Summary Report

1997 S.B. 271 Watershed Restoration Planning Project within East Austin Creek and Fife Creek, Tributaries to the Russian River, Sonoma County, CA.

prepared for

the Austin Creek State Recreation Area,
the Sotoyome-Santa Rosa Resource Conservation District
and
the California Department of Fish and Game

by

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Background
Austin Creek State Recreation Area and Armstrong Redwoods State Reserve are located in Sonoma County, 10 miles west of Santa Rosa (Figure 1). The Austin Creek State Recreation Area (ACSRA) contains approximately 17.4 miles of road in the East Austin Creek watershed. The Armstrong Redwoods State Reserve contains approximately 2.75 miles of road in the Fife Creek watershed. Within the 5,683 acre State Recreation Area boundary (25% of the East Austin Creek watershed), there is a total of 9.5 miles of anadromous stream. This includes five miles of main stem stream in East Austin Creek, as well as 1.5 miles in Thompson Creek and 3 miles in Gilliam Creek. Gilliam and Thompson Creeks are major tributary to East Austin Creek. Fife Creek is a small tributary stream draining directly to the Russian River through the town of Guerneville, CA. It contains approximately 1.5 miles of salmon and steelhead habitat.

The Department of Fish and Game records (stream surveys of 1947, ‘62, ‘68, ‘77, and habitat typing survey of ‘96) indicate all three streams in Austin Creek have historic runs of Steelhead Trout. Coho Salmon were found in Gilliam Creek in the 1962 survey, and in several tributaries to Austin Creek outside the ACSRA in 1996. Although coho salmon have never been observed in Fife Creek, habitat conditions indicate they most likely inhabited the drainage historically (Bob Coey and Bill Cox, CDFG). Today, Fife Creek is so aggraded with sediment that the entire length of stream within the State Park Campground has intermittent flow in the summer months. Much of the aggradation and loss of habitat is associated with numerous concrete grade control structures placed throughout the channel during the 1960's.

The 1996 CDFG Summary Stream Report for the East Austin tributaries indicates ample rearing habitat exists (pool, shelter and canopy values are among the best seen within the Russian River basin) for anadromous fish. The biological inventories documented fair numbers of juvenile steelhead trout in all year age classes. However, spawning habitat was identified as the primary limiting factor as reflected by sediment embeddedness values in these streams consistently in the higher ranges (50% and above) according to the CDFG habitat typing protocol.

As a result of the CDFG habitat study, CDFG initiated a road inventory and sediment delivery assessment along all road on State lands by Northwest Emergency Assistance Program workers under

Figure 1. Location map of East Austin Creek and Fife Creek watersheds, Russian River basin identifying portions of the watershed inventoried for future sediment sources in 1997/1998.

a Sotoyome-Santa Rosa Resource Conservation District (SSRRCD) sponsored grant utilizing standardized protocols developed by Pacific Watershed Associates (PWA). In June, 1998, PWA received a contract from CDFG to review and finalize the field inventories conducted by displaced fishermen, and to develop a prioritizing erosion control plan for all roads within the State Park.

The East Austin Creek basin was primarily logged for redwood around the turn of the century, and still contains some minor stands of marketable timber. Until the 1940's there was a magnesite mine in operation with a narrow gage railroad approximately 11 miles upstream from Cazadero. Today, the lower reaches below the state park property are populated with summer homes and privately owned ranches.

Above the State Park, the East Austin Creek watershed is sparsely populated, contains very steep terrain and experiences no industrial land use practices such as mining or gravel extraction. Very little timber is currently being logged from the surrounding area. These factors, and its proximity to the Pacific Ocean (approximately 8 miles), make East Austin Creek and its tributaries prime refugia habitat for restoring salmonid species in the Russian River Basin.

This summary report describes the watershed assessment and inventory process, as well as serves as a plan-of-action for erosion control and erosion prevention treatments for the entire assessment area in the East Austin Creek and Fife Creek watersheds managed by the State of California. Separate assessments and implementation plans are also provided in Appendix A and B for East Austin Creek and Fife Creek, respectively.

Project Description

In the first phase of the East Austin Creek/Fife Creek inventory project all roads within the study area were identified and age dated from historic aerial photography. Aerial photographs were analyzed to identify the location and approximate date of road construction. Each road identified was mapped on mylar overlays on the most recent aerial photos. A composite map of the road system in the assessment area was drafted and served as the base map for locating sites. The base map, used in combination with the aerial photos, shows the primary road network managed by ASCRA and Sonoma County in the watershed and shows the location of sites with future erosion and sediment delivery to the stream system.

The second phase of the project involved a complete inventory of the road systems, as well as selected hillslope areas. Each road was walked by experienced PWA staff and all existing and potential erosion sites were classified as either sediment delivery sites or as maintenance sites (i.e. where there is no future sediment yield to streams, but if left untreated the sites could affect the road integrity). Inventoried sites generally consisted of stream crossings, potential and existing landslides related to the road system, gullies below ditch relief culverts and long sections of uncontrolled road and ditch surface runoff. For each identified existing or potential erosion source, a database form was filled out and the site was mapped on a mylar overlay over 1" = 1000 foot and 1" = 660 foot scale aerial photographs. The database form (Figure 2) contained questions regarding the site location, the nature and magnitude of existing and potential erosion problems, the likelihood of erosion or slope failure and recommended treatments to eliminate the site as a future sediment yield site. All sites were assigned a treatment priority, based on either their potential to deliver sediment to stream

Check?___ **PWA ROAD INVENTORY DATA FORM** *(6/23/97 FULLER VERSION)* ASAP?___

GENERAL INFO. **Site #:** GPS coord: Watershed: Photo: T/R/S:
Road: Mileage: Maintained(Y): Abandoned(Y): Driveable(Y):
Inspector(s): Date: Year built: Sketch?(Y):
Treat? (Y,N): Upgrade?(Y): Decommission?(Y):

PROBLEM (circle)- Landslide (fillslope, cutbank or hillslope) Stream crossing Gully
Road bed (rd surface, ditch, cutbank) Ditch Relief CMP Other

Landslide - road fill failure: landing fill failure: deep-seated landslide:
cutbank slide: already failed: potential failure:
dist. to stream (ft): slope(%):

Stream - culvert (Y): bridge (Y): Humboldt (log)(Y): fill (Y): ditch/rd length (ft) - L: R:
pipe diameter (in): pipe condition (O,C,R,P) ------> inlet: outlet: bottom:
headwall hgt(in): cmp slope(%): stream class(1,2,3): rustline(in) - inlet: outlet:
% washed out: D.P. (Y, N): diverted (Y,N)?: plug potential (H,M,L):
channel grad(%): channel dimensions W: D: sed. transport (H,M,L):

Fish - Outlet drop(ft) - at time of survey: at bankful: Max step hgt. below cmp outlet(ft):
Outlet pool dimensions (ft) - at time of survey - L: D: Pool at bankful flow - L: D:

Erosion - Erosion Potential (H,M,L):
Past erosion (field-yds): Delivery (%): Size W: D: L:
Future eros (field-yds): Delivery (%): Size W: D: L:

Comment on problem -

SOLUTION Treatment immediacy (H,M,L): Complexity (H,M,L): Mulch area (ft^2):

Treatment-
excavate soil(Y): install critical dip(Y): install ford(Y): sill hgt: width:
add TR/DS(Y): (ft): repair/clean cmp (Y): install/repl cmp (Y): (dia.): (ft):
reconst. fill (Y): armor fill face (Y) - up/down: (ft^2):
clean or cut ditch (Y): (ft): *outslope rd (Y): (ft):* *rolling dips (Y): (#):*
remove berm(Y): (ft): *inslope road (Y): (ft):* *rock surface (Y): (ft):* check cmp size (Y): other (Y): none (Y):

Tot vol excav (field-yds): Vol put back in (yds): Vol removed (yds):
Vol stockpiled (yds): Volume endhauled (yds): Exc prod rate (yds/hr):

Hours- excavator: dozer: dump truck: grader:
loader: backhoe labor: other:

Comment on Treatment:

channels in the watershed or their potential to affect the road integrity. In addition to the database information, tape and clinometer surveys were completed on virtually all stream crossings. These surveys included a longitudinal profile of the stream crossing through the road prism, as well as one or more cross sections. The survey data was entered into a computer program that computed the volume of fill contained in each stream crossing and allowed for accurate and repeatable volume estimates to be made for a variety of possible erosion prevention treatments (culvert installation, culvert replacement, complete excavation, etc.).

