NT	L	45	120	0
1615	East of Eureka Hill	HT 3-7	Landslide	Upgrade	L	L	9		
1616	East of Eureka Hill	HT-3-7	Stream crossing	Upgrade	ML	ML	31	75	0
1617	East of Eureka Hill	HT 3-7	Stream crossing	Upgrade	HM	HM	68	200	0
1618	East of Eureka Hill	HT-3-7	Stream crossing	Upgrade	M	M	101	200	50
1619	East of Eureka Hill	HT 3-7	Spring	Upgrade	ML	ML	7	0	0
1620	East of Eureka Hill	HT-3-7	Stream crossing	Upgrade	M	ML	121	1395	0
1621	East of Eureka Hill	HT-3-7	Road drainage discharge point	Upgrade	L	L		200	0
1622	East of Eureka Hill	HT-3	Stream crossing	Upgrade	L	L	263	25	115
1623	East of Eureka Hill	HT-3	Stream crossing	Upgrade	ML	L	78	1150	0
1624	East of Eureka Hill	HT-3-2	Stream crossing	Upgrade	L	L	8	295	40
1625	East of Eureka Hill	HT-3	Stream crossing	Upgrade	L	L	188	400	20
1626	East of Eureka Hill	HT-3	Stream crossing	Upgrade	M	M	54	20	20
1627	East of Eureka Hill	HT-3	Stream crossing	Upgrade	ML	ML	37	75	760
1628	East of Eureka Hill	HT-3	Stream crossing	Upgrade	HM	HM	406	120	0
1629	East of Eureka Hill	HT-3	Stream crossing	Upgrade	L	L	197	100	60
1630	East of Eureka Hill	HT-3	Gully	Upgrade	H	H	15	0	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1631	East of Eureka Hill	HT-3	Stream crossing	Upgrade	ML	M	3	750	0
1632	East of Eureka Hill	HT-3	Spring	Upgrade	L	L	3	450	0
1633	East of Eureka Hill	HT-3	Stream crossing	Upgrade	M	ML	58	750	0
1634	East of Eureka Hill	HT-3	Stream crossing	Upgrade	HM	HM	964	25	35
1635	East of Eureka Hill	HT-3-1	Stream crossing	Upgrade	M	M	258	250	875
1636	East of Eureka Hill	HT-3-1	Stream crossing	Upgrade	ML	M	142	1000	365
1637	East of Eureka Hill	HT-3-1	Stream crossing	Upgrade	L	L	129	320	105
1638	East of Eureka Hill	HT-3-1	Spring	Upgrade	L	L	65	180	20
1639	East of Eureka Hill	HT 3-1	Landslide	Upgrade	M	M	134	360	0
1640	East of Eureka Hill	HT-3-6	Stream crossing	Decommission	ML	ML	90	0	980
1641	East of Eureka Hill	HT-3-6	Stream crossing	Decommission	HM	HM	18	20	200
1642	East of Eureka Hill	HT-3-6	Stream crossing	Decommission	L	ML	48	0	250
1643	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	M	38	375	0
1644	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	M	95	125	0
1644.1	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	M	5	0	860
1644.2	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	M	8	0	400
1644.3	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	ML	25	0	25
1644.4	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	M	115	0	125
1644.5	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	L	ML	52	0	310
1645	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	HM	71	400	105
1646	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	M	54	0	0
1647	East of Eureka Hill	41.3.2	Landslide	Upgrade	M	M	3		
1648	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	H	H	109	320	0
1649	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	M	29	60	20
1650	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	H	H	148	40	100
1651	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	L	ML	50	100	0
1652	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	H	H	194	270	100
1653	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	M	HM	139	350	0
1654	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	M	20	0	0
1655	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	L	4	400	200

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1656	East of Eureka Hill	41.3.2	Stream crossing	Upgrade	ML	ML	7	300	0
1657	East of Eureka Hill	41.3.2.1	Stream crossing	Upgrade	M	M	157	30	0
1658	East of Eureka Hill	41.3.2.1	Stream crossing	Upgrade	H	H	40	300	0
1659	East of Eureka Hill	41.3.2.1	Stream crossing	Upgrade	H	H	11	0	100
1660	East of Eureka Hill	41.3.2.1	Spring	Upgrade	H	H	15	0	0
1661	East of Eureka Hill	41.3.2.1	Stream crossing	Upgrade	L	L	10	100	215
1662	East of Eureka Hill	41.3.2.1 spur	Landslide	Decommission	HM	H	307	100	0
1663	East of Eureka Hill	41.3.2.1 spur 1	Stream crossing	Upgrade	L	ML	20	100	180
1664	East of Eureka Hill	41.3.2.1 spur 2	Landslide	Decommission	M	M	519		
1665	East of Eureka Hill	41.3.2.1 spur 1	Landslide	Decommission	H	H	4		
1675	North of Gualala Mountain	46.1	Stream crossing	Decommission	L	L	20	0	2200
1678	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	ML	ML	8	380	0
1679	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	ML	L	20	380	0
1680	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	ML	ML	11	15	205
1681	East of Eureka Hill	41.3.2.	Landslide	Upgrade	HM	HM	284	240	110
1682	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	HM	HM	95	0	180
1683	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	HM	HM	84	12	600
1684	East of Eureka Hill	41.3.2.3	Stream crossing	Upgrade	ML	ML	54	40	50
1685	East of Eureka Hill	41.3.2.3	Landslide	Upgrade	HM	HM	93	0	100
1686	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	ML	ML	58	20	60
1687	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	L	L	20	180	130
1688	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	M	HM	21	0	715
1689	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	ML	ML	21	10	145
1690	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	ML	M	16	0	85
1691	East of Eureka Hill	41.3.2.2	Stream crossing	Upgrade	ML	ML	90	60	170
1692	North of Gualala Mountain	46.3	Stream crossing	NT	NT	L	15	50	100
1693	North of Gualala Mountain	46.3	Spring	NT	NT	L		0	60

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1694	North of Gualala Mountain	46.3	Stream crossing	NT	NT	L	50	0	0
1695	North of Gualala Mountain	46.3	Stream crossing	NT	NT	L	0	0	0
1696	East of Eureka Hill	Graphite Road	Stream crossing	Upgrade	ML	ML	117	0	470
1697	East of Eureka Hill	Graphite Road	Stream crossing	Upgrade	ML	ML	193	0	450
1698	East of Eureka Hill	Graphite Road	Stream crossing	Upgrade	HM	HM	196	0	625
1699	East of Eureka Hill	Graphite Road	Stream crossing	Upgrade	M	M	157	0	405
1699.1	East of Eureka Hill	Graphite Road	Ditch relief culvert	Upgrade	H	H	22	0	650
1700	East of Eureka Hill	Signal Creek Road	Stream crossing	Upgrade	H	ML	38	490	730
1701	East of Eureka Hill	Signal Creek Road	Stream crossing	Upgrade	M	ML	488	540	0
1701.1	East of Eureka Hill	HT-2-10	Stream crossing	Decommission	HM	HM	140	50	30
1701.2	East of Eureka Hill	HT-2-10-1	Landslide	Decommission	ML	ML	100	165	0
1702	East of Eureka Hill	Signal Creek Road	Ditch relief culvert	Upgrade	M	ML	3	1050	260
1703	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	150	370	0
1704	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	L	L	123	300	300
1705	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	HM	M	268	80	0
1706	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	M	ML	1989	150	0
1707	East of Eureka Hill	Hollow Tree Road	Landslide	NT	NT	M	78	0	0
1708	East of Eureka Hill	Hollow Tree Road	Ditch relief culvert	Upgrade	ML	ML	5	0	475
1709	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	L	853	200	930
1710	East of Eureka Hill	Hollow Tree Road	Landslide	Upgrade	ML	ML	31		
1711	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	M	M	169	100	240
1712	East of Eureka Hill	Hollow Tree Road	Ditch relief culvert	Upgrade	ML	ML		1130	235
1713	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	HM	HM	294	210	0
1714	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	HM	M	649	2800	1275

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1715	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	M	M	3360	270	600
1716	East of Eureka Hill	Hollow Tree Road	Ditch relief culvert	Upgrade	L	ML	7	240	0
1717	East of Eureka Hill	Hollow Tree Road	Ditch relief culvert	Upgrade	L	ML	6	100	120
1718	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	L	L	86	180	270
1719	East of Eureka Hill	Hollow Tree Road	Ditch relief culvert	Upgrade	M	ML	6	100	0
1720	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	M	M	101	500	330
1721	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	L	ML	23	200	0
1722	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	ML	L	1525	480	335
1723	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	L	L	274	175	0
1723.1	East of Eureka Hill	Hollow Tree Road	Stream crossing	Upgrade	M	L	13	0	0
1724	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	HM	M	354	700	400
1725	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	L	L	122	100	0
1725.1	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	33	210	0
1726	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	ML	L	68	755	0
1727	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	M	426	250	0
1728	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	M	39	50	0
1729	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	L	L	75	0	300
1730	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	ML	119	0	890
1731	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	ML	158	170	60
1732	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	M	100	0	155
1733	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	98	125	85
1734	Victoria Fork	Hollow Tree Road	Stream crossing	Upgrade	M	M	171	570	140
1735	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	39	145	0
1736	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	L	44	200	0
1737	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	L	L	31	0	25
1738	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	L	126	750	225
1739	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	M	L	25	450	500

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1740	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	L	376	375	135
1741	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	M	121	0	375
1742	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	M	ML	95	0	625
1743	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	M	ML	318	0	365
1744	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	HM	HM	167	325	200
1745	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	HM	M	351	25	700
1746	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	157	0	800
1747	Little Penney	Hollow Tree Road	Ditch relief culvert	NT	NT	ML	2	0	140
1748	Little Penney	Hollow Tree Road	Stream crossing	Upgrade	M	M	1076	0	500
1749	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	HM	HM	468	0	185
1750	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	281	0	300
1751	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	L	2578	40	300
1752	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	HM	M	323	25	500
1752.1	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	L	L	148	0	320
1753	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	ML	150	0	925
1753.1	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	125	25	125
1754	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	M	343	0	785
1755	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	ML	L	228	75	0
1756	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	469	125	0
1757	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	ML	281	445	0
1758	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	ML	ML	179	95	0
1759	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	M	523	375	180
1760	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	M	200	450	100
1760.1	Larmour Creek	HT-15	Stream crossing	Upgrade	ML	ML	14	0	100
1761	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	L	L	132	0	320
1762	Larmour Creek	Hollow Tree Road	Ditch relief culvert	Upgrade	M	M	4	825	0
1763	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	HM	M	491	440	0
1764	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	L	L	185	150	0

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1765	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	M	190	445	0
1766	Larmour Creek	Hollow Tree Road	Spring	Upgrade	L	L	2	80	0
1767	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	M	M	747	100	0
1768	Larmour Creek	Hollow Tree Road	Ditch relief culvert	Upgrade	ML	ML	4	250	0
1769	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	HM	M	649	465	0
1770	Larmour Creek	Hollow Tree Road	Stream crossing	Upgrade	H	H	15	40	0
1800	Little Penney	HT-4	Stream crossing	Upgrade	ML	L	147	0	0
1801	Little Penney	HT-7-1	Stream crossing	Upgrade	ML	ML	73	140	100
1802	Victoria Fork	HT-4	Spring	Decommission	ML	ML	3	0	400
1803	Victoria Fork	HT-4-3	Stream crossing	NT	NT	L		0	30
1804	Victoria Fork	HT-4-3	Stream crossing	Upgrade	M	M	18	25	95
1805	Victoria Fork	HT-4-3	Stream crossing	Upgrade	ML	ML	5	80	10
1806	Little Penney	HT-4	Spring	Upgrade	ML	ML		0	975
1807	Little Penney	HT-4	Stream crossing	Upgrade	ML	ML	14	10	50
1808	Little Penney	HT-4	Stream crossing	Upgrade	L	L	66	35	230
1809	Little Penney	HT-4	Stream crossing	Upgrade	ML	ML	78	35	130
1810	Little Penney	HT-5	Stream crossing	Decommission	L	ML	6	50	115
1811	Little Penney	HT-5	Spring	Decommission	L	ML	5	55	130
1812	Little Penney	HT-5	Spring	Decommission	M	M	8	320	0
1813	Little Penney	HT-5	Spring	Decommission	ML	ML	1	150	25
1814	Little Penney	HT-7	Gully	Upgrade	M	M	10	60	180
1815	Little Penney	HT-7	Stream crossing	Upgrade	ML	ML	29	95	80
1816	Little Penney	HT-7	Stream crossing	NT	NT	L	37	40	45
1817	Little Penney	HT-7	Stream crossing	Upgrade	M	M	45	90	480
1818	Little Penney	HT-7	Stream crossing	Upgrade	ML	ML	10	140	15
1819	Little Penney	HT-9	Gully	Upgrade	HM	M	2	980	0
1820	Larmour Creek	HT-14	Stream crossing	Decommission	ML	ML	82	200	0
1821	Larmour Creek	HT-14	Stream crossing	Decommission	L	M	54	90	50
1822	Larmour Creek	HT-14	Stream crossing	Decommission	L	L	35	0	190

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1823	Larmour Creek	HT-14	Stream crossing	Upgrade	M	M	235	210	0
1824	Larmour Creek	HT-14	Stream crossing	Upgrade	HM	M	400	0	1770
1825	Larmour Creek	HT-14	Stream crossing	Upgrade	M	M	155	0	1480
1826	Larmour Creek	HT-14	Stream crossing	Upgrade	ML	ML	67	0	150
1827	Larmour Creek	HT-14-2	Stream crossing	Decommission	L	L	8	100	175
1828	Larmour Creek	HT-14-2	Stream crossing	Upgrade	ML	ML	55	55	130
1829	Larmour Creek	HT-14-2	Stream crossing	Upgrade	HM	HM	356	550	108
1830	Larmour Creek	HT-14-3	Stream crossing	Upgrade	L	L	222	120	0
1831	Larmour Creek	HT-14-3	Stream crossing	Upgrade	M	M	89	30	65
1832	Larmour Creek	HT-14-3	Stream crossing	Upgrade	HM	M	144	0	280
1833	Larmour Creek	HT-14-3	Stream crossing	Upgrade	ML	M	53	0	165
1834	Larmour Creek	HT-14-3	Stream crossing	Upgrade	ML	ML	73	80	30
1835	Larmour Creek	HT-14-3	Stream crossing	Decommission	L	ML	12	180	60
1836	Larmour Creek	HT-15	Stream crossing	Upgrade	L	L	5	50	200
1837	Larmour Creek	HT-11	Stream crossing	Decommission	L	ML	7	0	50
1838	Larmour Creek	HT-11	Stream crossing	Decommission	M	ML	40	40	50
1839	Larmour Creek	HT-11-Skid	Stream crossing	Decommission	HM	H	200	75	85
1840	Larmour Creek	HT-11	Stream crossing	Decommission	M	M	26	25	0
1841	Larmour Creek	HT-11	Stream crossing	Decommission	M	ML	16	740	41
1842	Larmour Creek	HT-11	Stream crossing	Upgrade	ML	ML	127	25	0
1843	Larmour Creek	HT-11	Stream crossing	Upgrade	ML	ML	137	165	0
1844	Larmour Creek	HT-11	Stream crossing	Upgrade	ML	ML	59	145	0
1845	Larmour Creek	HT-13	Stream crossing	Upgrade	M	HM	105	0	30
1846	Larmour Creek	HT-13	Stream crossing	Upgrade	HM	M	106	20	1115
1847	Little Penney	HT-10	Road drainage discharge point	Upgrade	ML	L		150	0
1848	Little Penney	HT-10	Spring	Upgrade	ML	L		465	380
1849	Larmour Creek	HT-10	Stream crossing	Upgrade	M	ML	299	750	25
1850	Larmour Creek	HT-10	Stream crossing	Upgrade	M	ML	228	190	190
1851	Larmour Creek	HT-10-Skid	Stream crossing	Decommission	M	ML	2	60	50

