Summary Report

Indian Creek Upslope Road Sediment Reduction Project,
Navarro River Watershed,
Mendocino County, California

prepared for

Mendocino County Resource Conservation District
and
California Coastal Conservancy

by

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Background

Indian Creek is located in southern Mendocino County, California. Roads within the two properties assessed in the Indian Creek Upslope Road Sediment Reduction Project traverse several major tributaries to Indian Creek, a tributary of the Navarro River, north of the community of Boonville (Map 1). The Navarro River, is an important anadromous stream to the California North Coast, supporting coho salmon and steelhead trout.

Road Assessment and Implementation

Perhaps the most important element needed for long term protection and restoration of salmonid habitat, and the eventual recovery of salmonid populations in Indian Creek, is the reduction of accelerated erosion and sediment delivery to the channel system from upland erosion. This summary report describes the watershed assessment and inventory process that was employed on the roads in the Indian Creek assessment area. The Indian Creek assessment area is composed of the Addison and Clow properties within the Indian Creek watershed.

The summary report also serves as a prioritized plan-of-action for cost-effective erosion control and erosion prevention treatments for the assessed roads. When implemented and employed in combination with protective road maintenance and land use practices, the proposed project is expected to significantly contribute to the long term protection and improvement of salmonid habitat in the basin. The implementation of erosion control and erosion prevention work is an important step towards protecting and restoring watersheds and their anadromous fisheries (especially where sediment input is a limiting or potentially limiting factor to fisheries production, as is thought to be the case for the Navarro River (U.S. Environmental Protection Agency, 2000).

Road systems are now widely recognized throughout the north and central coast region as one of the most significant, and the most easily controlled, sources of sediment production and delivery to stream channels. Indian Creek is underlain by erodible and potentially unstable geologic substrate, and field observations suggest that roads have been a significant source of accelerated sediment production in the watershed. In Indian Creek, as elsewhere, the disturbance caused by excess sediment input to stream channels during large rainfall events is perhaps one of the most significant factors affecting salmonid populations. Unlike many watershed improvement and restoration activities, erosion prevention and "storm-proofing" of road systems has an immediate benefit to the streams and aquatic habitat of the basin. It helps ensure that the biological productivity of the watershed's streams is not impacted by future human-caused erosion, and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment, rather than depositing additional sediment from managed areas. Sites targeted as high or moderate treatment immediacy within the Indian Creek assessment area have been identified as priority sites for implementation so that road fill failures, stream crossing washouts and stream diversions do not further degrade the stream system. The road assessment identified all recognizable current and future sediment sources from approximately 11.7 miles of roads on the Addison and Clow properties. The primary objective of the proposed road upgrading is to implement cost-effective erosion control and erosion prevention work on high, moderate and low priority sites that were identified as a part of this inventory.

Project Description

The project involved a complete inventory of approximately 11.7 miles of roads on the Addison and Clow properties. Technically, this assessment is neither an erosion inventory nor a road maintenance inventory. Rather, it is an inventory of sites where there is a potential for future sediment delivery to the stream system that could impact fish bearing streams in the watershed. Sites, as defined in this assessment, include locations where there is direct evidence that future erosion or mass wasting could be expected to deliver sediment to a stream channel. Sites of past erosion were not inventoried unless there was a potential for additional future sediment delivery. Similarly, sites of future erosion that were not expected to deliver sediment to a stream channel were not inventoried as part of this assessment, but their location was mapped on topographic base maps.

Inventoried sites generally consisted of stream crossings, potential landslides, and gullies below ditch relief culverts and long sections of uncontrolled road and ditch surface runoff which currently discharge to the stream system. For each identified existing or potential erosion source, a database form was filled out and the site was mapped on Mylar overlays over 1:12,000 and 1:7,920 scale topographic maps. The database form (Appendix A) 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 source of sediment delivery.

The erosion potential (and percentage of sediment delivery to stream channels) was estimated for each major problem site or potential problem site. The future expected volume of sediment to be eroded and the volume to be 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. All sites were assigned a treatment priority, based on their potential to deliver deleterious quantities of sediment to stream channels in the watershed and the cost-effectiveness of the proposed treatment.