Inventory Results

Approximately 20.2 miles of road were inventoried within the Austin Creek State Recreation Area and the Armstrong Woods State Reserve assessment area. 17.4 miles are located in the East Austin Creek watershed and 2.75 miles are located in the Fife Creek watershed. The East Austin Creek roads are all maintained by State Park personnel, whereas virtually all the inventoried roads in Fife Creek are maintained by the Sonoma County Public Works Department.

Inventoried sites fell into one of three types: 1) ***upgrade -*** defined as sites on maintained open roads with future sediment delivery to a stream channel and 2) ***decomission -*** defined as sites on abandoned, non-driving roads with future sediment delivery that are recommended for permanent hydrological closure. Past and potential erosion sites that did not deliver, or would not deliver eroded sediment to a stream channel or seriously affect the condition of the road were not inventoried as sites for this assessment. They may represent potential sources of erosion, but they do not represent a threat to water quality, fisheries resources or the road integrity.

Virtually all future erosion and road-related sediment yield in the East Austin Creek and Fife Creek watersheds is expected to come from four sources: 1) the failure of man-made, road and landing fills (landsliding), 2) large deep seated landslides, 3) erosion at (or associated with) stream crossings (from several possible causes) and 4) road surface, cutbank and ditch erosion. The latter source of sediment (road and ditch erosion and subsequent sediment delivery) is defined by the length of road and ditch currently contributing runoff and fine sediment to nearby stream channels.

The erosion potential (and potential for sediment delivery) was estimated for each existing sediment delivery site or potential delivery site. Estimates of future expected volume of sediment to be eroded and the volume delivered to streams was estimated for each site. The data provides quantitative estimates of how much material could be eroded and delivered in the future, if no erosion control or erosion prevention work is performed. In a number of locations, especially at stream diversion sites, actual sediment loss could easily exceed field predictions.

A total of 135 sites were identified with potential to deliver sediment to streams. Of these, 130 sites were recommended for erosion control and erosion prevention treatment. Approximately 68% (n=92) of the sites are classified as stream crossings, 19% (n=26) as ditch relief culverts and 5% (n=7) as potential landslides (Table 1, Map 1 and 2). The remaining 8% of the inventoried sites consist of gullies and miscellaneous road surface problems.

Landslides - Only those landslide sites with a potential for sediment delivery to a stream channel were inventoried. Potential landslides account for approximately 5% of the inventoried sites in the ASCRA assessment area (Table 1). The majority of the potential landslide sites (71%) were found along roads and landings where material has been sidecast during earlier construction and now shows signs of instability. Total future sediment yield from potential landslide sites is approximately 2,261 yds^3 (10% of the total future sediment yield). Potential landslides currently do not appear to be a large sediment contributor to the East Austin Creek or Fife Creek watersheds. This may be due to the generally old age of most of the roads in the watershed, where past large storms have triggered failures at most of the locations where the road was poorly located or where spoil had been placed in inappropriate places. Correcting or preventing potential landslides associated with the road is relatively straightforward, and involves the physical excavation of potentially unstable road fill and sidecast materials.

There are a number of potential landslide sites located in the ACSRA assessment area that did not, or will not deliver sediment to streams. These sites were not inventoried using data sheets due to the lack of delivery to a stream channel. They are generally shallow, or located far enough away from an active stream such that delivery is unlikely to occur. For reference, the sites were mapped on the mylar overlays of the aerial photographs.

Table 1. Site classification and sediment yield from all inventoried sites with future sediment delivery in the Austin Creek State Recreation Area, East Austin Creek and Fife Creek, Sonoma County, California .

Site Type	Number of sites or road miles	Number of sites or road miles to treat	Future yield (yds^3)	Stream crossings w/ a diversion potential (#)	Streams currently diverted (#)	Stream culverts likely to plug (plug potential rating = high or moderate)
Landslides	7	7	2,261	NA	NA	NA
Stream crossings	92	87	6,152	57	20	44
Ditch relief culverts	26	26	3,932	NA	NA	NA
Other	10	10	1,655	NA	NA	NA
Total (all sites)	135	130	14,000	57	20	44
Persistent surface erosion[1]	8.03	8.03	7,910	NA	NA	NA
Totals	**135**	**130**	**21,910**	**57**	**20**	**44**

[1] Assumes 25' wide road prism and cutbank contributing area, and 0.2' of road/cutbank surface lowering per decade.

Stream crossings - Ninety-two stream crossings were inventoried in the ACSRA assessment area including 65 culverted crossings, 24 un-culverted fill crossings, 2 bridge crossings and 1 “Humboldt” log crossing. An un-culverted fill crossing refers to a stream crossing with no drainage structure to carry the flow through the road prism . Flow is either carried beneath or through the fill, or it flows over the fillslope, or it is diverted down the road to the inboard ditch. Most un-culverted fill crossings are located at small Class III streams that exhibit flow only in the larger runoff events. If logs were intentionally placed in the axis of the channel at or near the base of the fill to convey flow beneath the road, then these crossings are commonly known as "Humboldt" or log crossings.

Approximately 6,152 yds^3 of future road-related sediment yield in the ACSRA assessment area is expected to originate from stream crossings (Table 1). This amounts to nearly 28% of the total sediment yield from the road system. The most common mechanisms of erosion at stream crossings include crossings with undersized culverts, culverts that are likely to plug frequently, stream crossings with a diversion potential and collapsing Humboldt crossings. The sediment delivery from stream crossing sites is always classified as 100% because any sediment introduced to even small ephemeral streams will eventually be delivered to fish-bearing stream channels.

At stream crossings, the largest volumes of future erosion can occur when culverts plug or when potential storm flows exceed culvert capacity (i.e., the culvert is too small for the expected runoff from the drainage area) and flood runoff spills onto or across the road. When stream flow goes over the fill, part or all of the stream crossing fill may be eroded. Alternately, when flow is diverted down the road, either on the road bed or in the ditch (instead of spilling over the fill and back into the same stream channel), the crossing is said to have a "diversion potential" and the road bed, hillslope and/or stream channel that receives the diverted flow can become deeply gullied. These hillslope gullies can be quite large and can deliver significant quantities of sediment to stream channels. Of the 92 stream crossings inventoried, 57 have the potential to divert in the future and 20 stream crossings are currently diverted (Table 1).

Three road design conditions indicate a high potential for future erosion at stream crossings. These include 1) undersized culverts (the culvert is too small for the 50 year design storm flow), 2) culverts that are prone to plugging because the stream frequently transports high amounts of sediment or organic debris and 3) stream crossings with a diversion potential. The worst scenario in a major storm is for the culvert to plug causing the stream crossing to either wash out or the stream to divert down the road.

The majority of the stream crossings on the roads inventoried in the ACSRA assessment area will need to be upgraded. For example, 48% of the existing culverts had a moderate to high plugging potential and nearly 62% of the stream crossings exhibit a diversion potential (Table 1). Because the roads were constructed many years ago, many culverted stream crossings are under designed for the 50 year storm flow. At stream crossings with undersized culverts or where there was a diversion potential, corrective prescriptions have been outlined on the data sheets and in the following tables. Preventative treatments include such measures as constructing critical dips (rolling dips) at stream crossings to prevent stream diversions, installing larger culverts wherever current pipes are under designed for the 50 year storm flow, installing culverts at the natural channel gradient to maximize the sediment transport efficiency of the pipe and ensuring that the culvert outlet will discharge on the natural channel bed below the base of the road fill, and installing debris barriers (i.e. trash racks) and/or downspouts to prevent culvert plugging and outlet erosion, respectively.

Ditch relief culverts and "Other"sites - A total of 26 ditch relief culvert and 10 "other" sites were identified in the ACSRA assessment area. The main cause of existing or future erosion at these sites is long sections of uncontrolled flow along the road surface and ditch . Uncontrolled flow along the road or ditch may affect the road bed integrity as well as cause gully erosion on the hillslopes below ditch relief culverts. It is also a major source of fine sediment input to nearby stream channels. In general, 8.03 miles of roads in the assessment area (40% of the total mileage of roads inventoried) deliver cutbank, ditch and road sediment and runoff to stream channels in the East Austin and Fife Creek watersheds. Although road fine sediment contributions may seem to be an unimportant sediment source relative to stream crossings and landslides, it can significantly affect the recovery of fish-bearing streams.