Site #	CALWAA	Road name	Site type	Treatment type[a]	Treatment immediacy[b]	Erosion potential[b]	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U=upgrade; D=decommission; NT=no treat. [b]H=high; HM=high-moderate; M=moderate; ML=moderate-low; L=low									
1852	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	L	4	325	35
1853	Little Penney	HT-7-2	Stream crossing	Upgrade	M	M	142	60	365
1854	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	L	7	270	10
1855	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	ML	64	30	36
1856	Little Penney	HT-7-2	Stream crossing	Upgrade	M	ML	96	50	375
1857	Little Penney	HT-7-2	Stream crossing	Upgrade	L	L	19	250	35
1858	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	L	24	325	225
1859	Little Penney	HT-7-2	Stream crossing	Upgrade	L	L	15	100	25
1860	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	L	32	65	165
1861	Little Penney	HT-7-2	Stream crossing	Upgrade	M	M	78	90	70
1862	Little Penney	HT-7-2	Stream crossing	Upgrade	L	L	23	70	60
1863	Little Penney	HT-7-2	Stream crossing	Upgrade	L	L	1	55	55
1864	Little Penney	HT-7-2	Gully	Upgrade	L	L	2	40	0
1865	Little Penney	HT-7-2	Stream crossing	Upgrade	M	ML	23	160	15
1866	Little Penney	HT-7-2	Stream crossing	Upgrade	HM	HM	57	0	50
1867	Little Penney	HT-7-2-1	Gully	Upgrade	M	M	34	0	535
1868	Little Penney	HT-7-2-1	Stream crossing	Upgrade	ML	ML	12	70	0
1869	Little Penney	HT-7-2-1	Gully	Upgrade	ML	L	6	0	150
1870	Little Penney	HT-7-2-1	Stream crossing	Upgrade	M	M	23	0	230
1871	Little Penney	HT-7-2-1	Gully	Upgrade	M	M	1	0	220
1872	Little Penney	HT-7-2	Gully	Upgrade	ML	L		15	185
1873	Little Penney	HT-7-2	Stream crossing	Upgrade	ML	ML	26	30	60
1874	Little Penney	HT-7-2	Stream crossing	Upgrade	M	M	14	20	75
1875	Little Penney	HT-7-2	Stream crossing	Upgrade	L	L	4	80	155

APPENDIX D

Typical drawings (schematic diagrams) showing components of erosion control and erosion prevention treatments, and techniques for construction.

No.	Drawing title
1	Typical problems and applied treatments for a non-fish bearing upgraded stream crossing
2	Typical design of a non-fish bearing culverted stream crossing
3	Typical design of a single-post culvert inlet trash rack
4	Typical design for armoring fillslopes
5	General armored fill dimensions
6	Typical armored fill crossing installation
7	Ten steps for constructing a typical armored fill crossing
8	Typical ditch relief culvert installation
9	Typical designs for using road shape to control road runoff (using insloping, outsloping, and crowning)
10	Typical methods for dispersing road surface runoff with waterbars, cross-road drains, and rolling dips
11	Typical road surface drainage by rolling dips
12	Typical sidecast or excavation methods for removing outboard berms on a maintained road
13	Typical excavation of unstable fillslope on an upgraded road
14	Typical problems and applied treatments for a decommissioned stream crossing
15	Typical design for road decommissioning treatments employing export and in-place outsloping techniques
16	Typical excavation of unstable fillslope on a decommissioned road

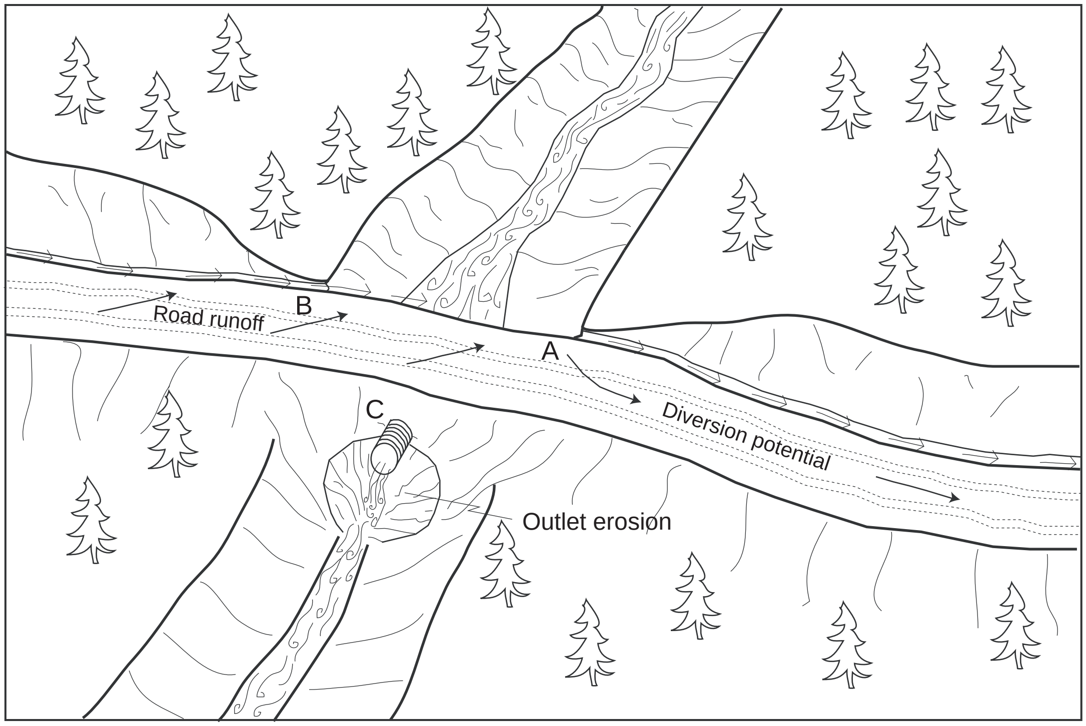
Typical Problems and Applied Treatments for a Non-fish Bearing Upgraded Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

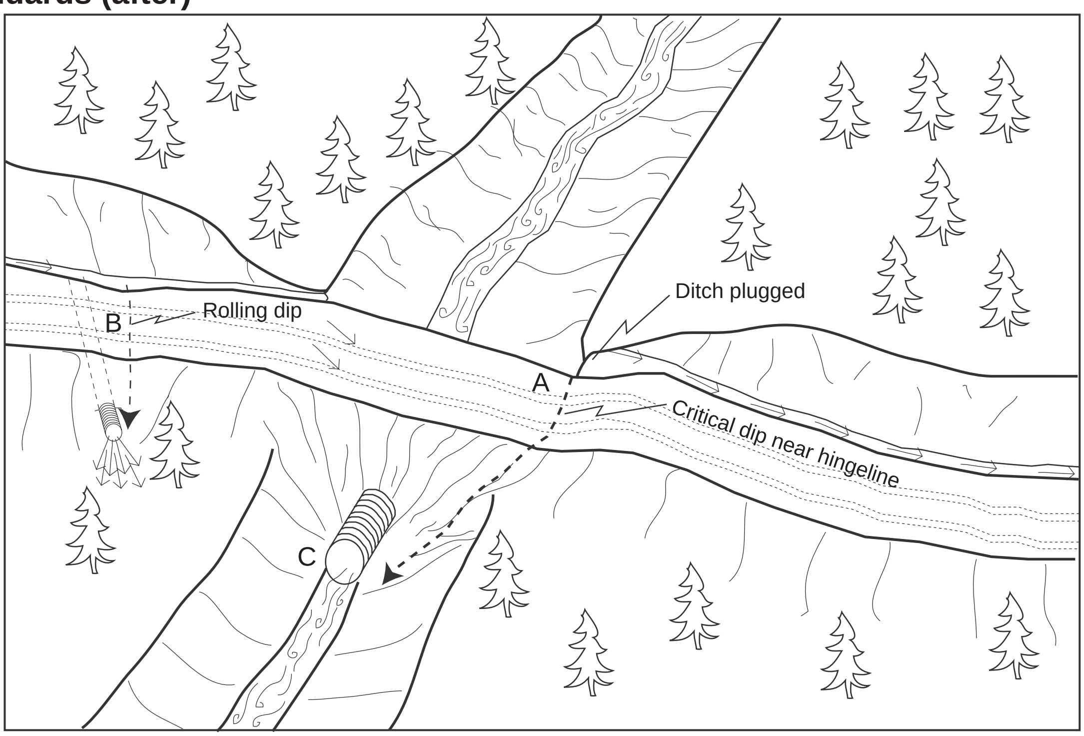


Treatment standards (after)

A - No diversion potential with critical dip installed near hingeline

B - Road surface and ditch disconnected from stream by rolling dip and ditch relief culvert

C - 100-year culvert set at base of fill



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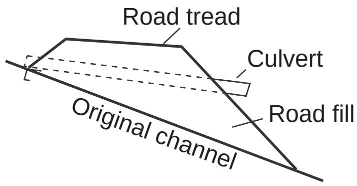
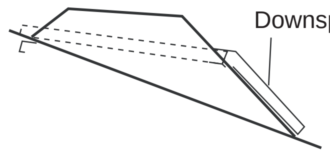
Typical Design of a Non-fish Bearing Culverted Stream Crossing

Existing



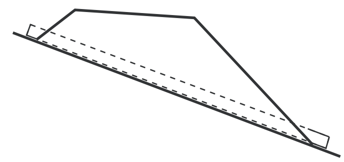
1. Culvert not placed at channel grade.
2. culvert does not extend past base of fill.

Upgraded



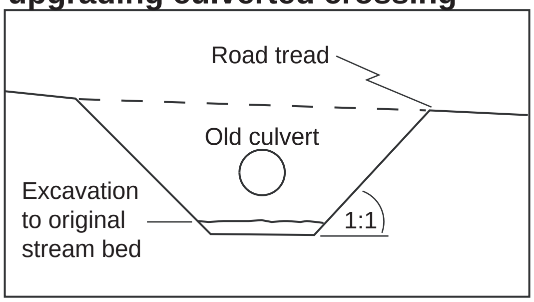
1. Culvert not placed at channel grade.
2. Downspout added to extend outlet past road fill.

Upgraded (preferred)

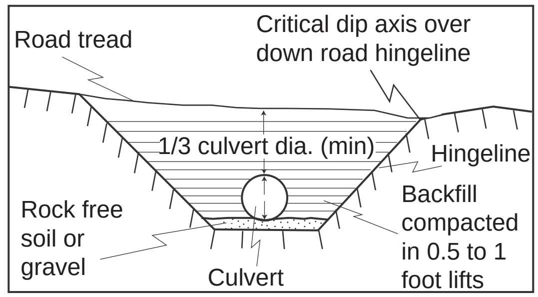


1. Culvert placed at channel grade.
2. Culvert inlet and outlet rest on, or partially in, the originial streambed.

Excavation in preparation for upgrading culverted crossing



Upgraded stream crossing culvert installation



Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calulations using a procedure such as the Rational Formula.

Stream crossing culvert Installation

1. Culverts shall be aligned with natural stream channels to ensure proper function, and prevent bank erosion and plugging by debris.
2. Culverts shall be placed at the base of the fill and the grade of the original streambed, or downspouted past the base of the fill.
3. Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
6. Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7. First one end then the other end of the culvert shall be covered and secured.;The center is covered last.
8. Backfill material shall be tamped and compacted throughout the entire process:
   - Base and side wall material will be compacted before the pipe is placed in its bed.
   - Backfill compacting will be done in 0.5 - 1 foot lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9. Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10. Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11. Layers of fill will be pushed over the crossing until the final designed road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

Erosion control measures for culvert replacement

Both mechanical and vegetative measures will be employed to minimize accelerated erosion from stream crossing and ditch relief culvert upgrading. Erosion control measures implemented will be evaluated on a site by site basis. Erosion control measures include but are not limited to:

1. Minimizing soil exposure by limiting excavation areas and heavy equipment distrubance.
2. Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to downslope areas and stream channels.
3. Retaining rooted trees and shrubs at the base of the fill as “anchor” for the fill and filter windrows.
4. Bare slopes created by construction operations will be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills will be minimized by mulching, seeding, planting, compacting, armoring, and/or benching prior to the first rains.
5. Excess or unusable soil will be stored in long term spoil disposal locations that are not limited by factors such as excessive moisture, steep slopes greater than 10%, archeology potential, or proximity to a watercourse.
6. On running streams, water will be pumped or diverted past the crossing and into the downstream channel during the construction process.
7. Straw bales and/or silt fencing will be employed where necessary to control runoff within the construction zone.