Inventory Results

Approximately 11.7 miles of road was inventoried for future sediment sources within the Indian Creek assessment area. Inventoried road-related erosion sites within the assessment are all categorized as upgrade sites - defined as sites on maintained open roads that are to be retained for access. Virtuallyall future road-related erosion and sediment yield in the Indian Creek assessment area is expected to come from three sources: 1) erosion at or associated with stream crossings (from several possible causes), 2) potential road fill failures (landslides) and 3) road surface and ditch erosion.

A total of 80 sites with sediment delivery were identified along the roads in the Indian Creek assessment area (Table 1 and Maps 2A and 2B). These sites were identified as having a high, high-moderate, moderate, moderate-low or low potential of future sediment delivery to Indian Creek. Sites include 57 stream crossings, 8 potential fill failures (landslides) and 15 "other" sites. All 80 sites have been recommended for erosion control and erosion prevention treatment. In addition, 7.17 miles (61%) of the 11.7 miles of the Addisson and Clow road networks surveyed are currently connected to stream crossings and delivering fine sediment and road surface runoff to streams.

Stream crossings - Fifty-seven (57) stream crossings were inventoried within the Indian Creek assessment area including 24 culverted stream crossings, 32 unculverted fill crossings, and 1 ford crossing. An unculverted fill crossing refers to stream crossings with no formal drainage structure to carry the flow through the road prism. Flow is carried over the road surface and is diverted down the road, to the inboard ditch, or onto the native hillslope at some location down the road. The unculverted fill crossings are located at small streams that exhibit flow only in the larger runoff events.

All stream crossing sites identified in the assessment have been recommended for erosion control and erosion prevention treatment. Approximately 4,323 yds^3 of future road-related sediment yield in the Indian Creek assessment area could originate from erosion at stream crossings if they are not treated (Table 1). This amounts to nearly 22% of the total expected future sediment yield from the road. The most common problems which can lead to erosion at stream crossings include: 1) crossings with undersized drainage structures, 2) crossings with no drainage structures and 3) stream crossings with a diversion potential. The sediment delivery from stream crossing sites is always classified as 100% because any sediment eroded at the crossing site is delivered directly to the channel. Any sediment which is delivered to small ephemeral streams will eventually be delivered to downstream fish-bearing stream channels of Indian Creek.

At stream crossings, the largest volumes of future erosion can occur when drainage structures plug or when flood runoff spills onto or across the road and diverts down the road. When stream flow goes over the fill, part or all of the stream crossing fill may be eroded. Alternately, when flow is diverted down the road, either on the road bed or in the ditch (instead of spilling over the fill and back into the same stream channel), the crossing is said to have a "diversion potential" and the road bed, hillslope and/or stream channel that receives the diverted flow can become deeply gullied or destabilized. These hillslope gullies can be quite large and can deliver significant quantities of sediment to stream channels. Alternately, diverted stream flow which is discharged onto steep, potentially unstable slopes can also trigger large hillslope landslides. Thirty-nine (39) stream crossings identified in the Indian Creek assessment area have a diversion potential and 11 are currently diverted (Table 1). Treatment for stream crossings diversions are straight forward and require the construction of a broad "critical dip" at the down-road hinge line of the stream crossing to re-direct flow back into its natural drainage.

Table 1. Site classification and sediment yield from all inventoried sites with future sediment delivery in the Indian Creek assessment area, Mendocino County, California.

Site Type	Number of sites or road miles inventoried	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)
Stream crossings	57	57	4,323	39	11	23
Landslides	8	8	668	-	-	-
Other	15	15	251	-	-	-
Total (all sites)	80	80	5,242	39	11	23
Persistent surface erosion[1]	7.17	7.17	14,019	-	-	-
Totals	**80**	**80**	**19,261**	**39**	**11**	**23**

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

Fifty-seven (57) stream crossings inventoried in the Indian Creek assessment area will need to be upgraded for the road to be considered “storm-proofed.” The roads in this assessment area was constructed on steep hillslopes and prairie slopes and stream crossings are typically diverted, have no drainage structure or are under-designed for the 100-year storm flow. Preventative treatments include such measures as constructing critical dips (rolling dips) at stream crossings to prevent stream diversions, installing larger culverts wherever culverts are under-designed for the 100-year storm flow (or where they are prone to plugging) or installing properly sized culverts at crossings with no drainage structure.