We estimate 5,587 yds^3 of sediment will be delivered to streams from the 26 ditch relief culvert and 10 "other" specific sites inventoried (Table 1). From the 8.03 miles of road, we calculated nearly 7,910 yds^3 of sediment will be delivered to stream channels in the East Austin and Fife Creek watersheds over the next 10 years if no efforts are made to change road drainage practices. This equates to 36% of the total estimated sediment yield within the assessment area, and represents the single largest sediment source/sediment production mechanism in the assessment area. This erosion will occur through a combination of 1) cutbank erosion delivering sediment to the ditch triggered by dry ravel, rainfall, freeze-thaw processes, cutbank slides and brushing practices, 2) inboard ditch erosion and sediment transport, 3) mechanically pulverizing and wearing down the road surface during dry periods due to high amounts of vehicular use, and 4) erosion of the road surface during wet weather periods where every vehicle pass entrains sediment which is transported to nearby streams.

Relatively easy treatments can be applied to upgrade road systems to prevent fine sediment from entering stream channels. These include installing a series or combination of road surface treatments such as rolling dips, outsloping, and/or additional ditch relief culverts to disperse runoff and hydrologically disconnect the roads from the stream network.

Treatment Priority

An erosion inventory is intended to provide information which can guide long range transportation planning, as well as identify and prioritize erosion prevention, erosion control and road decomissioning activities in the watershed. As a result, not all of the sites that have been recommended for treatment have the same priority, and some are more cost effective than others to treat. Treatment priorities are evaluated on the basis of several factors and conditions associated with each potential erosion site.

1) the expected volume of sediment to be delivered to streams,
2) the potential for future erosion (high, moderate, low),
3) the "urgency" of treating the site (treatment immediacy),
4) the ease and cost of accessing the site for treatments, and
5) recommended treatments, logistics and costs.

The likelihood of erosion (erosion potential) and the volume of sediment expected to enter stream channels from future erosion (sediment delivery) at each site play a significant roles in determining its treatment priority. The larger the potential future contribution of sediment to a stream, the more important it becomes to closely evaluate its potential for cost-effective treatment. The ***erosion potential*** of a site is a professional evaluation of the likelihood that future erosion will occur during a storm with a greater than 50 year peak flow return interval. Erosion potential was evaluated for each site, and expressed as "High", "Moderate" or "Low". Erosion potential is an estimate of the potential for additional erosion, based on local site conditions and field observations. Thus, it is employed as a subjective probability estimate, and not an estimate of how much erosion is likely to occur.

Treatment immediacy (treatment priority) is a professional evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is also defined as "High", "Moderate" and "Low" and represents the severity or urgency of the threat to downstream areas. An evaluation of treatment immediacy considers erosion potential, future erosion and delivery volumes, the value or sensitivity of downstream resources being protected, and treatability, as well as, in some cases, whether or not there is a potential for an extremely large erosion event occurring at the site (larger than field evidence might at first suggest). If mass movement, culvert failure or sediment delivery is imminent, even in an average winter, then treatment immediacy might be judged "High". ***Treatment immediacy is a summary, professional assessment of a site's need for immediate treatment.*** Generally, sites that are likely to erode or fail in a normal winter, and that are expected to deliver significant quantities of sediment to a stream channel, are rated as having a high treatment immediacy or priority.

One other factor influencing a site's treatment priority is the difficulty (cost and environmental impact) of reaching the site with the necessary equipment to effectively treat the potential erosion. Many sites found on abandoned or un-maintained roads require brushing and tree removal to provide access to the site(s). Other roads require minor or major road rebuilding of washed out stream crossings and/or existing landslides in order to reach potential work sites farther out the alignment. Road reconstruction adds to the overall cost of erosion control work and reduces project cost-effectiveness. Potential work sites with lower cost-effectiveness, in turn may be of relatively lower priority. However, just because a road is abandoned and/or overgrown with vegetation is not sufficient reason to discount its need for assessment and potential treatment. Treatments on heavily overgrown, abandoned roads may still be both beneficial and cost-effective.

Evaluating Treatment Cost-Effectiveness

Treatment priorities are developed from the above factors, as well as from the estimated cost-effectiveness of the proposed erosion control or erosion prevention treatment. 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. For example, if it would cost $2000 to develop access and treat an eroding stream crossing that would have delivered 500 yds^3 (had it been left to erode), the predicted cost-effectiveness would be \$4/yds^3 (\$2000/500yds^3).

To be considered for a priority treatment a site should typically exhibit: 1) potential for significant (>25-50 yds^3) sediment delivery to a stream channel (with the potential for transport to a fish-bearing stream), 2) a high or moderate treatment immediacy and 3) a predicted cost-effectiveness value averaging in the general range of approximately \$5 to \$15/yds^3, or less. Treatment cost-effectiveness analysis is often applied to a group of sites (rather than on a single site-by-site basis) so that only the most cost-effective groups or projects are undertaken. During road decomissioning, groups of sites are usually considered together since there will only be one opportunity to treat potential sediment sources along the road.

Cost-effectiveness can be used as a tool to prioritize potential treatment sites throughout a sub-watershed (Weaver and Sonnevil, 1984; Weaver and others, 1987). It assures that the greatest benefit is receive for the limited funding that is typically available for protection and restoration projects. Sites, or groups of sites, that have a predicted marginal cost-effectiveness value (>\$15/yds^3), or are judged to have a lower erosion potential or treatment immediacy, or low sediment delivery rates, are less likely to be treated as part of the primary watershed protection and "erosion-proofing" program. However, these sites should be addressed during future road reconstruction (when access is reopened into areas for future management activities), or when heavy equipment is performing routine maintenance or restoration at nearby, higher priority sites.

Types of Prescribed Heavy Equipment Erosion Prevention Treatments

Forest roads can be erosion-proofed by one of two methods: upgrading or decommissioning. Upgraded roads are kept open and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate or withstand the 50-year storm. In contrast, properly decommissioned roads are closed and no longer require maintenance. Generic treatments for decommissioning roads and landings range from outsloping to simple cross-road drain construction, to full road decommissioning (closure), including the excavation of unstable and potentially unstable sidecast materials, road fills, and all stream crossing fills.

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 stream crossing upgrading (especially culvert up-sizing, to accommodate the 50-year storm flow and debris in transport, and to eliminate stream diversion potential), removal of unstable sidecast and fill materials from steep slopes, and the application of drainage techniques to improve dispersion of road surface runoff. The road drainage techniques include berm removal, ditch removal where it is deamed not necessary, road outsloping, rolling dip construction, and/or the installation of ditch relief culverts. The goal of all treatments is to make the road as "hydrologically invisible" as is possible. The majority of roads in the ACSRA and the AWSR assessment areas are recommended for upgrading.

Along some low strength road routes, such as those in the East Austin Creek watershed, re-rocking the road following rolling dip construction and road outsloping or insloping efforts will often be necessary. These activities will incorporate pre-existing road rock into the new road shape design, thereby providing some road bed strength and stability. However, this often may not be enough material to provide safe passage in the winter months. Predicting the total amount of new road rock required can be difficult, but at a minimum, rock should be applied at all newly constructed rolling dips. Sites recommended for culvert replacement and road surface treatments in the Fife Creek watershed will require re-asphalting the road
surface after implementation. Re-asphalting road surfaces will decrease the cost effectiveness of a project substantially depending on the area of the road that will be disturbed by treatment activities.

General heavy equipment treatments for ***road decommissioning*** or closure are newer and less well published, but the basic techniques have been tested, described and evaluated. Decommissioning essentially involves "reverse road construction," except that full topographic obliteration of the road bed is not normally required to accomplish sediment prevention goals. In order to protect the aquatic ecosystem, the goal is to "hydrologically" close the road; that is, to minimize the adverse effect of the road on natural hillslope processes and watershed hydrology.