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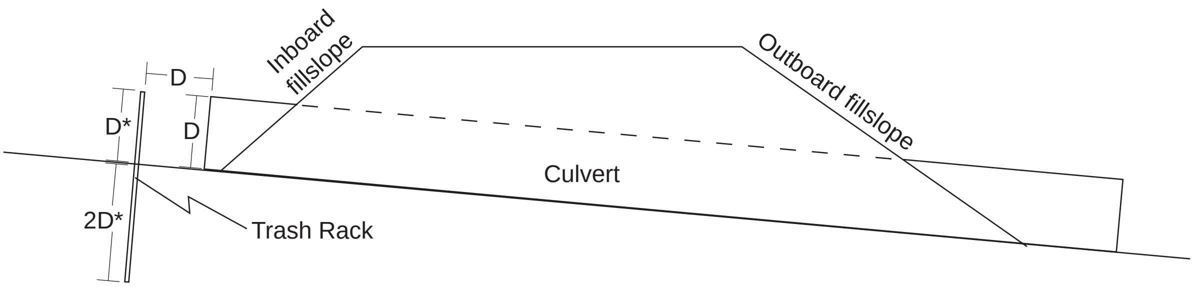
Typical Design of a Single-post Culvert Inlet Trash Rack

Cross section view



D - Culvert diameter

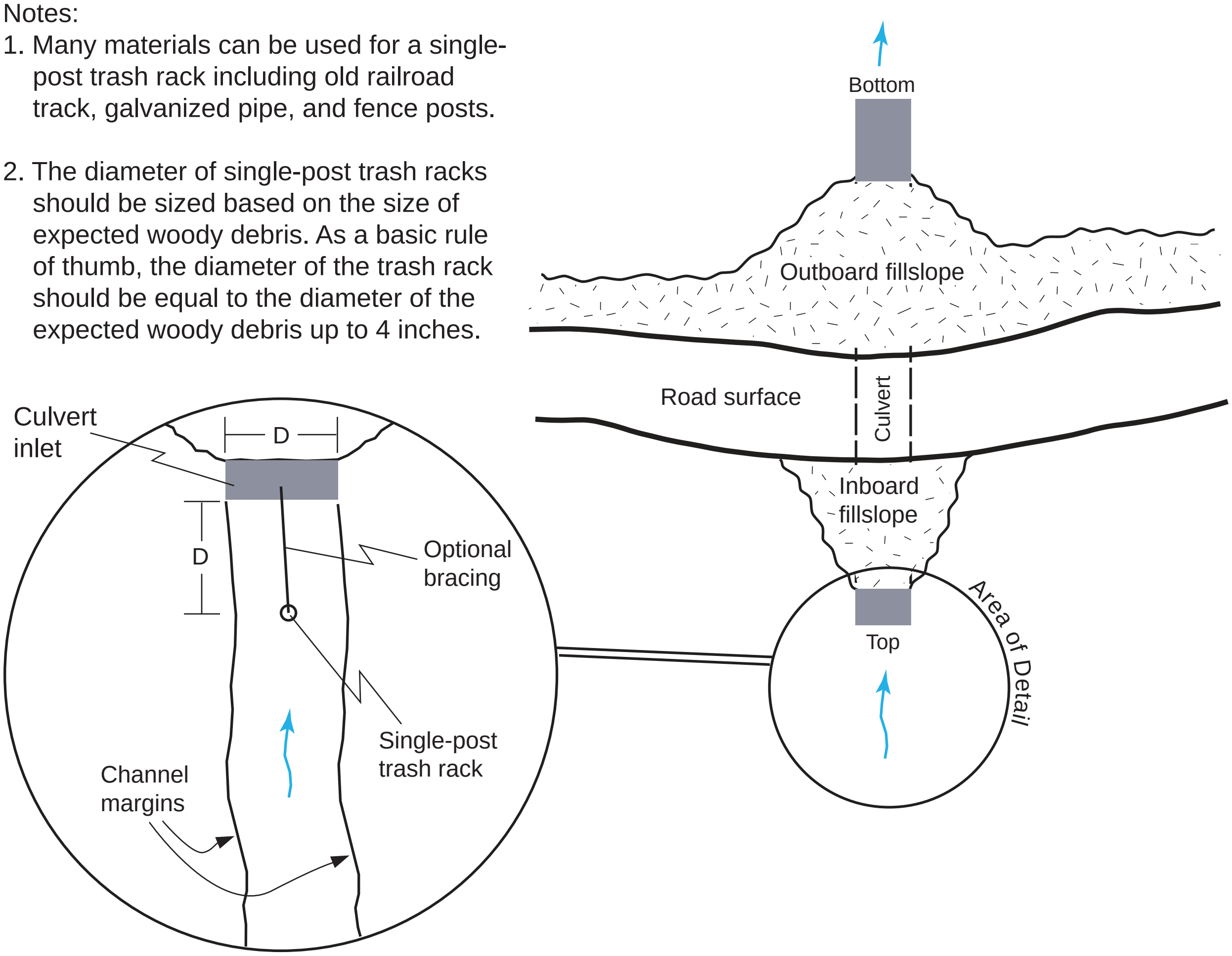
D* - If the culvert is designed for the 100-year peak storm flow, the trash rack height above the streambed should equal D.
If the culvert is undersized, then the trash rack needs to be extended vertically above the streambed to match or exceed the expected headwall height.

Plan view

Notes:

1. Many materials can be used for a single-post trash rack including old railroad track, galvanized pipe, and fence posts.

2. The diameter of single-post trash racks should be sized based on the size of expected woody debris. As a basic rule of thumb, the diameter of the trash rack should be equal to the diameter of the expected woody debris up to 4 inches.



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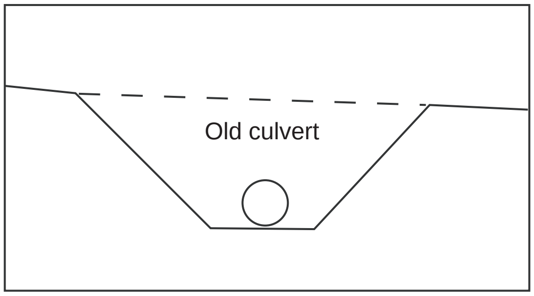
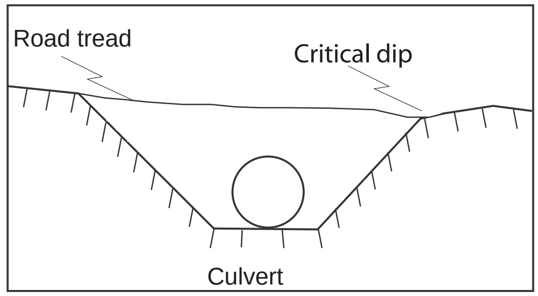
Typical Design of Upgraded Stream Crossings





Stream crossing culvert Installation

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2. Culverts shall be placed at the base of the fill and the grade of the original streambed or downspouted past the base of the fill.
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5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
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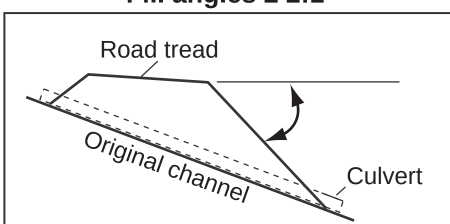
Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calculations using a procedure such as the Rational Formula.

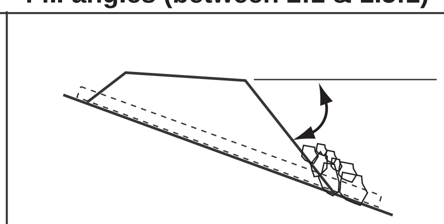
Armoring fill faces

Fill angles ≤ 2:1



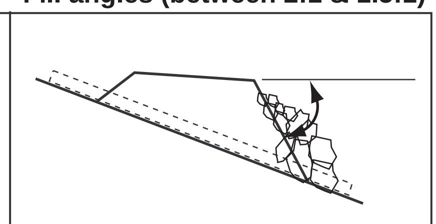
No rock armor needed

Fill angles (between 2:1 & 1.5:1)



Armor 1/4 up fill face

Fill angles (between 2:1 & 1.5:1)



Armor 3/4 way up fill face

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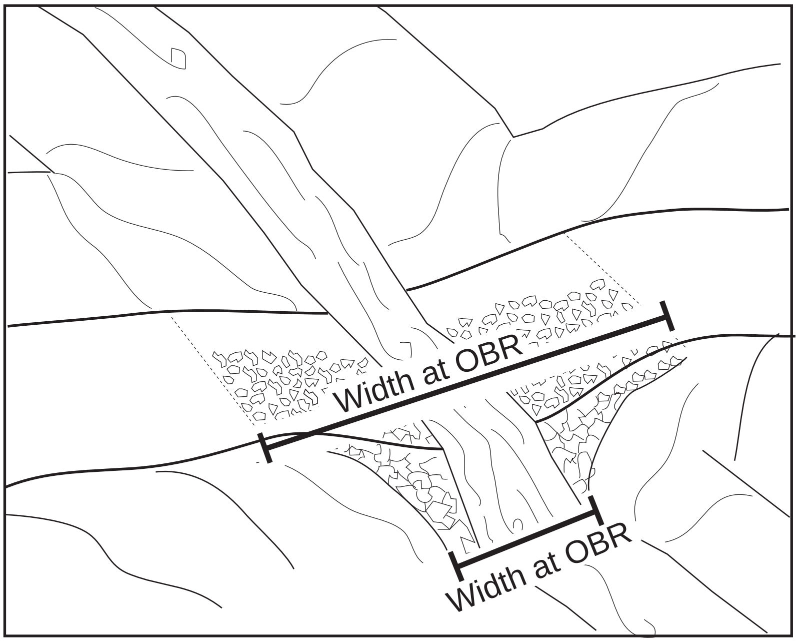
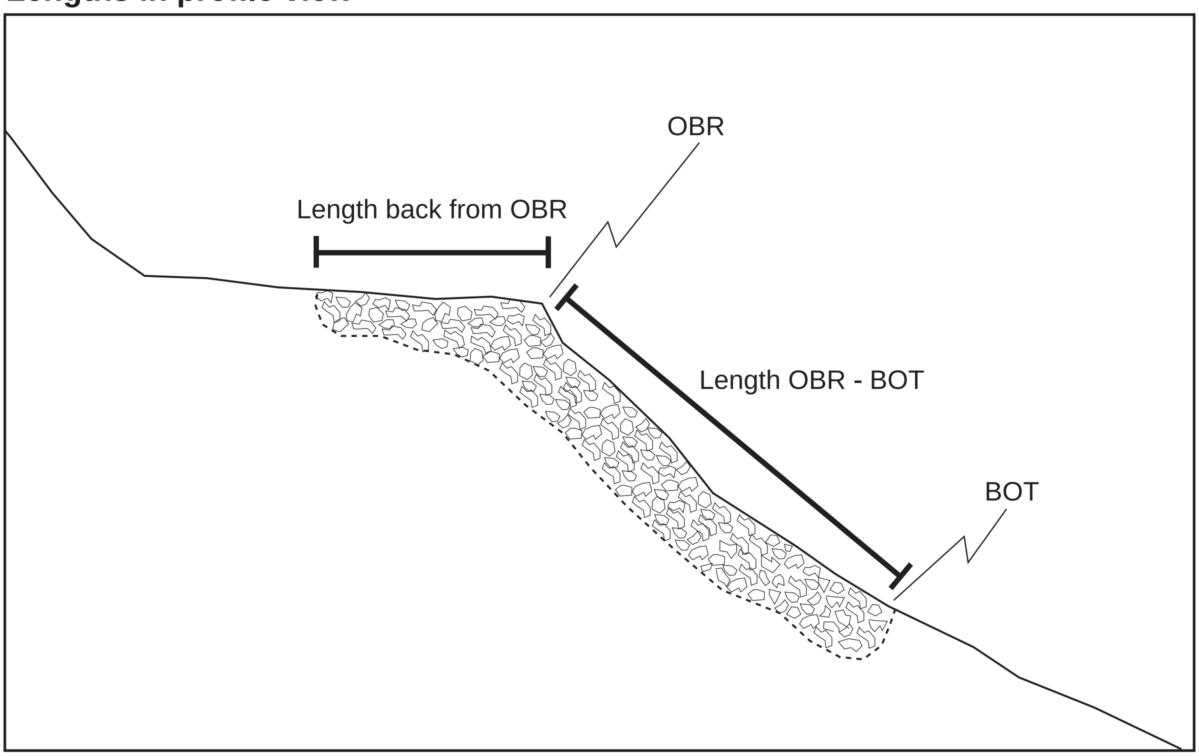
Typical Dimensions Refered to for Armored Fill Crossings

Widths in oblique view



OBR - Outboard edge of road

Lengths in profile view



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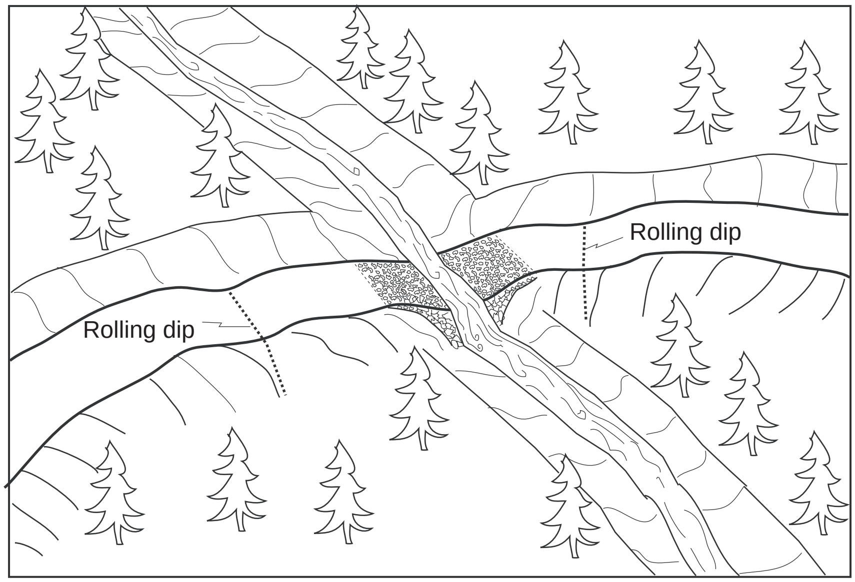
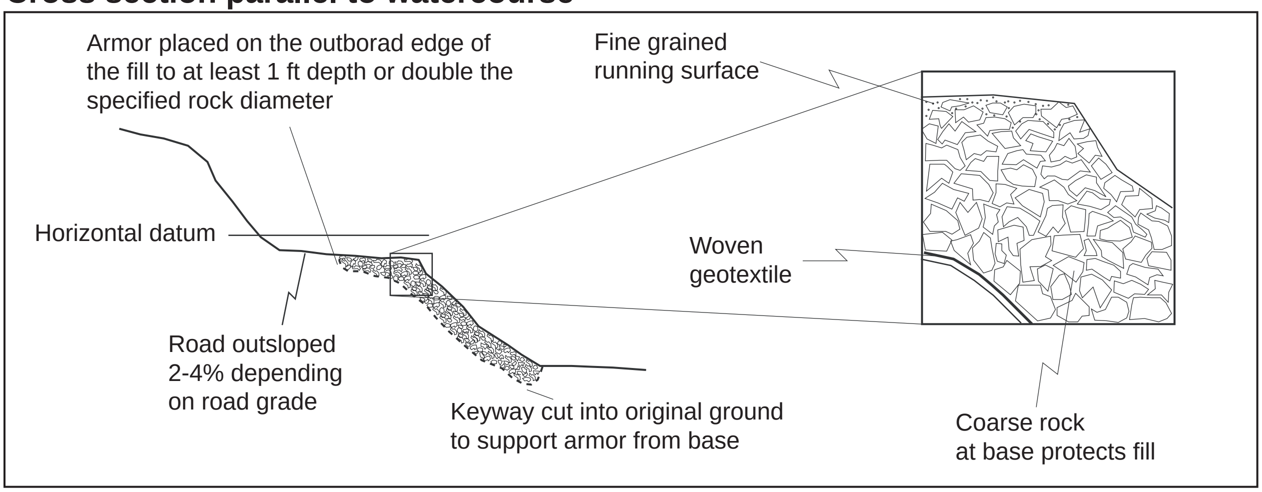
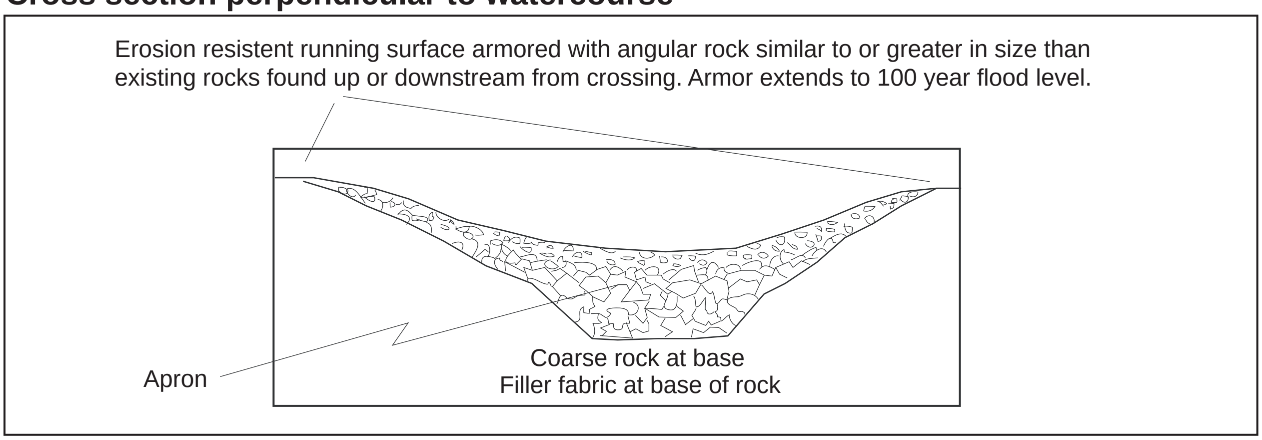
Typical Armored Fill Crossing Installation