Landslides - Only those landslides with a potential for sediment delivery to a stream channel were inventoried. A total of 8 “landslides” were identified and these account for less than 4% of the total expected future sediment delivery volume in the Indian Creek assessment area (Table 1). Most of the potential landslide sites were found along the road where material had been sidecast during road construction and recent road maintenance grading and now show signs of instability. These sites were identified using field evidence such as road surface cracks, scarps or J-shaped trees.
The two landslides identified within the Indian Creek assessment area have been recommended for erosion control and erosion prevention treatment. Potential landslides are expected to deliver nearly 668 yds^3 of sediment to Indian Creek and its tributaries in the future if they are not treated. Correcting or preventing potential landslides associated with the road is relatively

straight-forward, and involves the physical excavation of potentially unstable road fill and sidecast materials. There are a number of potential landslide sites located on the road that did not, or will not, deliver sediment to streams. These sites were not inventoried using data sheets due to the lack of expected sediment delivery to a stream channel. They are generally shallow and of small volume, or located far enough away from an active stream such that delivery is unlikely to occur. For reference, all landslide sites were mapped on the mylar overlay of the field inventory maps, but only those with the potential for future sediment delivery were inventoried using a datasheet.

Other" sites - A total of 15 "other" sites were also identified within the Indian Creek assessment area. Other sites include ditch relief culverts, major springs and gullies which exhibited the potential to deliver sediment to streams. The main cause of existing or future erosion at these sites is surface runoff and uncontrolled flow from long sections of undrained road surface and/or inboard ditch. Uncontrolled flow along the road or ditch may affect the road bed integrity as well as cause gully erosion on the adjacent hillslopes. Road runoff is also a major source of fine sediment input to nearby stream channels. Gully erosion can occur below ditch relief culvert outlets due to excessive road and/or ditch contribution to the inlet. Gully erosion can also occur as a result of poor installation techniques such as shotgunned outlets or the culvert being placed too high in the fill without a functional downspout.

All 15 "other" sites have been recommended for erosion control and erosion prevention treatment. We estimate 251 yds^3 of sediment could be delivered to streams if they are left untreated. Sediment delivery from these sites represents less than 2% of the total potential sediment delivery from sites recommended for erosion control and erosion prevention treatment.

Persistent surface erosion - We measured approximately 7.17 miles of road surface and/or road ditch (representing 61% of the 11.7 mile Indian Creek assessment area) which currently drain directly to streams, and delivers ditch and road runoff and fine sediment to stream channels. The roads in this area are said to be "hydrologically connected" to the stream channel network. When these roads are being actively maintained and used for access, they represent a potentially important source of chronic fine sediment delivery to the stream system throughout the year.

All 7.17 miles of road surface and/or ditch contribution have been recommended for treatment. From these "connected" road segments, we calculated approximately 14,019 yds^3 of sediment will be delivered to Indian Creek and its tributaries over the next 20 years if no efforts are made to change road drainage patterns (Table 1)[1]. This will occur through a combination of 1) cutbank erosion delivering sediment to the ditch triggered by dry ravel, surface erosion, freeze-thaw processes, cutbank landslides and brushing/grading practices, 2) inboard ditch erosion and sediment transport, 3) mechanical pulverizing and wearing down of the road surface, and 4) erosion of the road surface during wet weather periods.

[1] The applied, average rate of surface lowering on cutbanks and along road beds (i.e. 0.2 feet/decade) is based on observed retreat or erosion rates in the Upper Rancheria watershed, and on un-published data from sediment budget studies on similar geologies in the Redwood Creek watershed, Humboldt County (Redwood National Park, unpublished data).