Treatments

Basic treatments priorities and prescriptions were formulated concurrent with the identification, description and mapping of potential sources of road-related sediment yield. Table 2 and Map 3 and 4 outline the treatment priorities for all 130 inventoried sites with future sediment delivery in the assessment area. Of the 130 sites with future sediment delivery, 45 sites were identified as having a high or high-moderate treatment immediacy with a potential sediment delivery "savings" of approximately 7,135 yds^3. Seventy sites were listed with a moderate or moderate-low treatment immediacy and account for nearly 5,890 yds^3 of saved sediment. Finally, 15 sites were listed as having a low treatment immediacy and approximately 923 yds^3 of future sediment delivery. Table 3 summarizes the proposed treatments for sites inventoried on all roads in the assessment area. These prescriptions include both

Table 2. Treatment priorities for all inventoried sediment sources in the Austin Creek State Recreation Area, East Austin Creek and Fife Creek, Sonoma County, California

Treatment Priority	Upgrade sites (#)	Decommission sites (#)	Upgrade/ Decom. Problem	Future sediment delivery (yds^3)
High	**26** (site #: 6, 7, 14, 15, 16, 18, 24, 28, 36, 38, 39, 40, 41, 54, 63, 64, 75, 80, 86, 102, 104, 109, 122, 123, 127, 130)	**2** (site: 76, 77)	2 landslides, 9 ditch relief culverts, 2 gullies 15 stream crossings	6,290
High Moderate	**16** (site #:2.1, 11, 13, 32, 33, 34, 37, 41.1, 46, 47, 49, 52, 74, 85, 107, 129)	**1** (site #:95)	2 gullies, 6 ditch relief culverts, 9 stream crossings	845
Moderate	**35** (site #: 3, 4, 8, 10, 17, 20, 25, 26, 27, 30, 31, 35, 42, 43, 44, 56, 57, 58, 60, 62, 66, 70, 73, 79, 81, 82, 83, 97, 101, 105, 110, 119, 120, 121)	**4** (site: 78, 89, 90, 94)	2 landslides, 1 gully, 6 ditch relief culverts, 28 stream crossings, 1 road surface	3,739
Moderate Low	**24** (site #: 1, 2, 5, 9, 12, 20.1, 29, 48, 51, 65, 68, 69, 71, 98, 99, 100, 108, 117, 118, 124, 125, 126, 128, 13192,)	**7** (site #: 88, 91, 92, 93, 111, 112, 115)	2 landslides, 4 gullies, 5 ditch relief culverts, 20 stream crossings	2,151
Low	**13** (site #: 19, 21, 22, 23, 45, 53, 67, 72, 84, 87, 96, 103, 106)	**2** (site #:114, 116)	1 landslides, 14 stream crossings	923
Total	**114**	**16**		**13,948**

upgrading and road closure measures. The database, as well as the field inventory sheets, provide details of the upgrading and road closure measures. The database, as well as the field inventory sheets, provide details of the treatment prescriptions for each site. Most treatments require the use of heavy equipment, including an excavator, tractor, dump truck, grader and/or backhoe. Some hand labor is required at sites needing new culverts, downspouts, flared inlets or culvert repairs, trash racks or for applying seed, plants and mulch following ground disturbance activities. It is estimated that erosion prevention work will require the excavation of approximately 6,013 yds^3 at 56 sites. Approximately 71% of the volume excavated is associated with upgrading stream crossings and nearly 25% of the volume is proposed for excavating potentially unstable road fills (landslides).

Table 3. Recommended treatments along all inventoried roads in the Austin Creek State Recreation Area, East Austin Creek and Fife Creek, Sonoma County, California.

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	34	To prevent stream diversions	Re-route road	1	Re-route road through unstable area
Install CMP[1]	2	Install a CMP at an unculverted fill	Outslope road	66	Outslope 23,085 feet of road to improve road surface drainage
Replace CMP[1]	36	Upgrade an undersized CMP	Install rolling dip	1994	Install rolling dips to improve road drainage
Excavate soil	56	Typically fillslope & crossing excavations; excavate a total of 6,013 yds^3	Clean ditch	14	Clean 1,820 feet of ditch
Install Down spouts	3	Installed to protect the outlet fillslope from erosion	Remove berm	7	Remove 2,040 feet of berm to improve road surface drainage
Wet crossing	22	Install ford or armored fill crossings	Install ditch relief CMP	39[1,2]	Install ditch relief culverts to improve road surface drainage
Install trash rack	1	Installed to prevent culvert from plugging	Rock road surface	1	Rock road surface using 25 yds^3 of rock
Clean CMP	1	Remove debris and/or sediment from CMP inlet	Other	5	Miscellaneous treatments
Armor fill face	13	Rock armor to protect outboard fillslope from erosion using 388 yds^3 of rock	No treatment recommended	5	
Install flared inlet	5	Installed to increase CMP capacity			

[1] Culvert replacement and ditch relief installation requires placement of the following culvert sizes and lengths including couplers and flared inlets, where prescribed: 1) 1340' of 18" diameter pipe, 2) 780' of 24" diameter pipe, 3) 260' of 30" diameter pipe, 4) 335' of 36" diameter pipe, 5) 50' of 42" diameter pipe, 6) 220' of 48" diameter pipe and 7) 120' of 60" diameter pipe.

[2] In East Austin Creek, additional ditch relief culverts (DRC) can be substituted for rolling dips. Each additional DRC will increase costs by 125% (i.e. more than double the costs). In Fife Creek, additional rolling dips can be substituted for ditch relief culverts (DRC). Due to re-aphalting costs, one rolling dip could cost more than double the cost of a ditch relief culvert installation (includes materials and equipment).

Finally, long lengths of road are proposed to be converted from insloped, flat or crowned shapes to outsloped road routes, along some of which we will retain the ditch (Table 3). We have recommended 199 rolling dips be constructed at selected locations along the road, at different spacing, depending on the steepness of the road. A minimum of 39 new ditch relief culverts are recommended to be installed along the road routes inventoried. In East Austin Creek, some proposed rolling dips can be replaced with additional ditch relief culverts, but this will increase costs at each dip by 125%. Along paved roads in the Fife Creek watershed, ditch relief culverts have been recommended instead of rolling dips. Due to re-asphalting costs, one rolling dip can cost twice as much to install compared to 1 ditch relief culvert (includes materials & equipment).

Equipment needs

Treatments for the 130 sites identified with future sediment delivery in the assessment area will require approximately 509 hours of excavator time and 330 hours of tractor time to complete all prescribed upgrading, road closure, erosion control and erosion prevention work (Table 4). Excavator and tractor work is not needed at all the sites that have been recommended for treatment and, likewise, not all the sites will require both a tractor and an excavator. Approximately 141 hours of dump truck time has been listed for work in the basin for endhauling excavated spoil from stream crossings and unstable road and landing fill where local disposal sites are not available. Nearly 53 hours of grader time is necessary to apply road surface treatments including outsloping and insloping.

Labor intensive needs

Finally, approximately 339 hours of labor time is needed for a variety of tasks such as installation or replacement of culverts, installation of debris barriers and downspouts, and seed and mulching activities.

Table 4. Estimated heavy equipment and labor requirements for treatment of all inventoried sites with future sediment delivery in the Austin Creek State Recreation Area, East Austin Creek and Fife Creek, Sonoma County, California.

Treatment Immediacy	Site (#)	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Dump Trucks (hrs)	Backhoe (hrs)	Loader (hrs)	Grader (hrs)	Labor (hrs)
High, High/Moderate	45	2,033	217	138	88	0	20	19.5	116
Moderate, Low/Moderate	70	3,805	277	169	51	7	0	27.5	205
Low	15	175	15	23	2	2	0	6	18
Total	**130**	**6,013**	**509**	**330**	**141**	**9**	**20**	**53**	**339**

Estimated costs for erosion prevention treatments - The total costs for road related erosion control at sites with sediment delivery is estimated at approximately \$ 302,014. for an average cost-effectiveness value of approximately \$ 13.78 per cubic yard of sediment prevented from entering East Austin Creek and Fife Creek (Table 5).

Overall site specific erosion prevention work: Equipment needs for site specific erosion prevention work at sites with future sediment delivery are expressed in the database, and summarized in Table 4, as direct excavation times, in hours, to treat all sites in the basin which have a high, moderate, or low treatment immediacy. These hourly estimates include only the time needed to treat each of the sites and the adjacent road reaches, and do not include travel time between work sites, the time needed to reconstruct or clear roads which have been abandoned, or the time needed for work conferences at each site. These additional times are accumulated as "logistics" and must be added to the work times to determine total equipment costs as shown in Table 5. Costs in Table 5 assume that the work in this watershed is accomplished during one summer work period employing two equipment teams. This minimizes moving and transport costs for equipment and personnel.