Cross section parallel to watercourse



Cross section perpendicular to watercourse



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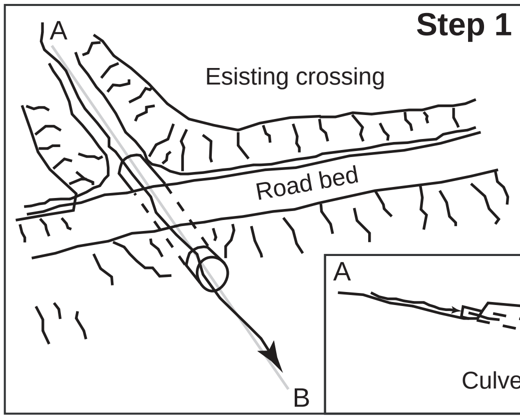
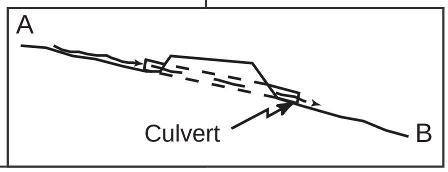
Ten Steps for Constructing a Typical Armored Fill Stream Crossing

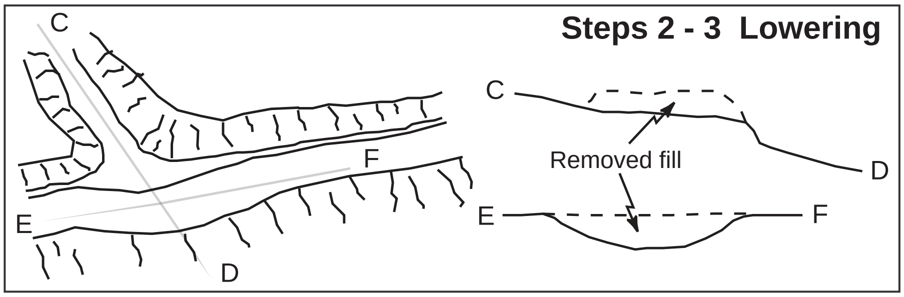


1. The two most important points are:

A) **The rock must be placed in a "U" shape across the channel to confine flow within the armored area.** (Flow around the rock armor will gully the remaining fill. Proper shape of surrounding road fill and good rock placement will reduce the likelihood of crossing failure).

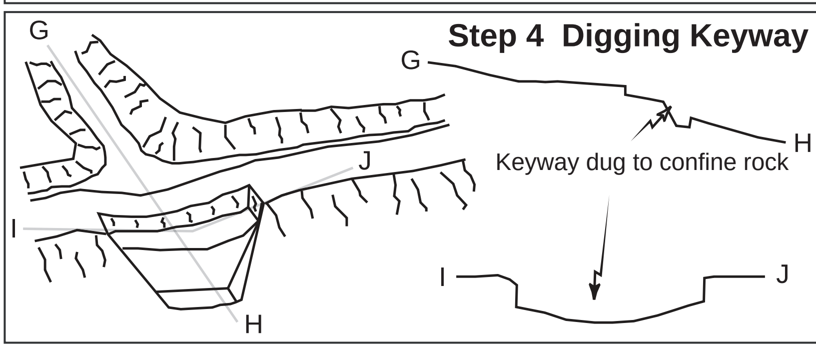
B) **The largest rocks must be used to buttress the rest of the armor in two locations:** (i) The base of the armored fill where the fill meets natural channel. (This will butress the armor placed on the outboard fill face and reduce the likelihood of it washing downslope). (ii) The break in slope from the road tread to the outer fill face. (This will butress the fill placed on the outer road tread and will determine the "base level" of the creek as it crosses the road surface).





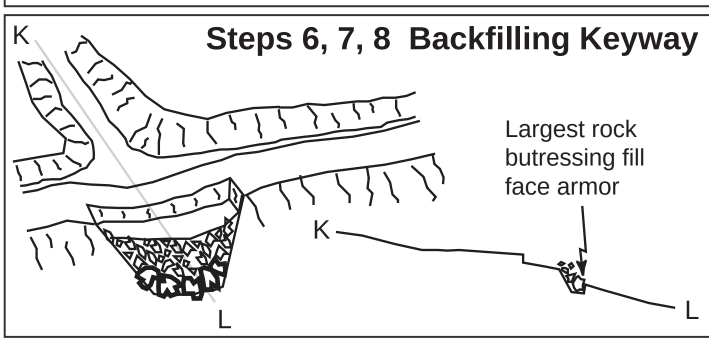
2. Remove any existing drainage structures including culverts and Humboldt logs.

3. Construct a dip centered at the crossing that is large enough to accomodate the 100-year peak storm flow and prevent diversion (C-D, E-F).



4. Dig a keyway (to place rock in) that extends from the outer 1/3 of the road tread down the outboard road fill to the point where outbaord fill meets natural channel (up to 3 feet into the channel bed depending on site specifics) (G-H, I-J).

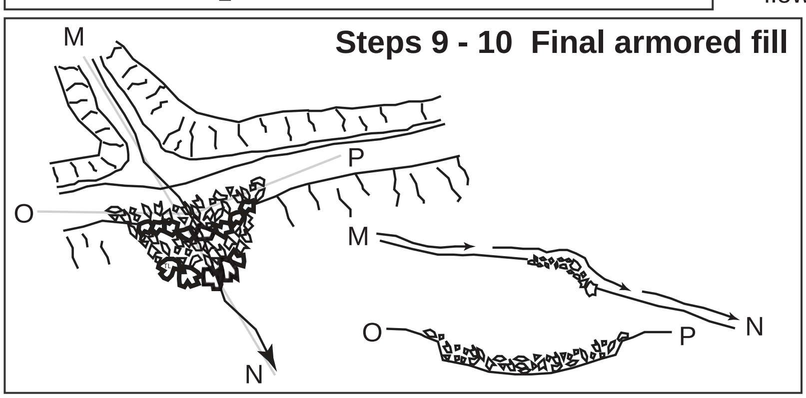
5. Install geofabric (optional) within keyway to support rock in wet areas and to prevent winnowing of the crossing at low flows.



6. Put aside the largest rock armoring to create 2 buttresses in the next step.

7. Create a buttress using the largest rock (as described in the site treatments specifications) at the base of fill. (This should have a "U" shape to it and will define the outlet of the armored fill.)

8. Backfill the fill face with remaining rock armor making sure the final armored area has "U" shape that will accomodate the largest expected flow (K-L).



9. Install a second buttress at the break in slope between the outboard road and the outboard fill face. (This should define the base level of the stream and determine how deep the stream will backfill after construction). (M-N)

10. Back fill the rest of the keyway with the unsorted rock armor making sure the final armored area has a "U" shape that will accommodate the largest expected flow (O-P).

Typical Drawing #7

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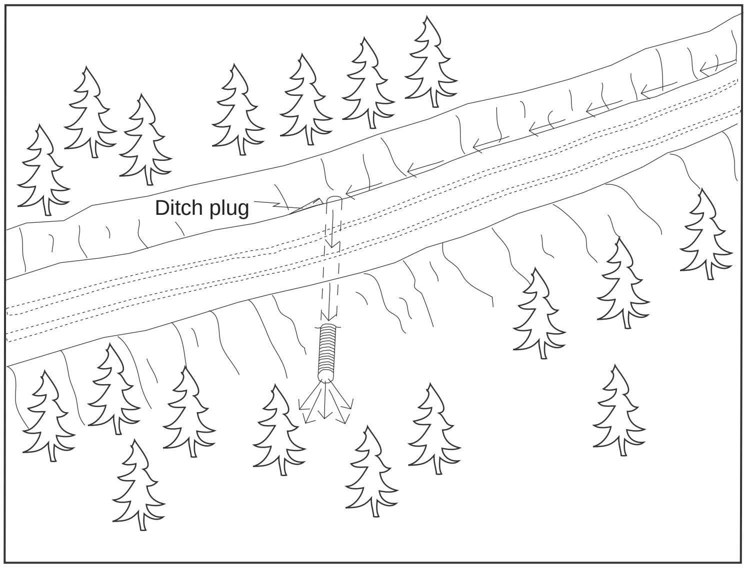
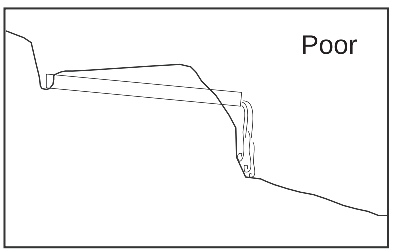
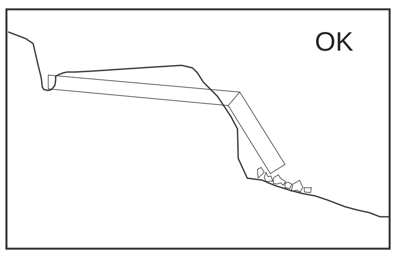
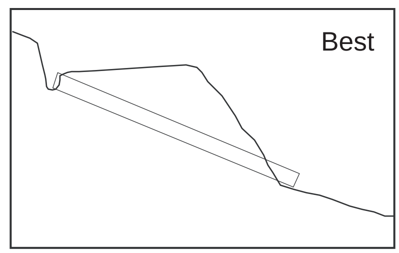
Typical Ditch Relief Culvert Installation









Ditch relief culvert installation

1) The same basic steps followed for stream crossing installation shall be employed.
2) Culverts shall be installed at a 30 degree angle to the ditch to lessen the chance of inlet erosion and plugging.
3) Culverts shall be seated on the natural slope or at a minimum depth of 5 feet at the outside edge of the road, whichever is less.
4) At a minimum, culverts shall be installed at a slope of 2 to 4 percent steeper than the approaching ditch grade, or at least 5 inches every 10 feet.
5) Backfill shall be compacted from the bed to a depth of 1 foot or 1/3 of the culvert diameter, which ever is greater, over the top of the culvert.
6) Culvert outlets shall extend beyond the base of the road fill (or a flume downspout will be used). Culverts will be seated on the natural slope or at a depth of 5 feet at the outside edge of the road, whichever is less.

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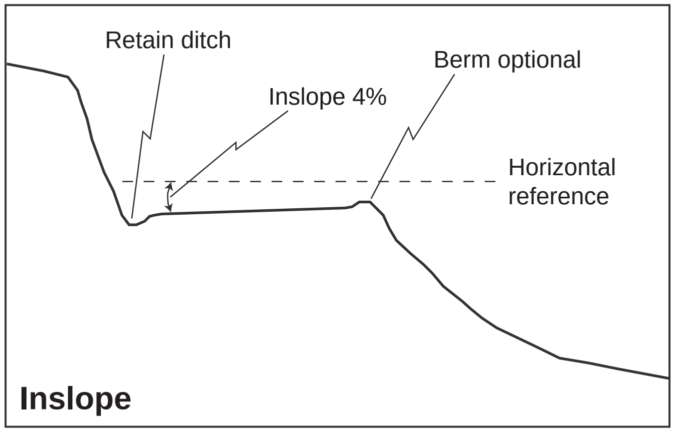
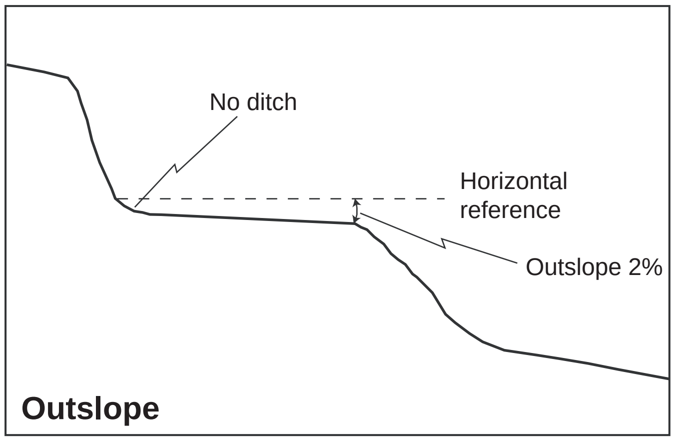
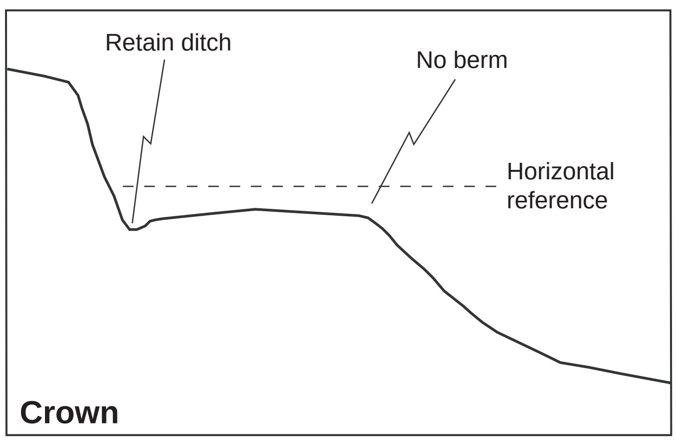
Typical Designs for Using Road Shape to Control Road Runoff







Outsloping Pitch for Roads Up to 8% Grade		
Road grade	**Unsurfaced roads**	**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 1/4" per foot