Relatively straightforward erosion prevention treatments can be applied to upgrade road systems to prevent fine sediment from entering stream channels. These treatments generally involve dispersing road runoff and disconnecting road surface and ditch drainage from the natural stream channel network. Road surface treatments include the installation of rolling dips, road surface outsloping and/or installation of additional ditch relief culverts prior to rocking road surfaces.

Treatment Priority

An inventory of future or potential erosion and sediment delivery sites is intended to provide information which can guide long range transportation planning, as well as identify and prioritize erosion prevention and erosion control activities within the Indian Creek assessment area. Not all of the sites that have been recommended for treatment have the same priority, and some can be treated more cost effectively than others. Treatment priorities are evaluated on the basis of several factors and conditions associated with each potential erosion site:

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

The ***erosion potential*** of a site is a professional evaluation of the likelihood that erosion will occur during a future storm event. Erosion potential is an estimate of the potential for additional erosion, based on field observations of a number of local site conditions. Erosion potential was evaluated for each site, and expressed as "High", "Moderate" or "Low." The evaluation of erosion potential is a subjective estimate of the probability of erosion, and not an estimate of how much erosion is likely to occur. It is based on the age and nature of direct physical indicators and evidence of pending instability or erosion. The likelihood of erosion (erosion potential) and the volume of sediment expected to enter a stream channel from future erosion (sediment delivery) play significant roles in determining the treatment priority of each inventoried site (see "treatment immediacy," below). Field indicators that are evaluated in determining the potential for sediment delivery include such factors as slope steepness, slope shape, distance to the stream channel, soil moisture and evaluation of the erosional processes. 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.

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 both the severity and urgency of addressing the threat of sediment delivery 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.

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 150 yds^3 (had it been left to erode), the predicted cost-effectiveness would be $13/$yds^3$ ($2000/150 yds^3).

To be considered for priority treatment a site should typically exhibit: 1) potential for 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 $7 to $15/$yd^3$, or less.[2] Treatment cost-effectiveness analysis is

[2] The cost-effectiveness values of $7 to $15/$yd^3$, or less, was developed by the CDF&G in 1996 based on cost estimates to treat and upgrade road erosion sites along roads in the northern California counties of Humboldt, Trinity, Del Norte and Mendocino. Several factors indicate that in the San Francisco Bay Area counties, a more appropriate cost-effectiveness value should be between $10 to $25/$yd^3$ saved or prevented from entering a stream channel. The acceptability of the proposed revision in cost-effectiveness values is based on the following considerations: 1) numerous road assessments PWA has performed over the last 5 years in the greater Bay Area from Sonoma to Monterey Counties, where the cost-effectiveness values frequently exceed $15/$yd^3$ saved, 2) heavy equipment rental rates in the Bay Area counties on average, exceed the north coast counties by 25% to 50%, 3) the cost-effectiveness values established by CDF&G over 6 years ago have not been adjusted for cost-of-living rate

often applied to a group of sites (rather than on a single site-by-site basis) so that only the most cost-effective groups of sites or projects are undertaken. During road decommissioning, groups of sites are usually considered together since there will only be one opportunity to treat potential sediment sources along the road. In this case, cost-effectiveness may be calculated for entire roads or road reaches that fall into logical treatment units.

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 received 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 (>$20/yd^3$), or are judged to have a lower erosion potential or treatment immediacy, or low sediment delivery volumes, 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 storm-proofed by one of two methods: upgrading or decommissioning (Weaver and Hagans, 1999). Upgraded roads are kept open and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate or withstand the 100-year storm. In contrast, decommissioned roads are closed and no longer require maintenance. The goal of storm proofing is to make the road as "hydrologically invisible" as is possible; that is, to disconnect the road from the stream system and thereby reduce fine sediment and protect aquatic habitat. The characteristics of storm-proofed roads, including those which are either upgraded or decommissioned, are depicted in Figure 1.