The costs in Table 5 are based on a number of assumptions and estimates. The costs provided are reasonable if work is performed by outside contractors, with no added overhead for contract administration, and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road maintenance and road building operations on forest lands. The use of inexperienced operators would require additional technical oversight and supervision in the field. All recommended treatments conform to guidelines described in “The Handbook for Forest and Ranch Roads” prepared by PWA (1994) for the California Department of Forestry, Natural Resources Conservation Service and the Mendocino County Resource Conservation District.

Table 5 lists a total of 460 for “supervision” time for detailed pre-work layout, project planning (coordinating and securing equipment and obtaining plant and mulch materials), on-site equipment operator instruction and supervision, and post-project cost effectiveness analysis and reporting. It is expected that the project coordinator will be on-site full time at the beginning of the project and intermittently after equipment operations have begun.

Conclusion

The expected benefit of completing the erosion control and prevention planning work lies in the reduction of long term sediment delivery to East Austin Creek and Fife Creek, important salmonid streams in the Russian River watershed. With this prioritized plan of action, State Park managers can work with the Sotoyome RCD or other entities to obtain potential funding to implement the proposed projects. However, watershed assessment inventories should be conducted on upland roads, both driveable and abandoned, in the remainder of the East Austin Creek watershed and Fife Creek watersheds. This will permit us to continue to refine the prioritization of which sites throughout the watershed pose the most critical threats to salmonid recovery, as well as allow us to know we are spending the limited available funds on the highest priority work sites in the watershed.

Table 5. Estimated logistic requirements and draft costs for road-related erosion control and erosion prevention work on inventoried sites with future sediment delivery on roads in the Austin Creek State Recreation Area, East Austin Creek and Fife Creek, Sonoma County, California.

Cost Category[1]		Cost Rate2 ($/hr)	Estimated Project Times: Treatment3 (hours)	Logistics4 (hours)	Total (hours)	Total Estim. Costs5 ($)
Move-in; move-out6 (Low Boy expenses)		70	28	0	28	1,960
Heavy Equipment for Sites	Excavator	125	509	153	662	82,750
	D-5 size tractor	95	330	99	429	40,755
	Dump Truck	60	146	44	190	11,400
	Loader	95	20	6	26	2,470
	Backhoe	65	9	3	12	780
	Grader	90	53	16	69	6,210
Laborers[7]		25	472	142	614	15,350
Rock Costs:(includes trucking for 388 yds^3 of rock)						7,860
Culvert materials costs						50,101
Mulch, seed and plant materials for 8 acres of disturbed ground						12,000
Asphalt Costs: (includes asphalt, equipment needs and trucking expenses)[7]						47,378
Layout, Coordination, Supervision, and Reporting[8]		50	--	--	460	23,000
Total Estimated Costs						**$ 302,014.**
Sediment Savings: 21,910 yds^3, Cost Effectiveness = $ 13.78 / yds^3 saved						

[1]Costs for tools andmiscellaneous materials have not been included in this table. Costs for administration and contracting are variable and have not been included. Costs and dump truck time (if needed) for re-rocking the road surface at sites where upgraded roads are outsloped are not included.

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

[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.

[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.

[6] Lowboy hauling for tractor and excavator, five hours round trip for each ownership or road association area. Costs assume 2 hauls for two pieces of equipment to the watershed (one to move in and one to move out).

[7] Labor hours (133 hours) for mulch and seed acitivities have been added to total labor hours.

[7] 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
Inventory results, erosion control and erosion prevention plan for roads within the East Austin Creek watershed.

The Austin Creek State Recreational Area (ACSRA) contains approximately 17.4 miles of road within the East Austin Creek watershed, a major anadromous tributary within the Russian River watershed. The Austin Creek roads are mostly located along the mainstem of East Austin Creek and its larger tributaries. Sites with the risk of future sediment delivery were inventoried by displaced commercial salmon fishermen under the NEAPS program using methodologies developed by PWA. Table 6 displays the distribution of site types mapped during the sediment source investigation. Potential landslides which pose a risk of delivering sediment to streams were identified along all the inventoried roads. Every stream crossing was inventoried and described in detail for all Class I, II or III watercourses. Stream crossings are sensitive areas since they represent the greatest opportunity for sediment to be introduced into stream channels. Regardless of the size of the stream, once sediment is introduced to a stream it will eventually be transported downstream to a fish bearing stream and ultimately impact fish habitat.

Road surface drainage problems and ditch relief culverts were also identified where long stretches of road or ditch deliver fine sediment to stream channels. All sites were mapped on aerial photos at a scale of 1"= 660 feet.

A total of 118 sites were identified with a risk of future sediment delivery along 17.4 miles in the East Austin Creek watershed (Table 6 and Map1). Sites include 86 stream crossings, 7 potential landslides, 20 ditch relief culvert sites where gullies below the outlet are contributing sediment to nearby stream channels and 5 "other" sites. Of the 118 inventoried sites, 113 have been recommended for erosion prevention treatment. In addition, 6.5 miles (37%) of the 17.4 miles of road in the East Austin Creek watershed function as man-made streams and currently deliver sediment and runoff to streams annually.

Landslides - Potential road-related landslides identified during the road inventory were divided into cutbank failures, landing fill failures, road fill failures, deep seated failures and others. Of the 7 identified sites of future road-related mass wasting, 4 are potential road fill failures, 1 is a cutbank slide and 2 are road-related, deep-seated failures. Left untreated, road-related landslides are expected to deliver approximately 2,261 yds^3 of sediment to the stream system.

Stream crossings - Eighty-six stream crossings were identified in the field with 59 being culverted fill crossings, 24 being unculverted fill crossings, 2 being bridge crossings and 1 "Humboldt" log crossing. Total future erosion and sediment yield from stream crossing sites is, at a minimum, approximately 5,704 yds^3 if erosion prevention measures are not undertaken.

The most significant problem from stream crossings inventoried on roads in the East Austin Creek watershed arise from stream crossings with a diversion potential. Of the 86 crossings inventoried, 53 have a diversion potential and 20 are currently diverted (Table 6). Treatments to correct stream diversions are easy, straight forward and require the installation of a "critical" dip placed at the down-road hinge line of the stream crossing to direct flow back into its natural drainage. Significant erosion can also occur from undersized culverts and poor culvert installation. Undersized culverts can plug causing flow to overtop the road and cause erosion of the stream crossing fill, or flow can be diverted down the road to create hillslope gullies. Of the 59 culverted stream crossings, 39 have a moderate to high plug potential. Erosion can also occur as a result of poorly installed culverts causing major gully erosion below the outlet. Approximately 34 % of the total future sediment yield would result from erosion associated with stream crossing failures.

Table 6. Site classification and sediment yield from inventoried sites with future sediment delivery on all roads in the East Austin Creek watershed assessment area, Sonoma County, California.

Site Type	Number of sites or road miles	Number of sites or road miles to treat	Future yield (yds^3)	Stream crossings w/ a diversion potential (#)	Streams currently diverted (#)	Stream culverts likely to plug (plug potential rating = high or moderate)
Landslides	7	7	2,261	NA	NA	NA
Stream crossings	86	81	5,704	53	20	39
Ditch relief culverts	20	20	2,208	NA	NA	NA
"Other" sites	5	5	334	NA	NA	NA
Total (all sites)	118	113	10,507	53	20	39
Persistent road surface erosion[1]	6.5	6.5	6,355	NA	NA	NA
Total future yield (yds^3)			16,862	53	20	39

[1] Road bed, ditch and cutbank sediment yield calculated over a 10 year period where the road is lowered an average of 0.20 feet with 25' average road width.

Road Surface and Ditch Relief Culvert sites - Twenty ditch relief culverts with gullies at the outlets were identified with sediment yield to streams. Long sections of uncontrolled ditch flow to ditch relief culverts is expected to cause 2,208 yds^3 of future sediment yield (Table 6).

Concentrated road surface runoff can generate fine sediment which can negatively impact general stream health and fish habitat. A total of 6.5 miles of the roadbed, ditch and cutbank currently persistently deliver fine sediment and runoff to stream channels. Cutbank, road bed and ditch erosional processes are predicted to yield nearly 6,355 yds^3 (38% of the predicted minimum total yield) of sediment to nearby streams over the next decade, if road drainage practices remain the same. Relatively easy treatments can be applied to upgrade road systems to prevent material from entering stream channels. These include installing a series or combination of road surface treatments such as rolling dips, outsloping, ditch or berm removal, and/or additional ditch relief culverts to disperse runoff.