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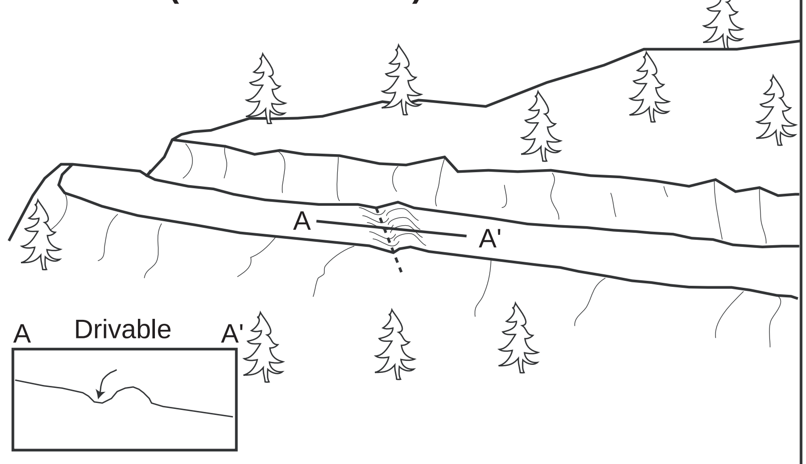
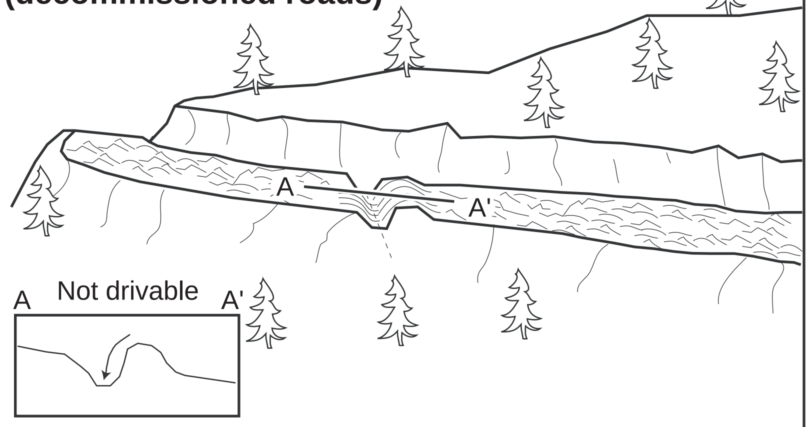
Typical Methods for Dispersing Road Surface Runoff with Waterbars, Cross-road Drains, and Rolling Dips

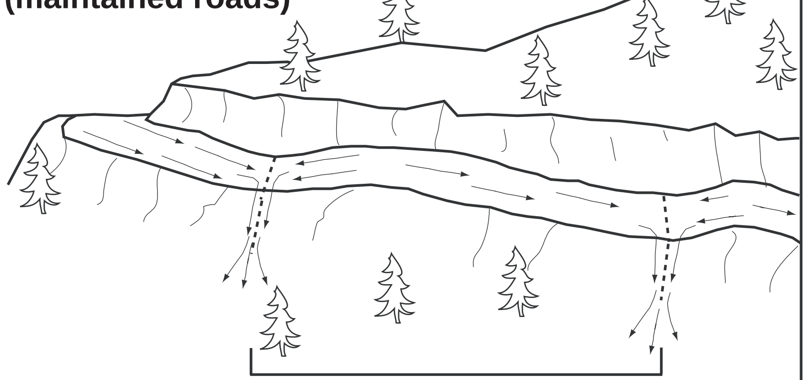
Waterbars (seasonal roads)



Cross-road drain and decompaction (decommissioned roads)



Rolling dips (maintained roads)



Rolling dip spacing dependent on road grade,
soil erodibility, and proximity to stream

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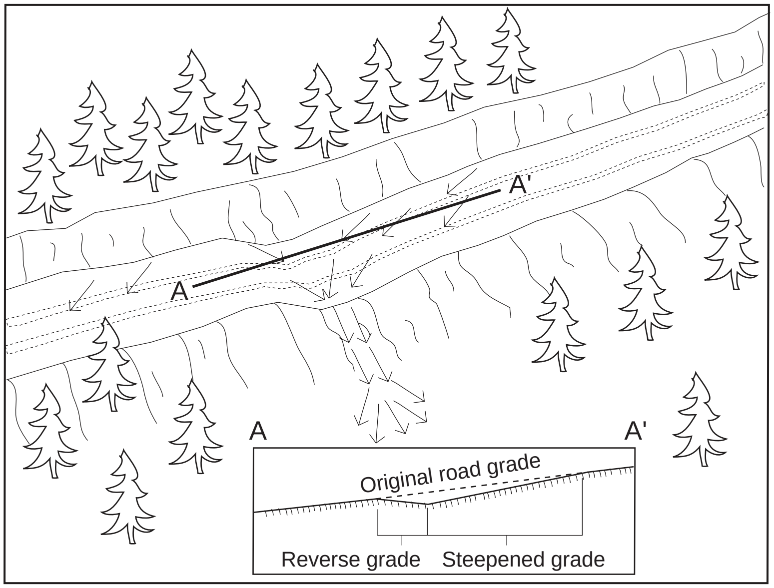
Typical Road Surface Drainage by Rolling Dips



Rolling dip installation:

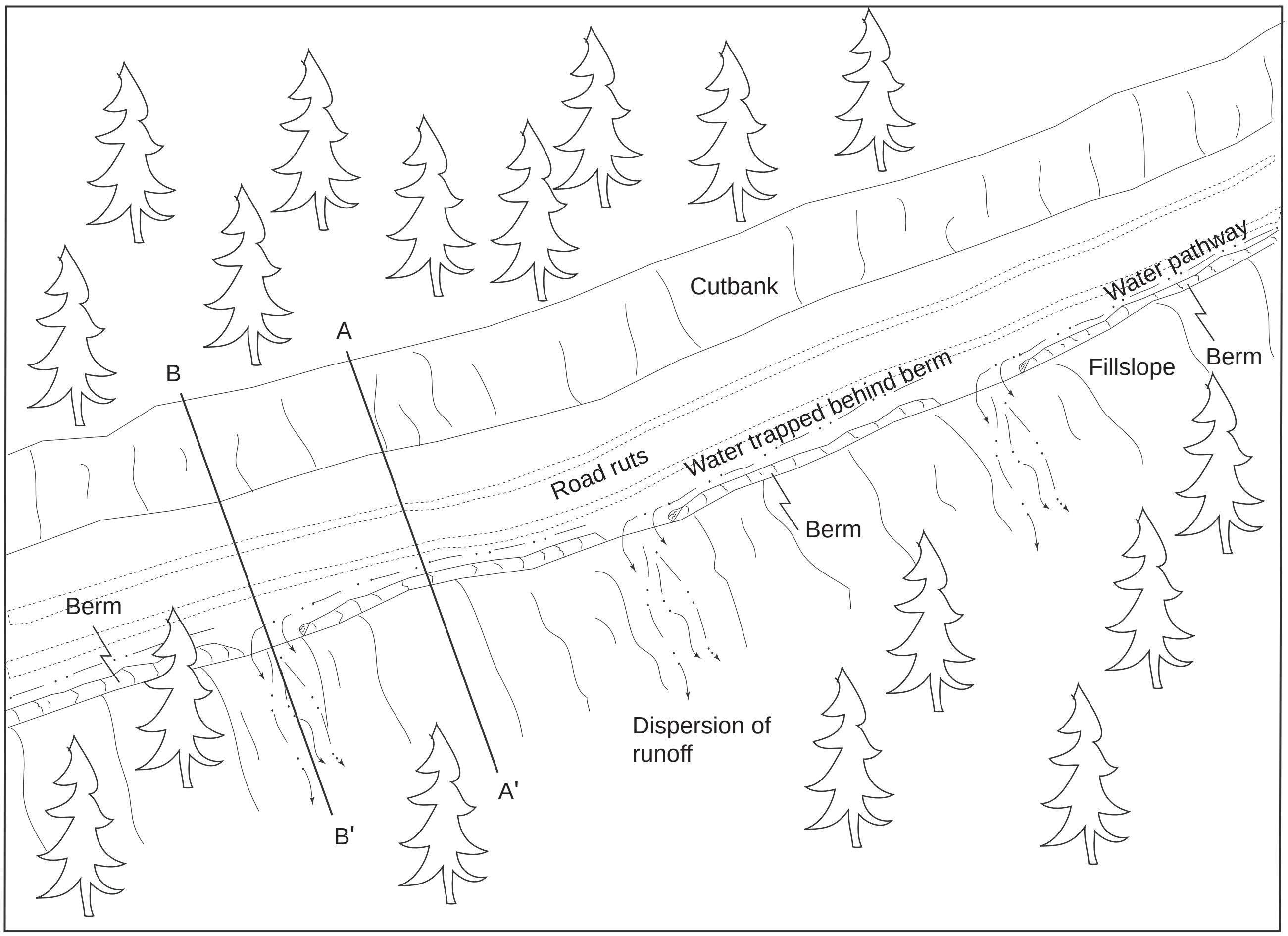
1. Rolling dips will be installed in the roadbed as needed to drain the road surface.
2. Rolling dips will be sloped either into the ditch or to the outside of the road edge as required to properly drain the road.
3. Rolling dips are usually built at 30 to 45 degree angles to the road alignment with cross road grade of at least 1% greater than the grade of the road.
4. Excavation for the dips will be done with a medium-size bulldozer or similar equipment.
5. Excavation of the dips will begin 50 to 100 feet up road from where the axis of the dip is planned as per guidelines established in the rolling dip dimensions table.
6. Material will be progressively excavated from the roadbed, steepening the grade unitl the axis is reached.
7. The depth of the dip will be determined by the grade of the road (see table below).
8. On the down road side of the rolling dip axis, a grade change will be installed to prevent the runoff from continuing down the road (see figure above).
9. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to the original slope.
10. The transition from axis to bottom, through rising grade to falling grade, will be in a road distance of at least 15 to 30 feet.

Table of rolling dip dimensions by road grade

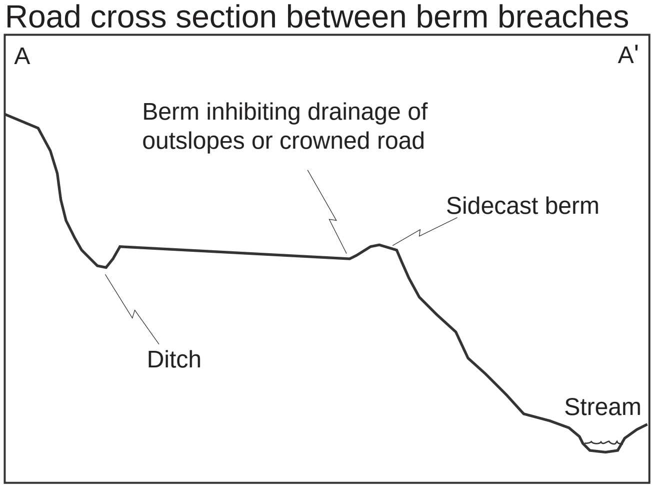
Road grade %	**Upslope approach distance** (from up road start to trough) ft	**Reverse grade distance** (from trough to crest) ft	**Depth at trough outlet** (below average road grade) ft	**Depth at trough inlet** (below average road grade) ft
<6	55	15 - 20	0.9	0.3
8	65	15 - 20	1.0	0.2
10	75	15 - 20	1.1	0.01
12	85	20 - 25	1.2	0.01
>12	100	20 - 25	1.3	0.01

Typical Sidecast or Excavation Methods for Removing Outboard Berms on a Maintained Road

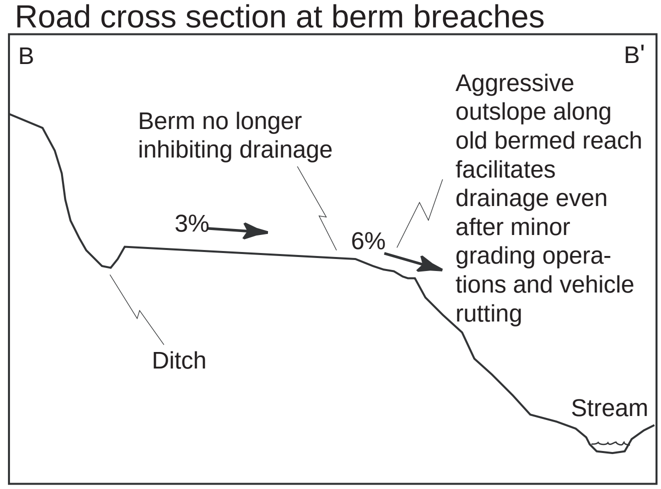
1. On gentle road segments berms can be removed continuously (see B-B').
2. On steep road segments, where safety is a concern, the berm can be frequently breached (see A-A' & B-B') Berm breaches should be spaced every 30 to 100 feet to provide adequate drainage of the road system while maintaining a semi-continuous berm for vehicle safety.



Road cross section between berm breaches



Road cross section at berm breaches



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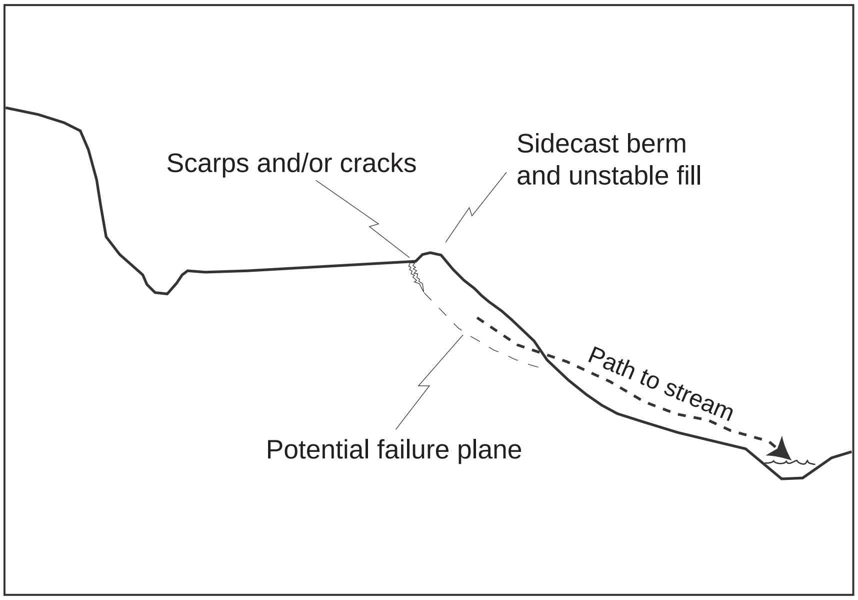
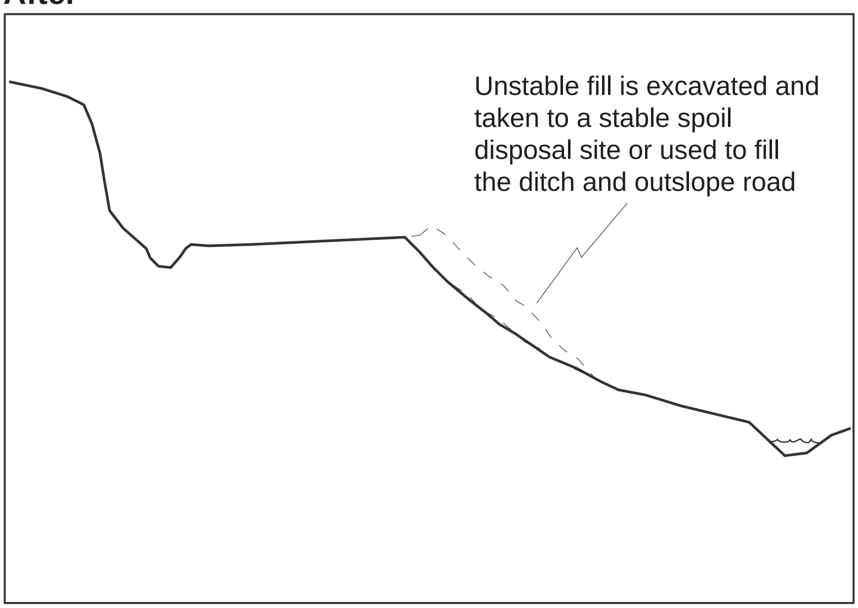
Typical Excavation of Unstable Fillslope on an Upgraded Road