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 100-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. Road drainage techniques include berm removal, road outsloping, rolling dip construction, and/or the installation of ditch relief culverts. Along some low strength road routes

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changes, whether based on inflation or the higher cost of living in the greater Bay Area, and 4) the vast majority of upland road projects in the Bay Area counties are conducted at prevailing wage rates compared to owner-operator rates charged on similar projects in the north coast counties.

within the Addison and Clow road networks, re-rocking the road following rolling dip construction and road outsloping or insloping efforts will be necessary.

Recommended Treatments

Basic treatment priorities and prescriptions were formulated concurrent with the identification, description and mapping of potential sources of road-related sediment delivery. Table 2 and Map 3A and 3B outline the treatment priorities for all 80 inventoried sites with future sediment delivery that have been recommended for treatment within the Indian Creek assessment area. Of the 80 sites, 7 sites were identified as having a high treatment immediacy with a potential sediment delivery of approximately 1,963 yds^3. Nine (9) sites were listed with a high-moderate treatment immediacy and these account for up to 2,881 yds^3. Thirty-eight (38) sites were listed with a moderate treatment immediacy and these account for 8,759 yds^3. Sixteen (16) sites were listed with a moderate low treatment immediacy and these account for nearly 3,734ds^3. Finally, 10 sites were listed with a low treatment immediacy and account for approximately 1,924 yds^3 of future sediment delivery from the road.

FIGURE 1. CHARACTERISTICS OF STORM-PROOFED ROADS

The following abbreviated criteria identify common characteristics of "storm-proofed" roads. Roads are "storm-proofed" when sediment delivery to streams is strictly minimized. This is accomplished by dispersing road surface drainage, preventing road erosion from entering streams, protecting stream crossings from failure or diversion, and preventing failure of unstable fills which would otherwise deliver sediment to a stream. Minor exceptions to these "guidelines" can occur at specific sites within a forest or rural road system.

STREAM CROSSINGS

_ all stream crossings have a drainage structure designed for the 100-year flow
_ stream crossings have no diversion potential (functional critical dips are in place)
_ stream crossing inlets have low plug potential (trash barriers & graded drainage)
_ stream crossing outlets are protected from erosion (extended, transported or dissipated)
_ culvert inlet, outlet and bottom are open and in sound condition
_ undersized culverts in deep fills (> backhoe reach) have emergency overflow culvert
_ bridges have stable, non-eroding abutments & do not significantly restrict 100-year flood flow
_ fills are stable (unstable fills are removed or stabilized)
_ road surfaces and ditches are "disconnected" from streams and stream crossing culverts
_ decommissioned roads have all stream crossings completely excavated to original grade
_ Class 1 (fish) streams accommodate fish passage

ROAD AND LANDING FILLS

_ unstable and potentially unstable road and landing fills are excavated (removed)
_ excavated spoil is placed in locations where eroded material will not enter a stream
_ excavated spoil is placed where it will not cause a slope failure or landslide

ROAD SURFACE DRAINAGE

_ road surfaces and ditches are "disconnected" from streams and stream crossing culverts
_ ditches are drained frequently by functional rolling dips or ditch relief culverts
_ outflow from ditch relief culverts does not discharge to streams
_ gullies (including those below ditch relief culverts) are dewatered to the extent possible
_ ditches do not discharge (through culverts or rolling dips) onto active or potential
_ decommissioned roads have permanent road surface drainage and do not rely on ditches

Table 2. Treatment priorities for all inventoried sediment sources in the Indian Creek assessment area, Mendocino County, California

Treatment Priority	Upgrade sites (# and site #)	Decommission sites (# and site #)	Problem	Future sediment delivery (yds^3)
High	**7** (site #: 106, 109, 136, 137, 139, 142, 146)	**0**	5 stream crossings, 2 other	1,963
Moderate High	**8** (site #: 26, 28, 30, 103, 108, 111, 138, 144)	**1** (site#:116)	7 stream crossings, 2 landslides	2,881
Moderate	**27** (site #:1, 2, 7, 9, 12, 13, 14, 15, 16, 24, 27, 105, 107, 117, 118, 119, 121, 123, 124, 125, 126, 127, 130, 133, 140, 141, 145)	**11** (site #: 18, 20, 100, 114, 120, 131, 147, 148, 149, 150, 151)	28 stream crossings, 3 landslides, 7 other	8,759
Moderate Low	**11** (site #:3, 4, 5, 8, 10, 23, 25, 32, 104, 110, 128)	**5** (site #: 22, 31, 102, 115, 132)	11 stream crossings, 2 landslides, 3 other	3,734
Low	**7** (site #: 11,21, 122, 129, 134, 135, 143)	**3** (site #: 101, 112, 113)	6 stream crossings, 1 landslide, 3 other	1,924
Total	**60**	**20**	**57 stream crossings, 8 landslides, 15 other**	**19,261**