Treatment Priority

Table 7 and Map 3 outline the location of all 113 inventoried sites with future sediment delivery recommended for erosion prevention treatment on inventoried roads in the East Austin Creek watershed. Altogether, 40 sites were identified as having a high or high-moderate treatment immediacy with a potential sediment delivery of approximately 4,725 yds^3. Fifty-nine sites were listed with a moderate or moderate-low treatment immediacy and account for nearly 4,827 yds^3 of future sediment delivery from individual sites. Finally, 14 sites were listed as having a low treatment immediacy which could yield approximately 903 yds^3 of future sediment delivery.

Table 7. Treatment priorities for all inventoried sediment sources in the East Austin Creek watershed assessment area, Sonoma County,California.

Treatment Priority	Upgrade sites (#)	Decommission sites (#)	Upgrade/ Decom. Problem	Future sediment delivery (yds^3)
High	**22** (site #: 6, 7, 14, 15, 16, 18, 24, 28, 36, 38, 39, 40, 41, 54, 63, 64, 75, 80, 86, 102, 104, 109)	**2** (site #: 76, 77)	13 stream crossings, 2 landslides, 8 ditch relief culverts, 1 gully	3,916
Moderate High	**15** (site #: 2.1, 11, 13, 32, 33, 34, 37, 41.1, 46, 47, 49, 52, 74, 85, 107)	**1** (site #: 95)	8 stream crossings, 6 ditch relief culverts, 2 gullies	809
Moderate	**31** (site #: 3, 4, 8, 10, 17, 20, 25, 26, 27, 30, 31, 35, 42, 43, 44, 56, 57, 58, 60, 62, 66, 70, 73, 79, 81, 82, 83, 97, 101, 105, 110)	**4** (site #: 78, 89, 90, 94)	27 stream crossings, 2 landslides, 4 ditch relief culverts, 1 road surface	2,888
Moderate Low	**17** (site #: 1, 2, 5, 9, 12, 20.1, 29, 48, 51, 65, 68, 69, 71, 100, 108, 117, 118)	**7** (site #: 88, 91, 92, 93, 111, 112, 115)	19 stream crossings, 2 landslides, 2 ditch relief culverts,1 gully	1,939
Low	**12** (site #: 19, 21, 22, 23, 45, 53, 67, 72, 84, 87, 103, 106)	**2** (site #: 114, 116)	13 stream crossings, 1 landslide	903
Total	**97**	**16**		**10,455**

Treatments

Table 8 lists the site specific treatments for all inventoried sites recommended for erosion prevention work on roads in the East Austin Creek watershed. Recommended erosion prevention work includes upgrading 15.2 miles of existing roads located in stable locations. Upgrading typically consists of properly installing new culverts designed to accommodate the 50 - year return interval peak storm flow and debris which will be in transport. Upgrading also includes improving the road drainage by utilizing different road surface treatments such as installing frequent rolling dips or additional ditch relief culverts and/or outsloping the road bed.

An additional 2.2 of currently abandoned roads is planned for permanent or temporary closure or decomissioning. General heavy equipment treatments for *road decommissioning* or closure are newer and less well published, but the basic techniques have been tested, described and evaluated.

Table 8. Recommended treatments along all inventoried roads in the East Austin Creek watershed assessment area, Sonoma County,California.

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	30	To prevent stream diversions	Install flared inlet	5	Installed to increase CMP capacity
Install downspout	3	Installed to protect the fillslope from culvert outlet erosion	Outslope road	66	Outslope 23,085 feet of road to improve road surface drainage
Install CMP	2	Install CMP at stream crossing	Rock road surface	1	Rock road surface for 30,000 ft^2
Replace CMP[1]	30	Upgrade an undersized CMP at stream crossing	Install rolling dips	199	Install rolling dips to improve road drainage
Excavate soil	55	Typically fillslope & crossing excavations; excavate a total of 5,957 yds^3	Clean ditch	11	Clean ditch for 1,570'
Wet crossing	22	Install armored fill crossings or ford crossings	Remove berm	2	Remove 300' feet of berm to improve road surface drainage
Install trash rack	1	Installed to prevent culvert from plugging	Install ditch relief culverts	4	Install ditch relief culvert to improve road surface drainage
Armor fill face	11	Rock armor to protect outboard fillslope from erosion using 368 yd^3 of rock	Other	3	Miscellaneous treatments
Clean CMP	1	Clean debris from CMP inlet	No treatment recommended	5	
Reconstruct Road	1	Reconstruct road with engineered approach			

[1] Culvert replacement and ditch relief installation requires placement of the following culvert sizes and lengths including couplers and flared inlets, where prescribed: 1) 130' of 18" diameter pipe, 2) 660' of 24" diameter pipe, 3) 260' of 30" diameter pipe, 4) 255' of 36" diameter pipe, 5) 50' of 42" diameter pipe, 6) 170' of 48" diameter pipe and 7) 90' of 60" diameter pipe.

Decommissioning essentially involves “reverse road construction,” except that full topographic obliteration of the road bed is not normally required to accomplish sediment prevention goals. In order to protect the aquatic ecosystem, the goal is to “hydrologically” close the road; that is, to minimize the adverse effect of the road on natural hillslope processes and watershed hydrology. It is estimated that erosion prevention work will require the excavation of approximately 5,957 yds^3 of material at 55 sites. Approximately 71 % of the volume excavated is associated with upgrading stream crossings and nearly 25% of the volume is a result of excavating potentially unstable road fills (landslides).

Other treatments for inventoried sites will include 32 new culvert replacements or installations, converting 22 culvert or fill stream crossings to armored fill or wet “ford” crossings on smaller class II and III streams, armoring the downstream fill face at 11 stream crossings to protect the crossing from failure and to prevent culvert outlet erosion, installing 5 flared inlets to increase the culvert capacity and reduce the plug potential, constructing 30 critical rolling dips to prevent stream diversions when culverts plug with wood and sediment, and a variety of road surface treatments (such as rolling dips, berm removal and outsloping) to lessen erosion and fine sediment delivery from the road surface during wet winter months. Each site has an individual data form which outlines the problem and describes in detail the recommended treatment and the estimated heavy equipment and labor requirements necessary at each site.

Equipment needs
Table 9 lists the expected heavy equipment and labor requirements by treatment immediacy to treat inventoried sites with future sediment delivery. Treatments for the 113 sites with potential sediment delivery along 17.4 miles of the roads in the East Austin Creek watershed will require approximately 324 hours of excavator and 317 hours of tractor time to complete all prescribed upgrading, erosion control and erosion prevention work.

Table 9. Estimated heavy equipment and labor requirements for treatment of all inventoried sites with future sediment delivery on roads in the East Austin Creek watershed assessment area, Sonoma County,California.

Treatment Immediacy	Site (#)	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Dump Trucks (hrs)	Backhoe (hrs)	Loader (hrs)	Grader (hrs)	Labor (hrs)
High, High/Moderate	40	2,033	172	135	86	0	20	18.5	76
Moderate, Low/Moderate	59	3,749	140	159	50	7	0	24.5	111
Low	14	175	12	23	2	2	0	6	16
Total	**113**	**5,957**	**324**	**317**	**138**	**9**	**20**	**49**	**203**

Approximately 138 dump truck hours are needed for end-hauling excess spoil and importing rock for rocking wet crossings, building armored fill crossings and the road surface rock in selected locations. Two hundred and three hours of labor is necessary for installing new culverts, flared inlets and other miscellaneous tasks, and 117 hours are for seeding, mulching and planting activities. The remaining equipment hours apply to prescribed road surfacing treatments (Table 9).

Labor intensive needs

Many potential work sites will need mulching, seeding and/or tree planting following re-construction activities. These include fillslopes at stream crossings where new culverts are to be installed, at fillslope excavations to prevent future landsliding, as well as at all areas where excess spoil material derived from excavations is disposed of. Where roads are proposed for outsloping or where rolling dips will be constructed, all disturbed areas outside the road prism/bed will also be seeded and mulched. Costs have been included for laborers to seed and mulch approximately 1.5 acres of ground following heavy equipment work along the East Austin Creek road system. Weed free straw mulch will be applied at 4000 pounds/acre. Native seeds should be applied at 20 pounds/acre and follow the guidelines prepared by Circuit Riders Inc. in the Navarro Watershed Restoration Plan (Entrix, 1998).