Before



After



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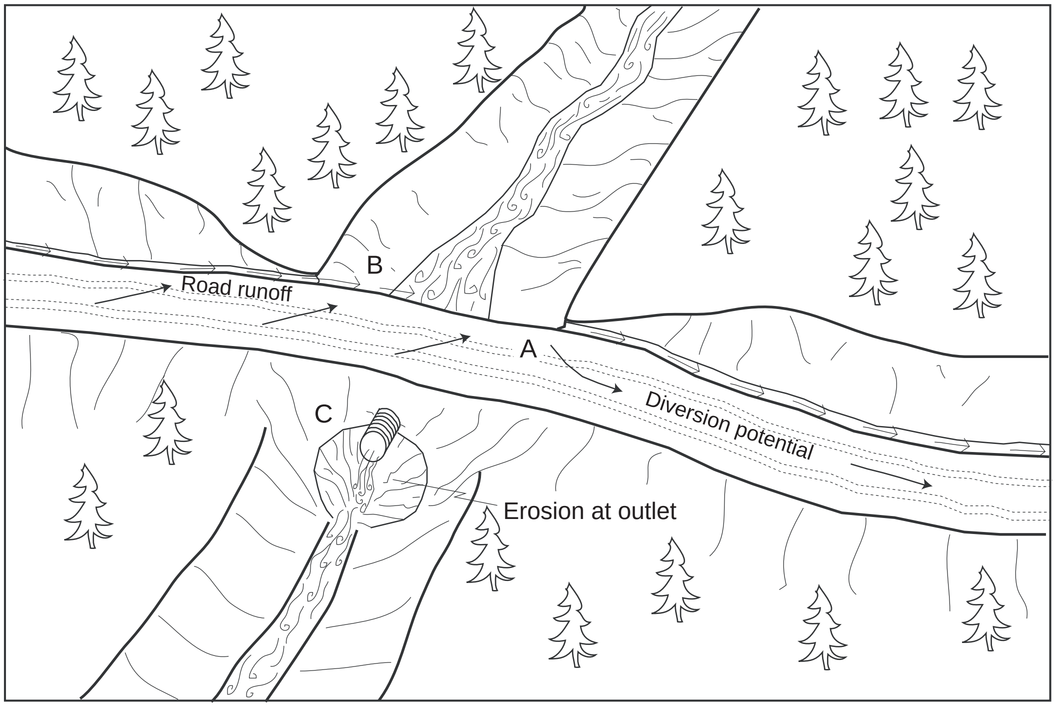
Typical Problems and Applied Treatments for a Decommissioned Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

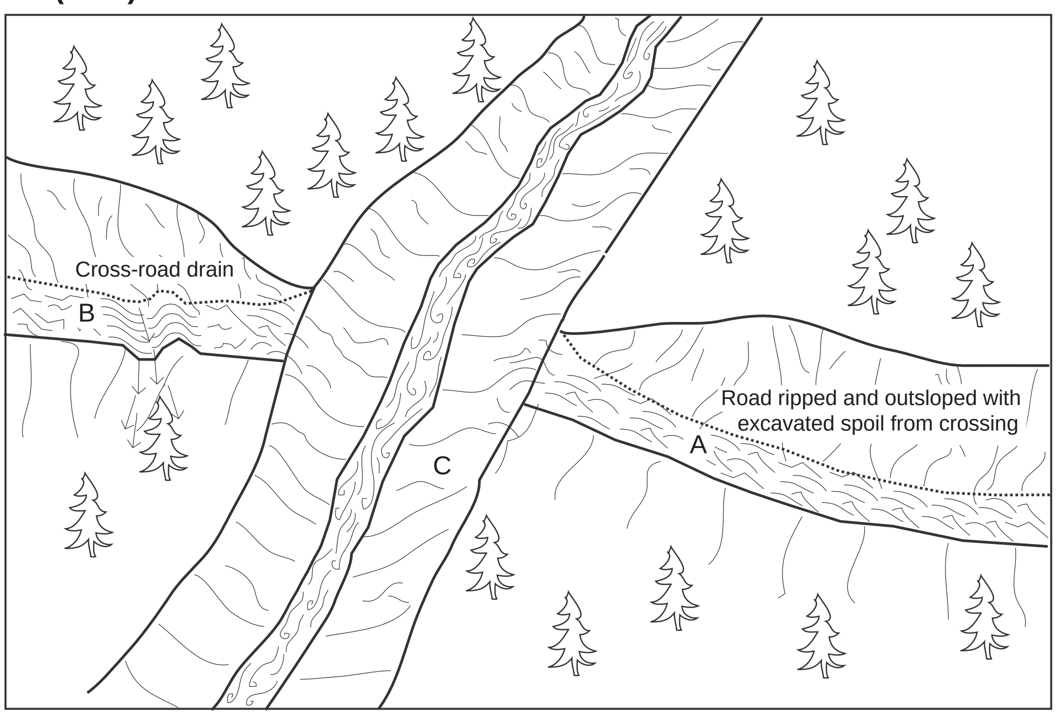


Treatment standards (after)

A - Diversion prevented by road surface ripping and outsloping using excavated spoils

B - Road surface and ditch disconnected from stream by road surface decompaction and cross-road drains

C - Stream crossing fill completely excavated



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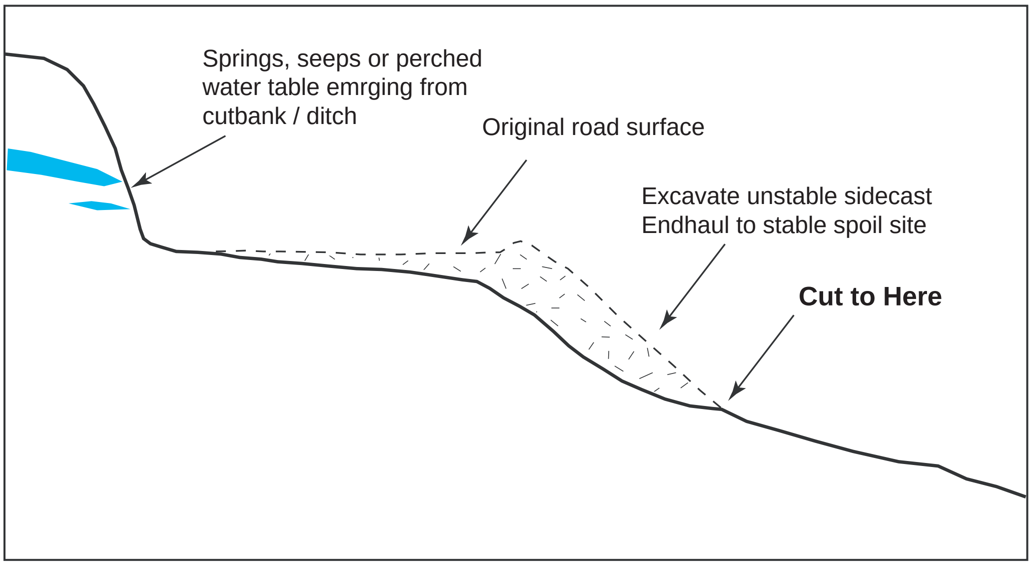
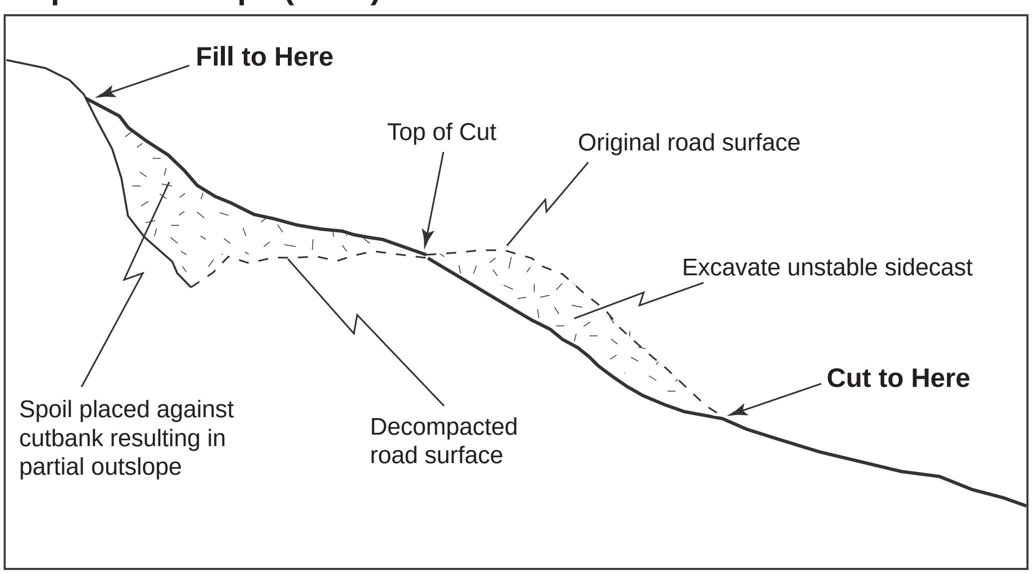
Typical Design for Road Decommisioning Treatments Employing Export and In-Place Outsloping Techniques

Export outslope (EPOS)



In-place outslope (IPOS)



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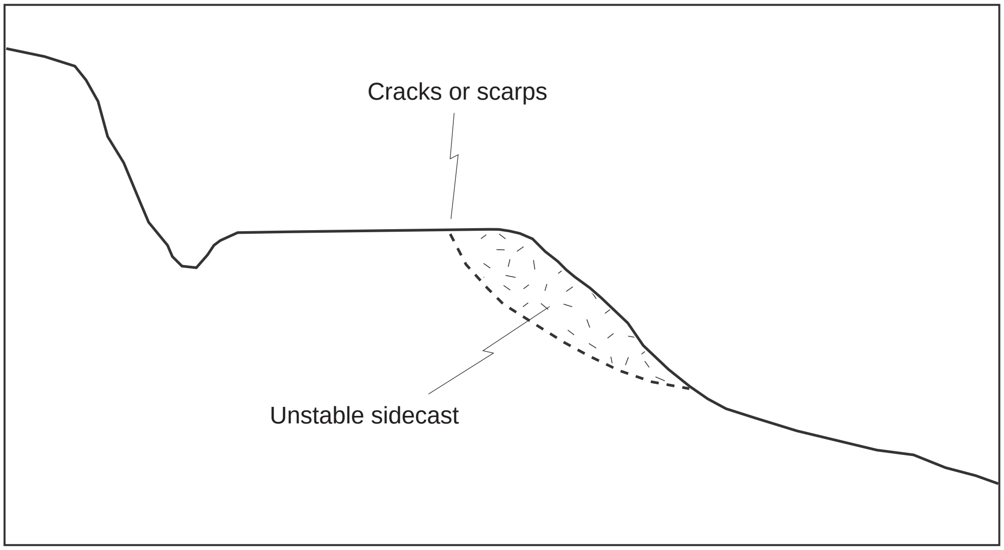
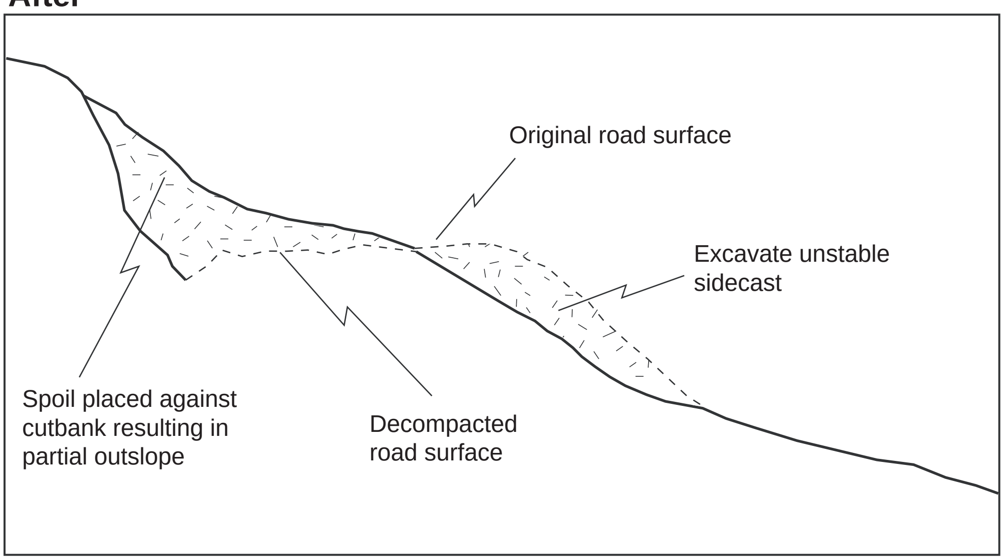
Typical Excavation of Unstable Fillslope on a Decommissioned Road

Before



After



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Appendix E

2008 Garcia River and Tributary Stream Surveys within The Conservation Fund "Garcia River Forest"

by
Craig Bell
Watershed Consultant

(CDFG Contract# P0530404)

2008 Garcia River and Tributary Stream Surveys within The Conservation Fund "Garcia River Forest"

Performed Under Contract to:

Pacific Watershed Associates
P.O. Box 4433
Arcata, CA 95518-4433
(707) 839-5130

By Craig Bell
Watershed Consultant
P.O. Box 1256
Gualala, CA 95445
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Background

These surveys were carried out under California Department of Fish and Game (CDFG) contract # P0530404 within the Garcia River watershed, a tributary to the Pacific Ocean, located in Mendocino County, California. The purpose of these stream surveys was to identify 1) sites of; current and potential bank erosion, 2) potential instream habitat enhancement locations, 3) opportunities for riparian planting, and 4) identify potential and complete barriers to salmonid migration. Additionally, observations were recorded such as year class and salmonid species present, wildlife, pools with special significance, riparian vegetation recruitment, and presence of large woody debris. The surveys complement the larger, upslope, erosion control assessment performed by Pacific Watershed Associates (PWA). The findings and recommendations will serve to guide the planning and implementation of comprehensive watershed restoration on the Garcia River Forest Property. The surveys were carried out in November and December 2008 on the mainstem Garcia River, North Fork Garcia, Blue Water Hole Creek, Graphite Creek and Whitlow Creek.

Methods

This project entailed stream surveys conducted by walking stream reaches accessible to anadromous fish. Key information from sites of interest was captured including GPS locations (lat/lon), selectively photo documented and marked by numbered flagging tape. Surveys were conducted in late November and early December 2008 with the hope that adult coho and steelhead might be sighted while holding or spawning, but the preceding rain was insufficient for adults to pass upstream.

Garcia River Mainstem

The mainstem Garcia River was surveyed within the Garcia River Forest property from Garcia River Forest Bridge B4 (N38.55.008, W123.28.813) to Bridge B6 (N38.53.016, W 123.30.159) in late November 2008. Bridge B4 crosses the Garcia River at the point it enters the Garcia River Forest property. Vehicle access exists via Highway 1 to Mountain View Road near the town of Manchester. At approximately 8.3 miles, enter through a Garcia River Forest gate onto Graphite Road. Follow Graphite Road south east until reaching the main stem Garcia River. Turn left and follow the main road along Garcia River for approximately 2 miles to Bridge B4 crossing over the Garcia River.

The surveyed reach has very high quality boulder pocket water and bedrock trench pool habitat. (Figure 1-3). Some of the largest and deepest pools in the upper Garcia River are located in this reach. (Figure 2) and these pools should be considered as very important holding water for up and downstream migrating adult salmonids especially during low flow condition between storm events. Adult salmonids holding in these pools are vulnerable to poaching, and should be monitored for this illegal activity during the winter months. There has been poaching in the past at these sites (CDFG Warden Ed Ramos personal communication). Currently, juvenile salmonid rearing in this reach of the main stem Garcia River is limited by high water temperatures (Figure 4). These deep pools should be temperature monitored to discover whether they are stratifying (cool water at depths). If suitable temperatures exist, these pools may be serving as thermal refugia for coho salmon juveniles at present. A dive survey in early August to monitor for juvenile salmonid presence is also recommended.


Figure 1: Boulder pocket water along the mainstem Garcia River that would be good rearing habitat, if temperatures were suitable.


Figure 2: Garcia River mainstem deep, bedrock trench pool suitable for holding migrating adult salmon and steelhead.

Figure 3: Close up of bedrock trench pool greater than 10 feet.

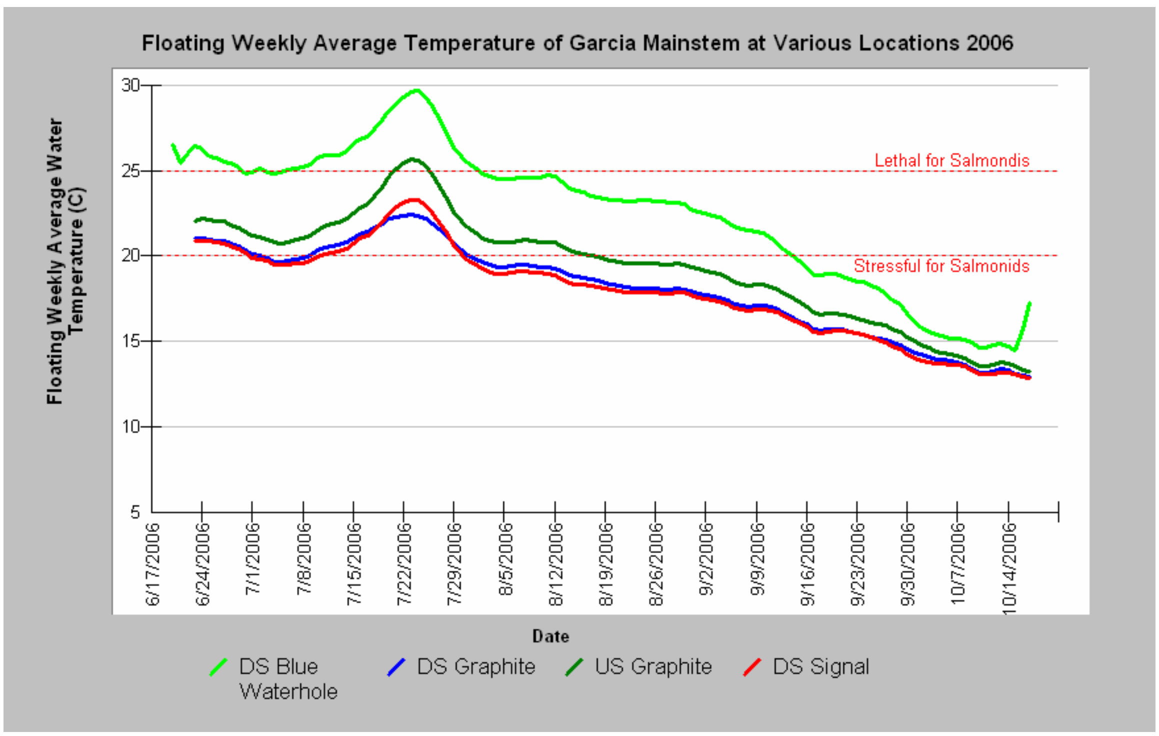

Figure 4. Maximum floating weekly average water temperature for various Garcia River mainstem locations for 2006.

Survey Highlights

- Begin survey at Garcia River Forest Bridge B4 N 38.55.025, W13.28.820
- Deep 10ft.+ holding pool N38.54.312, W123.29.748
- Erosion site #1 evidence of past slide from Hollowtree Rd.
  Recommend small scale planting of alder, conifer
- Deep 12ft.+ holding pool N38.53.858, W12330.217
- Deep 10ft holding pool N38.53.214
- End Survey at Garcia River Forest Bridge B6 N38.53.016, W123.30.159

Riparian Conditions: Riparian canopy is generally 30% throughout surveyed reach, but natural recruitment of alders and conifers is excellent where adequate soil depth is present (Figure 5). However, near stream riparian growth is limited by lack of soil depth due to prevalence of bedrock. There is a 300 foot Conservation Reserve designation along the entire main stem reach of the Garcia River Forest property. Over time conifers will reach late seral size and provide near historic levels of shade and large woody debris (LWD) recruitment. Boulder habitat in this mainstem reach is abundant and assist in creating substantial scour locally with pool and pocket water habitat development. No effort should be made to add instream habitat improvement until expected water temperature improvement occurs over time. This should be aided by watershed wide reduction of sediment inputs through the TMDL Plan and riparian canopy recovery.

Fish and Wildlife Species Observed: Although no coho salmon were observed, steelhead of four different age classes were present, including young of the year (YOY), yearlings (1+), two year olds (2+) and older age steelhead or resident trout (3+, >12"). Avian wildlife species sited include wood ducks, mergansers, mallard ducks, kingfisher, water ouzel, and great blue heron. Four carcasses of bandtail pigeons were noted along the river bar indicating kill by a raptor – likely a Peregrine Falcon. Terrestrial wildlife tracks and sign of otter, bobcat, deer, and feral pigs were also detected.

North Fork Garcia River

North Fork Garcia River is a tributary to Garcia River with the confluence of the two at T12N R16W S10 (38°55'49" N, 123°37'52" W). The North Fork is a third order stream and has approximately 7.59 miles of anadromous fish access and drains a watershed of approximately 10.4 square miles. Elevations range from about 45 feet at the mouth of the creek to 1,464 feet in the headwater areas. Mixed conifer forest dominates the watershed, which is entirely privately owned and managed for timber production.

The North Fork Garcia River is an important producer of steelhead and was likely historically a significant producer of coho salmon. CDFG presence/absence surveys from 2000-2002 observed coho in one year and coho juveniles were subsequently observed in the lower North Fork in 2006-2008 by this report's author. Temperatures are very suitable for steelhead and coho salmon, although currently coho are at remnant levels due in part to sub surface flows in lower reaches. The dry reach extends for nearly one mile from near the Garcia River Forest downstream property boundary (N38.55.514) to just above Bridge B9 (N38.55.586, W123.36.240). Coho salmon have been found below and above this sub-surface reach.
A major excavation of the lower reach of the North Fork was considered, but the project was found not to be feasible at this time. Therefore, no efforts should be undertaken to improve

instream habitat in this sub-surface reach. Test holes excavated at upstream end of this reach, showed the water table to be approximately ten feet below the surface. It is recommended that future test holes be excavated at lower end to determine if the water table is higher. A detailed geologic study will be required to determine options for restoration at the site to ultimately determine feasibility of restoring surface flows. Coho salmon juveniles need to be rescued in spring and early summer each year from dewatering reach and moved to suitable pools elsewhere. This recommendation can be found in the Recovery Strategy for California Coho Salmon (CDFG 2004) (9.70 MC-GA-13).

Survey Highlights

- Habitat enhancement efforts at this time should be concentrated upstream of Bridge B9 to the end of anadromy at the boulder falls.
- Pull large redwood rootwads and logs perched on North Fork terraces in to thalweg to enhance channel complexity and to scour pools for juvenile rearing and adult spawning and holding habitat (flags at appropriate sites).
    - Site #1: Fall live redwood across stream and construct spider log structure using existing root wad and roots. Large logs are also available on north bank, but might be too large for hand crew grip hoist capacity. Heavy equipment might be able to access some of these lower sites (N38.55.616, W123.36.145).
    - Site#2 Add temporary cover to pool (N38.55.648, W123.36.113)
    - Site#3: Add temporary cover to pool (N38.55.684, W123.35.926)
    - Site#4 Add temporary cover to pool (N38.55.714, W123.35.926)
    - Site#5 Reconfigure and fasten existing logs. Also add temporary cover (N38.55.718, W123.55.718, W123.35.912).
    - Site#6 Drop log spanning stream with chainsaw and allow to move unattached downstream. Pull perched log into channel and allow to move downstream unattached. (N38.55.724, W123.35.884)
    - Site#7 Cut live redwood growing from root wad and construct spider log by fastening to root wad. Could also be temporary cover site? (N38.55.732, W123.35.809).
    - Site#8 Note: this site has material available to build structure but it is likely to form migration barrier with evidence of past barrier removal. (N38.55.740, W123.35.762). Add temporary cover.
    - Site #9 Flood plain and canyon walls narrow, with increase in stream gradient and velocity. This is a likely shift point from coho salmon potential use to steelhead (N38.55.757,W123.34.743).
    - Site#10 Add temporary cover to boulder pools. High numbers of YOY and 1+ steelhead juveniles present. (N38.55.773, W123.35.739).
    - Site#11 Add temporary cover to pool. High number of YOY and 1+ steelhead juveniles present. (N38.55.796, W123.35.701)
    - Site#12: Add temporary cover using alder logs (N38.55.795,W123.35.686).
    - Site#13: Add temporary cover using alder logs (N38.55.827, W123.35.642).
    - Site #14: Add temporary cover. End reach recommended for installing temporary cover with volunteers. (N38.55.061, W123.35.619).

Figure 5. Natural recruitment of alder along a mainstem Garcia River terrace is shown during November 2008 surveys is a positive sign for succession as these will trap soil, build banks and ultimately a more confined and deeper mainstem.

- Site #15A: Old cut bank failure. Appears only to be delivering clean shale and small amounts of soil at this time and thus a healthy source of spawning gravel (N38.56.061, W123.35.383). (Figure 6).
- Site 15B (Figure 7) Erosion site delivering clean shale to stream channel. Failure likely occurred in 1995,1998 storm events. Site should be visible in aerials and could be further examined as part of upslope road survey. Site appears to be down to bedrock, shale. With a noted lack of spawning material in the surveyed reach of the North fork, this site is likely making a healthy contribution at this time. The site forms the south bank of Derby creek confluence with Garcia River. There was no alluvial fan of fine material at the confluence indicating delivery of upslope fine materials. Derby Creek was the site of successful, past landing removal, bank stabilization and planting project by Mendocino Resource Conservation District MCRCD/Jack Monschke Watershed Management. (N38.56.095,W123.35.289)

- End of Survey: Site#16 N38.56.059,W123.35.219 (Figure 8). Very large boulder pile/falls marking the end of anadromy. This barrier appears to be too large to modify in a cost effective manner with equipment or explosives.
- Spawning gravel is somewhat limited in the survey reach likely due to upstream storage above fish barrier and above.
- Recommend checking as part of upslope, road survey. Site should be visible in current aerials. Site likely failed in 1995, 1998 storm event.
- Skilled hand crew could utilize near steam LWD and a few selected dedicated live redwoods to build instream habitat, but priority is higher on Inman Creek and Signal Creeks where costs of projects would be less.

Figure 6. Debris slide on North Fork Garcia is not a site for riparian restoration (Site 15a).

Figure 7. Debris slide on North Fork Garcia may actually be a site of spawning gravel recruitment, which is important because spawning gravels may be limiting (Site 15b).

Figure 8. North Fork Garcia upper extent of steelhead access due to complete migration barrier formed by boulder jumble and LWD. May be preventing spawning gravel recruitment below.

Riparian Conditions: Canopy cover is at 90% throughout surveyed reaches with good recruitment of willows, alder, and conifer. No riparian planting is recommended.

Fish and Wildlife Observations: YOY, 1+ and 2+ steelhead are common through out the lower North Fork, with YOY fish mostly in riffle and run habitats and the older age juveniles in pools. Young of year coho salmon were observed in isolated pools near where Alder Creek joins the North Fork and the Nature Conservancy observed coho YOY above the dewatered reach in 2008 (Jennifer Carah personal communication). Pacific giant salamanders, water ouzels, mergansers, otter tracks, raccoon tracks and peregrine falcon kill were also observed in the field.

Graphite Creek

Graphite Creek is a tributary to the Garcia River and its legal description at the confluence with Garcia River is T12N R15W S22. The mouth of Graphite Creek is located at 38°53'36" north latitude and 123°30'27" west longitude. Graphite Creek is a first order stream and has approximately 1.31 miles of anadromous fish access with a watershed area of approximately 1.7 square miles. Elevations range from about 323 feet at the mouth of the creek to 1,605 feet in the headwater areas. Mixed conifer forest dominates the watershed, which is privately owned and managed for timber production. Vehicle access exists via Highway 1 to Mountain View Road near the town of Manchester. At approximately 8.3 miles, enter through a Garcia River Forest gate onto Graphite Road. Follow Graphite Road south east until reaching the main stem

Garcia River. Turn right and follow main road approximately 0.71 miles to Graphite Creek. The survey from the mouth (Bridge B-13) upstream to the end of anadromous fish access (1.3 mi.) (Figure 9).

Survey Highlights

- Stream substrate relatively course without an excess of fine sediment evident.
- Potential Barrier #1: The reach from the mouth to Bridge B-13 needs to be monitored because of high potential of formation of migration barrier due to narrow channel and shifting large wood and boulders.
- Potential Barrier #2: Redwood LWD spanning stream that could form impassable barrier (N38.53.734, W123.30.871).
- Potential Barrier #3: Very narrow channel with large wood jam upstream that may dislodge and form barrier (Figure 10). Recommend survey every three years. Evidence of past barrier removal/modification (1980's?) was visible. Upstream barrier to migration is boulder falls 1.3 miles from confluence with Garcia River (N 38.53.833, W123.30.923) (Figure 9).

Riparian Conditions: Hardwood and conifer canopy combined to equal high shade greater than 80% and topographic shading also exists. No riparian projects are recommended in this tributary.

Fish and Wildlife Observations: Mostly YOY steelhead observed in this small stream. Otter tracks were noted as was the presence of yellow legged frogs.

Figure 9. Ten foot high waterfall is the upper limit of steelhead access in Graphite Creek.