Cost estimate for treating inventoried sites along 17.4 miles of road in the East Austin Creek watershed

Table 10 summarizes the necessary costs by equipment types for the 113 sites with future sediment delivery, as well as to control sediment yield associated with poor road drainage along 6.5 miles of road. The estimate includes costs for seed and mulch, new culverts, flared inlets, as well as rock necessary for rip rapping and constructing sill stream crossings at many small class II and III streams. Hours represent direct equipment times and do not include travel time between work sites, additional costs for unseen complications or the time needed for conferences with equipment operators. These additional times are accounted for as "logistics" and are added to the total equipment hours to determine the total project cost (Table 10).

Total costs for the project are estimated at approximately $ 190,557. to treat the 113 sites recommended for treatment and to significantly reduce sediment yield from the 6.5 miles of road in East Austin Creek. The average cost effectiveness value of the project is $11.30 per cubic yard of sediment prevented from entering East Austin Creek and its tributaries. Costs in Table 10 assume that the work in the watershed will be accomplished during a single summer work period using one equipment team.

The cost estimate includes a minimal amount of layout, coordination, monitoring and reporting hours for a PWA professional to work with equipment operators to insure the plan is cost effectively implemented, as proposed, and treatments are installed or constructed properly and according to specifications. Pre and post permanent project photo points will be established to document effectiveness monitoring through time for all implemented work projects.

Finally, the costs in Table 10 are based on a number of assumptions and estimates. The costs provided are reasonable if work is performed by outside contractors, with no added overhead for contract administration, and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road maintenance and road building operations on forest lands. The use of inexperienced operators would require additional technical oversight and supervision in the field. All recommended treatments conform to guidelines described in

"The Handbook for Forest and Ranch Roads" prepared by PWA (1994) for the California Department of Forestry, Natural Resources Conservation Service and the Mendocino County Resource Conservation District.

Table 10. Estimated logistic requirements and draft costs for road-related erosion control and erosion prevention work on inventoried sites with future sediment delivery on roads in the East Austin Creek watershed.

Cost Category[1]		Cost Rate2 ($/hr)	Estimated Project Times			Total Estim. Costs5 ($)
			Treatment3 (hours)	Logistics4 (hours)	Total (hours)	
Move-in; move-out6 (Low Boy expenses)		70	18	0	18	1,260
Heavy Equipment (for both site and road surface treatments)	Excavator	125	324	97	421	52,625
	D-5 size tractor Excavator	95	317	95	412	39,140
	Dump Truck	60	143	43	186	11,160
	Loader	95	20	6	26	2,470
	Backhoe	65	9	3	12	780
	Grader	90	49	15	64	5,760
Laborers[7]		25	320	96	416	10,400
Rock Costs (includes trucking for 368 yds^3 of rock)						7,360
Culvert materials costs						34,102
Mulch, seed and plant materials for 7 acres of disturbed ground						10,500
Layout, Coordination, Supervision, and Reporting[8]		50	--	--	300	15,000
Total Estimated Costs						**$190,557**
Sediment Savings: 16,862 yd^3, Cost Effectiveness = \$ 11.30 / yds^3 saved						

[1]Costs for tools and miscellaneous materials have not been included in this table. Costs for administration and contracting are variable and have not been included.

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

[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.

[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.

[6] Lowboy hauling for tractor and excavator, five hours round trip. Costs assume 2 hauls for two pieces of equipment to the East Austin Creek watershed (one to move in and one to move out).

[7] Labor hours (117 hours) for mulch and seed acitivities have been added to total labor hours.

[8] 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).

Appendix B
Inventory results, erosion control and erosion prevention plan for roads in the Fife Creek watershed

The Armstrong Redwoods State Reserve (ARSR) and the Sonoma County Public Works Department manage approximately 2.75 miles of paved road in the Fife Creek watershed. Fife Creek is a small tributary which flows through the town of Guerneville, CA. into the Russian River. Sites with the risk of future sediment delivery were inventoried using methodologies developed by PWA. Table 11 displays the distribution of site types mapped during the sediment source investigation. Potential landslides which pose a risk of delivering sediment to streams were identified along all the inventoried roads. Every stream crossing was inventoried and described in detail for all Class I, II or III watercourses. Stream crossings are sensitive areas since they represent the greatest opportunity for sediment to be introduced into stream channels. Regardless of the size of the stream, once sediment is introduced to a stream it will eventually be transported downstream to a fish bearing stream and ultimately impact fish habitat.

Road surface drainage problems and ditch relief culverts were also identified where long stretches of road or ditch deliver fine sediment to stream channels. All sites were mapped on aerial photos at a scale of 1"= 660 feet.

A total of 17 sites were identified with a risk of future sediment delivery along roads within the Fife Creek watershed (Table 11 and Map 2). Sites include 6 stream crossings, 6 ditch relief culverts and 5 gullies. Of the 17 inventoried sites, all have been recommended for erosion prevention treatment. In addition, 1.59 miles (58%) of the 2.75 miles of roads inventoried in Fife Creek currently deliver sediment and runoff to streams.

Stream crossings - Six stream crossings were identified in the field with all being culverted fill crossings. Total future erosion and sediment yield from stream crossing sites is approximately 450 yds^3 if erosion prevention measures are not undertaken.

The most significant problem from stream crossings inventoried on roads in Fife Creek arise from stream crossings with a diversion potential. Of the 6 crossings inventoried, 4 have a diversion potential. Treatment for stream diversions is easy and requires installation of a “critical” dip placed at the down-road hinge line of the stream crossing to direct flow back into its natural drainage.

Significant erosion can also occur from undersized culverts and poor culvert installation. Undersized culverts can plug causing flow to overtop the road and cause erosion of the stream crossing fill, or flow can be diverted down the road to create hillslope gullies. Of the 6 culverted stream crossings, 5 have a moderate to high plug potential. Erosion can also occur as a result of poorly installed culverts causing major gully erosion below the outlet. Approximately 9% of the total future sediment yield would result from erosion associated with stream crossing failures.

Ditch relief culvert and gully sites - Eleven specific road surface erosion sites were identified with future sediment yield to stream channels. These sites include ditch relief culverts with gullies below their outlets and gullies caused by concentrated road surface runoff down the fillslope. Approximately 3,045 yds^3 of future sediment yield is expected to occur associated with these miscellaneous sites.

Table 11. Site classification and sediment yield from inventoried sites in the Fife Creek watershed, Sonoma County, California .

Site Type	Number of sites or road miles	Number of sites or road miles to treat	Future yield (yds^3)	Stream crossings w/ a diversion potential (#)	Stream culverts likely to plug (plug potential rating = high or moderate)
Stream crossings	6	6	448	4	5
Ditch relief culvert	6	6	1,724	NA	NA
Gully	5	5	1,321	NA	NA
Total (all sites)	17	17	3,493	4	5
Persistent surface erosion	1.59	1.59	1,555	**NA**	**NA**
Totals	**17**	**17**	**5,048**	**4**	**5**

[1]Assumes 25' wide road prism and cutbank contributing area, and 0.2' road/cutbank surface lowering over the next decade.

These miscellaneous gully and ditch relief culvert sites represent approximately 60% of the total predicted sediment yield from road-related erosion.

Concentrated road surface runoff can generate fine sediment which can negatively impact general stream health and fish habitat. A total of 1.59 miles of the roadbed, ditch and cutbank currently persistently deliver fine sediment and runoff to stream channels. Cutbank, road bed and ditch erosional processes are predicted to yield nearly 1,555 yds^3 (31%) of sediment to nearby streams over the next decade, if road drainage practices remain the same. Relatively easy treatments can be applied to upgrade road systems to prevent material from entering stream channels. These include installing a series or combination of road surface treatments such as rolling dips, outsloping, ditch and berm removal and/or additional ditch relief culverts to disperse runoff.

Treatment Priority

Table 12 and Map 4 outline the treatment immediacy for all 17 inventoried sites with future sediment delivery in the Fife Creek watershed. Altogether, 5 sites were identified as having a high or high-moderate treatment immediacy with a potential sediment delivery of approximately 2,410 yds^3. Eleven sites were listed with a moderate or moderate-low treatment immediacy and account for nearly 1,060 yds^3. Finally, 1 sites was listed as having a low treatment immediacy which could yield approximately 20 yds^3 of future sediment delivery.