Figure 10. Potential barrier #3 on Graphite Creek.

Blue Waterhole Creek

Blue Waterhole Creek is a tributary to Garcia River and its legal description at the confluence with Garcia River is T12N R15W S11. Its location is 38°54'58" north latitude and 123°29'20" west longitude. Blue Waterhole Creek is a third order stream and has approximately 4.8 miles of anadromous fish access and a watershed area of 7.4 square miles. Elevations range from about 380 feet at the mouth of the creek to 2,007 feet in the headwater areas. Mixed conifer forest dominates the privately owned watershed that is managed for timber production. Vehicle access exists via Highway 1 to Mountain View Road near the town of Manchester. At approximately 8.3 miles, enter through a Garcia River Forest gate onto Graphite Road. Follow Graphite Road south east until reaching the main stem Garcia River. Turn left and follow the main road along Garcia River for approximately 1.5 miles to a bridge crossing over Blue Waterhole Creek. Due to the relatively steep channel gradient in the Lower Creek (Figure 11) and current high stream temperatures (Figure 13), Blue Waterhole Creek should be considered a steelhead only producing stream. The lowest reach of Blue Waterhole Creek is strewn with boulders and relatively steep and not likely historically used by coho. Low gradient riffles with spawning gravels occur on benches higher in the watershed (Figure 12). Blue Waterhole does have large boulder bedrock pools in its mid-upper reach which have suitable temperatures for steelhead juveniles due to stratification or cool spring inputs. The unnamed Northwest tributary provides a very important input of cold water. This cold water tributary should be carefully protected from illegal diversions for cultivation of marijuana.

Figure 11. Lower Blue Waterhole Creek, moderate/high gradient boulder, riffle habitat but summer water temperatures exceed 25 C during summer that likely makes it sometimes unviable as salmonid rearing habitat.

Figure 12. Low gradient reach of Blue Waterhole suitable for steelhead spawning and rearing.

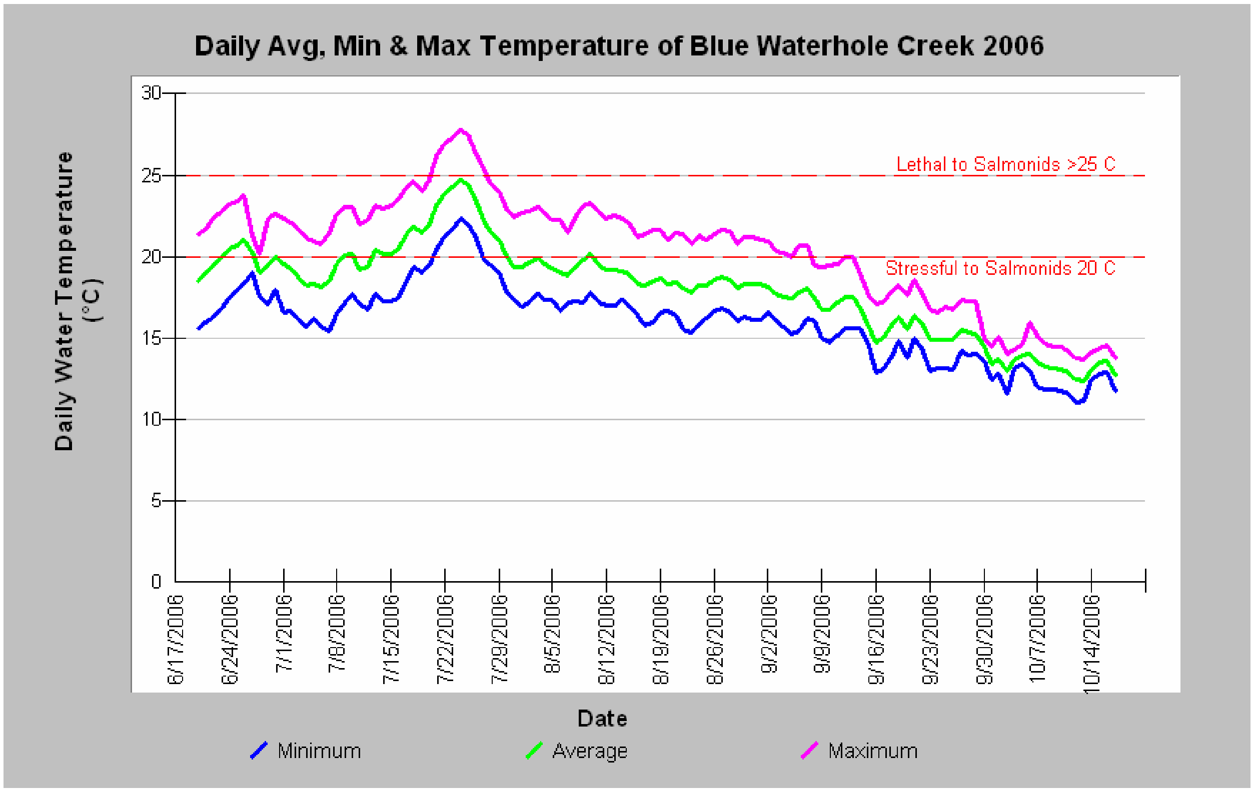

Figure 13. Minimum, average and maximum daily water temperature of Blue Waterhole Creek at its confluence with the Garcia River showing acutely stressful or lethal temperatures for salmonids during the warmest periods of summer.

There is the potential to form a project partnership with Landowner Stuart Bewley for upslope erosion control, riparian planting, and instream habitat improvement. Mr. Bewley owns approximately two thirds of the watershed with the Conservation Fund owning one third. Upslope stabilization, riparian planting and temperature improvement should proceed before any large wood or other instream structures are considered. Reductions in stream temperatures in Blue Waterhole over time would greatly increase the production of steelhead and could have a significant effect of cooling the main stem Garcia River immediately downstream of the confluence.

It is recommended that late summer snorkel survey be conducted in August to investigate cold water availability and the steelhead population within deep pools.

<u>Survey Highlights</u>

- Survey begins at Garcia River Bridge at confluence with mainstem Garcia River (N38.54.982,W123.29.421)
- Site #1 N38.35.235, W123.29.490 Transition from moderate gradient, boulder cobble to low gradient glide/pools. Beginning of potential spawning reaches (Figure 12).
- Site#2 Instream habitat structure built by contractor New Growth Forestry in the 1980's (Figure 14). Beginning of reach suitable for future instream structures and riparian planting due to spur off lower road along Blue Water Hole Creek.

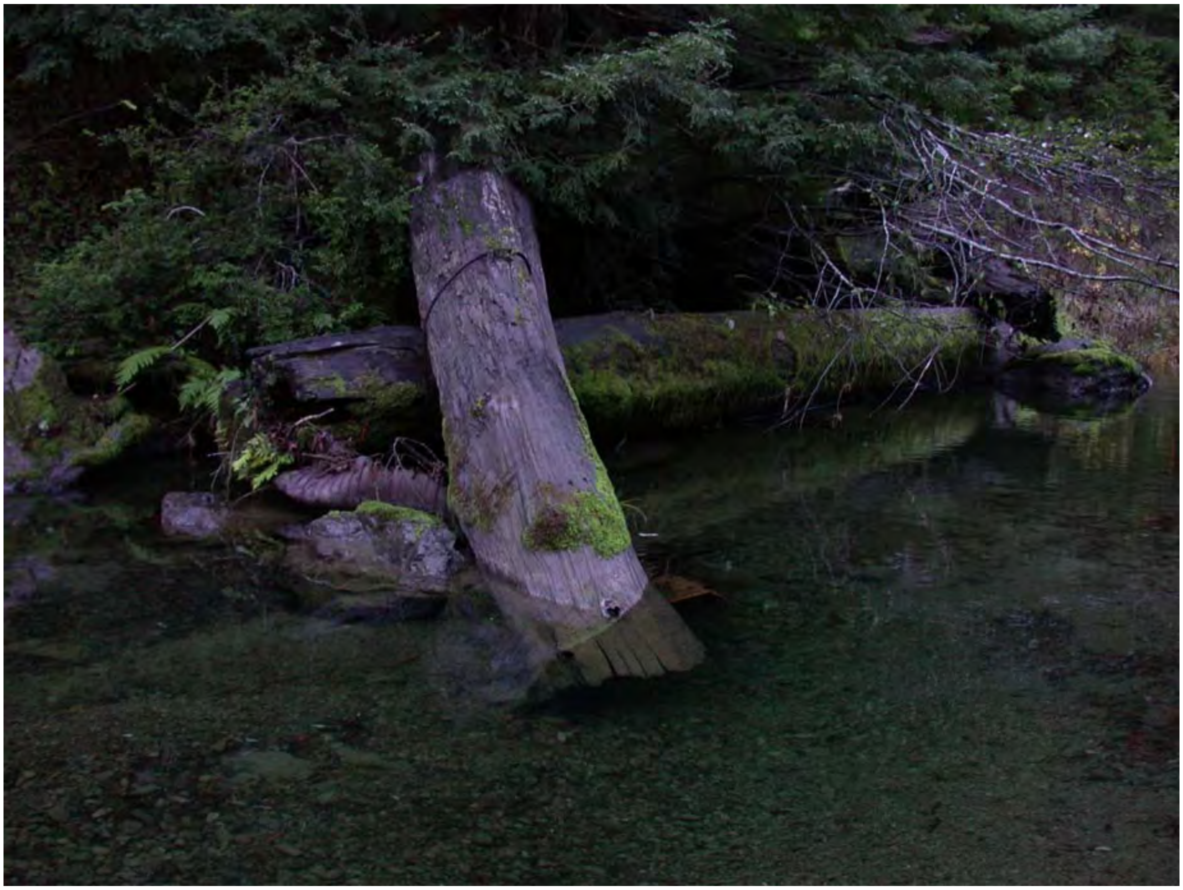

Figure 14. Instream structure on Blue Waterhole Creel built by New Growth Forestry in 1980's. Note crumpled culvert intertwined within structure likely from upstream crossing failure.

Riparian Conditions: Several past riparian projects along Blue Waterhole Creek have been carried out by New Growth Forestry, Jack Monschke and Friends of the Garcia River. The success of these past efforts needs to be studied before new projects are recommended.

Fish and Wildlife Observations: Mostly YOY steelhead observed in this small stream with older age juveniles predominantly in pools in upper reaches during summer. Otter tracks were noted as was the presence of yellow legged frogs.

Whitlow Creek

Surveyed from its confluence with the Garcia River (N 38.55.008, W 123.28.813) to a barrier that prevents anadromous fish migration (N 38.54.971, W 123.28.108).

Survey Highlights

- Some reaches surveyed were underground, likely due to aggradation.
- The upstream barrier to migration is a spanning LWD jam and sediment deposited upstream of it suggests that the stream is currently oversupplied (Figure 15). This location coincides with the upstream boundary of the Garcia River Forest property.
- Upstream sources of sediment need investigation and erosion prevention and control measures implemented.
- Recommend that upper barrier be considered for modification after excavating sediment.

Figure 15. Spanning logjam at upstream barrier to steelhead on Whitlow Creek at Garcia River Forest property boundary. Sediment trapped above the LWD suggests sediment over-supply from some unknown upstream sources in the watershed.

Riparian Conditions: Canopy is largely hardwood but may have been so historically in part (oak woodland transition zone).

Fish and Wildlife Observations: Mostly YOY steelhead but some 1+ observed in isolated pools. Raccoon and deer tracks were evident along the streambed of Whitlow Creek.

Other Project Opportunities

Potential for restoration projects on the Garcia River Forest property also exist outside the basins currently under study by PWA. It is recommended that volunteers be organized to add temporary habitat complexity in the form of small logs, alder branches and brush to existing pools in conjunction with an effort on Inman Creek and Signal Creek each spring.

References

California Department of Fish and Game. 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. 594 pp. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Sacramento, CA. 594 p.

Carah, Jennifer. Personal Communication. TNC, San Francisco.

Ramos, Edward. Personal Communication: CDFG Warden Point Arena area.

Appendix F

Summary of Measurable Project Metrics
And Budget Expenditure

for the Phase II 2009 Garcia River
Sediment Source Assessment,

Garcia River Watershed, Mendocino County, CA.

(CDFG Contract# P0530404)

Table F1. Summary of measurable project metrics, Phase II 2009 Garcia River Sediment Source Assessment project, Mendocino County, California.

1. Project Agreement Number	P0530404
2. Project Name	Phase II 2009 Garcia River Sediment Source Assessment
3. Property ownership	The Conservation Fund (TCF) Contact: Jenny Griffin 14951 “A” Caspar Road, Box 50 Caspar, CA 95420 Phone: (707) 962-0712
3. Geographic area	Garcia River
4. Project geospatial reference (center point of project area)	Lat/long (decimal degrees): -123.54, 38.91
5. Will the project funding support a local/watershed group? (Y/N)	Yes, the project funding supports The Conservation Fund and the Nature Conservancy, as well as regional efforts towards salmonid recovery.
6. Is the plan/assessment in development or completed?	The Phase II assessment is completed, and coupled with the Phase I Sediment Source Assessment results in the completion of the sediment source assessment for entire TCF ownership within the Garcia River.
7. Will the plan/assessment identify/prioritize specific factors limiting production of populations and ESUs or identify/prioritize conservation opportunities? (Y/N)	Yes, the Phase II sediment source assessment provides prioritized recommendations for cost-effective erosion prevention and erosion control which, when implemented and employed in combination with protective land use practices, can be expected to contribute to the long-term improvement of water quality and salmonid habitat in the Garcia River Forest and the greater Garcia River watershed
8. Will the plan and/or assessment incorporate biological goals that respond to State or Tribal Recovery Plans or Technical Recovery Team recommendations and identify actions needed to meet goals? (Y/N)	Yes, the project addresses biological goals and limiting factors regarding water quality (turbidity), excessive sediment yield, spawning requirements and rearing requirements; as defined in the Recovery Strategy for California Coho Salmon (CDFG, 2004); Total Maximum Daily Load” (TMDL) plan for the Garcia River basin (U.S. EPA, 1998), Action Plan for the Garcia River Watershed Sediment TMDL (NCRWQCB, 2000).

Table F2. Budget expenditure, Phase II 2009 Garcia River Sediment Source Assessment project, Mendocino County, California.

1. Project start/end dates	2/1/07-4/30/10			
2. Number of person hours expended	2,649.50			
3. Funding Source Expenditure for sediment source assessment				
Staff	Total Contract Budget ($)	Total Expended ($)	Funding expended[1] ($)	
			FRGP	TCF
Lead Professional	6,563	9,975.00	8,925.00	1,050.00
Project Geologist	18,200	17,312.75	15,583.75	1,729.00
Staff Geologist	79,105	62,960.63	49,455.00	13,505.63
GIS Specialist	2,835	3,622.50	2,835.00	787.50
Staff benefits	33,511	40833.83	33,407.46	7,426.37
Operating expenses	34,478	35,926.28	33,467.60	2,458.68
Administrative overhead	17,969	17,513.10	14,817.38	2,695.72
Total	**192,661**	**192,644.09**	**162,991.19**	**29,652.9**

[1] Total FRGP budget = $163,001; Total TCF budget = $29,660