Treatments

Table 13 lists the site specific treatments for all inventoried sites recommended for erosion prevention work along roads inventoried in the Fife Creek watershed. Recommended erosion prevention work

Table 12. Treatment priorities for all inventoried sediment sources in the Fife Creek watershed, Sonoma County, California.

Treatment Immediacy or Priority	Upgrade sites (#)	Upgrade/ Decom. Problem	Future sediment delivery (yds^3)
High	**4** (site #: 122, 123, 127, 130)	1 ditch relief culvert, 1 gully, 2 stream crossings	2,374
Moderate/High	**1** (site #: 129)	1 stream crossing	36
Moderate	**4** (site #: 97, 119, 120, 121)	2 ditch relief culverts, 1 gully, 1 stream crossing	851
Moderate/Low	**7** (site #: 98, 99, 124, 125, 126, 128, 131)	3 ditch relief culverts, 3 gullies, 1 stream crossing	212
Low	**1** (site #: 96)	1 stream crossing	20
Total	**17**		**3,493**

includes upgrading existing roads located in stable locations. Upgrading typically consists of properly installing new culverts designed to accommodate the 50 - year return interval peak storm flow and debris which will be in transport. Upgrading also includes improving the road drainage by utilizing different road surface treatments such as installing frequent rolling dips or additional ditch relief culverts and/or outsloping the road bed.

Treatments for inventoried sites on roads in Fife Creek will include culvert replacements, a variety of road surface treatments (such as cleaning ditches and berm removal) and additional ditch relief culverts to lessen erosion and fine sediment delivery from the road surface during wet winter months. Re-asphalting the road prism has been prescribed at every site location requiring road surface treatments such as installation of ditch relief culverts/rolling dips, stream culvert replacements and critical dips. Each site has an individual data form which outlines the problem and describes in detail the recommended treatment and the estimated heavy equipment and labor requirements necessary at each site.

Equipment needs

Tables 14 and 15 list the expected heavy equipment and labor requirements by treatment immediacy to treat inventoried sites with future sediment delivery. Treatments for the 17 sites with potential sediment delivery along 2.75 miles of the roads in the Fife Creek watershed will require approximately 185 hours of excavator and 13 hours of tractor time to complete all prescribed upgrading, erosion control and erosion prevention work (Table 13). Approximately 3 dump truck hours are needed for endhauling excess spoil and importing rock for rock armoring culverted crossings. One hundred and thirty-six hours of labor is necessary for installing new culverts and other miscellaneous tasks. The remaining equipment hours apply to prescribed road surfacing treatments.

Table 13. Recommended treatments along inventoried roads in the Fife Creek watershed, Sonoma County, California .

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	4	To prevent stream diversions	Clean ditch	3	Clean 250 feet of ditch
Replace cmp	6[1]	Replace an undersized cmp	Remove berm	5	Remove 1,740 feet of berm to improve road surface drainage
Excavate soil	1	Typically fillslope & crossing excavations; excavate a total of 56 yds^3	Install ditch relief cmp[1]	35[1,2]	Install ditch relief culverts to improve road surface drainage
Armor fill face	2	Rock armor to protect outboard fillslope from erosion using 20 yds^3 of rock	Other	2	Miscellaneous treatments
Re-route road	1	Re-route road through un-stable area			

[1] Culvert replacement and ditch relief installation requires placement of the following culvert sizes and lengths including couplers and flared inlets, where prescribed: 1) 1210' of 18" diameter pipe, 2) 120' of 24" diameter pipe, 3) 80' of 36" diameter pipe, 4)50' of 48" diameter pipe and 5) 30' of 60" diameter pipe.

[2] Additional rolling dips can be substituted for ditch relief culverts (DRC). Due to re-aphalting costs, one rolling dip could cost more than double the cost of a ditch relief culvert installation (includes materials and equipment).

Table 14. Estimated heavy equipment and labor requirements for treatment of inventoried sites with sediment delivery in the Fife Creek watershed, Sonoma County, California .

Treatment Immediacy	Site (#)	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Dump Truck (hrs)	Grader (hrs)	Labor (hrs)
High, High/Moderate	5	0	45	3	2	1	40
Moderate, Low/Moderate	11	56	137	10	1	3	94
Low	1	0	3	0	0	0	2
Total	**17**	**56**	**185**	**13**	**3**	**4**	**136**

Labor intensive needs

Potential work sites will need mulching, seeding and/or tree planting following re-construction activities. These include fillslopes at stream crossings where new culverts are to be installed, as well as at all areas where excess spoil material derived from excavations is disposed of. Costs have been included for laborers to seed and mulch approximately 1 acre of ground following heavy equipment work along the Fife Creek road system. Weed free straw mulch will be applied at 4000 pounds/acre. Native seeds should be applied at 20 pounds/acre and follow the guidelines in the Navarro Watershed Restoration Plan (Entrix, 1998).

Cost estimate for inventoried sites along 2.75 miles of road in the Fife Creek watershed
Table 15 summarizes the necessary costs by equipment types for the 17 sites with future sediment delivery. The estimate includes costs for re-asphalting the road, seed and mulch, new culverts, as well as rock necessary for rip rap at specified culverted crossings. Hours represent direct equipment times and do not include travel time between work sites, additional costs for unseen complications or the time needed for conferences with equipment operators. These additional times are accounted for as "logistics" and are added to the total equipment hours to determine the total project cost (Table 15).

Total costs for the project are estimated at approximately $ 111,457. to treat the 17 sites inventoried with future sediment delivery and to significantly reduce sediment yield from the 1.59 miles of road feeding sediment annually to streams. The average cost effectiveness value of the project is $ 22.08 per cubic yard of sediment prevented from entering Fife Creek and its tributaries. Costs in Table 15 assume that the work in the watershed will be accomplished during a single summer work period using one equipment team.

The cost estimate includes a minimal amount of layout, coordination, monitoring and reporting hours for a PWA professional to work with equipment operators to insure the plan is cost effectively implemented, as proposed, and treatments are installed or constructed properly and according to specifications.

Finally, the costs in Table 15 are based on a number of assumptions and estimates. The costs provided are reasonable if work is performed by outside contractors, with no added overhead for contract administration, and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road maintenance and road building operations on forest lands. The use of inexperienced operators would require additional technical oversight and supervision in the field. All recommended treatments conform to guidelines described in "The Handbook for Forest and Ranch Roads" prepared by PWA (1994) for the California Department of Forestry, Natural Resources Conservation Service and the Mendocino County Resource Conservation District.

Table 15. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on inventoried sites with future sediment delivery in the Fife Creek watershed, Sonoma County, California .

Cost Category[1]		Cost Rate2 ($/hr)	Estimated Project Times: Treatment3 (hours)	Estimated Project Times: Logistics4 (hours)	Estimated Project Times: Total (hours)	Total Estim. Costs5 ($)
Move-in; move-out6 (Low Boy expenses)		70	10	—	10	700
Heavy Equipment (for both sites and road surface treatments)	Excavator	125	185	56	241	30,125
	D-5 size tractor	95	13	4	17	1,615
	Dump Truck	60	3	1	4	240
	Grader	90	4	1	5	450
Laborers[7]		25	152	46	198	4,950
Rock Costs: (includes trucking for 20 yd^3 of 0.5 -1' diam. rock)						500
Mulch, seed and plant materials for 1 acre of disturbed ground						1,500
Asphalt Costs: (includes asphalt, equipment needs and trucking expenses)						47,378
Culvert materials costs						15,999
Layout, Coordination, Supervision, and Reporting[8]		50	--	--	160	8,000
Total Estimated Costs						**$ 111,457.**
Sediment Savings: 5,048 yd^3, Cost-effectiveness: $ 22.08 spent per cubic yard saved						

[1]Costs for miscellaneous tools and materials have not been included in this table. Costs for administration and contracting are variable and have not been included. Costs and dump truck time (if needed) for re-rocking the whole road surface have not been estimated.

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

[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.

[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.

[6] Lowboy hauling for tractor and excavator, five hours round trip. Costs assume 2 hauls for two pieces of equipment to the Fife Creek watershed (one to move in and one to move out).

[7] Labor hours (16 hours) for mulch and seed acitivities have been added to total labor hours.

[8] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, establishing permanent photo point and other effectiveness monitoring, training of equipment operators, supervision during equipment operations, supervision of labor work and post-project documentation and reporting).