Table 3 summarizes the proposed treatments for sites inventoried within the Indian Creek assessment area. The database, as well as the field inventory sheets provide details of the treatment prescription for each site. Most treatments require the use of heavy equipment, including an excavator, dozer, dump truck and/or grader. Some hand labor is required at sites needing new culverts, downspouts, and applying seed, plants and mulch following ground disturbance activities. A total of 20 critical dips have been recommended to prevent diversions at streams that currently have a diversion potential. A total of 30 culverts are recommended for replacement or for installation at unculverted streams. It is estimated that erosion prevention work will require the excavation and removal of approximately 4,066 yds^3 at 52 sites. Approximately 83% of the volume is associated with upgrading stream crossings, 11% of the volume excavated is a result of excavating future landslides and 6% of the volume excavated is a result of "other" sites. A total of 233 yds^3 of 0.25 to 1.25 foot diameter, mixed and clean rip-rap sized rock will be needed as armor for stream crossing fillslopes and to construct armored fill crossings and one ford. We have recommended 119 rolling dips and 8 ditch relief culverts be installed at selected locations along the road, at spacings dictated by the steepness of the road.

Table 3. Recommended treatments along all inventoried roads in the Indian Creek assessment area, Mendocino County, California.

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	20	To prevent stream diversions	Install rolling dips	119	Install rolling dips to improve road drainage
Install CMP	13	Install a CMP at an unculverted fill crossing	Install ditch relief CMP	4	Install ditch relief culverts to improve road surface drainage
Replace CMP	17	Upgrade an undersized CMP	Clean/cut ditch	5	Clean existing or cut new inboard ditch for a total of 450'
Excavate soil	52	Typically fillslope & crossing excavations; excavate a total of 4,066 yds^3	Outslope and remove ditch	1	Outslope road and remove inboard ditch for a total of 800' to improve road drainage
Wet crossing	8	Install 7 armored fill crossings and 1 ford using 113 yds^3 of rip-rap and armor	Remove berm	2	Remove 200' of berm to prevent concentration of flow
Trash rack	6	Install trash rack to reduce culvert plugging	Rock road surface	32	Rock or re-rock road surface using 434 yds^3 road rock and 233 yds^3 of rip-rap (includes rock for site specific location and post-installation at rolling dips and stream crossings)
CMP downspout	4	Install full-round downspout to CMP	Other treatment	1	Miscellaneous treatment
Armor fill face	9	Rock armor to protect fillslope using 120 yds^3 of rock			
Culvert downspout	1	Install downspout to protect fillslope form erosion			
Clean CMP	2	Clean debris from CMP inlet or outlet			

Equipment Needs and Costs

Table 4 lists the expected heavy equipment and labor requirements, by treatment immediacy, to treat all the specific inventoried sites as well as the 7.17 miles of contributing road bed and ditch.

Treatments for the 80 sites identified with future sediment delivery within the Indian Creek assessment area will require approximately 330 hours of excavator time and 441 hours of tractor time to complete all prescribed upgrading, 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 174 hours of labor time is needed for a variety of tasks such as installing new culverts, rock armor, filter fabric, downspouts and other miscellaneous tasks. An additional 71 hours of labor are allocated for mulching and planting activities. A water truck will be required for 80 hours to wet down material during road surface and stream crossing upgrades.

Table 4. Estimated heavy equipment and labor requirements for treatment of all inventoried sites with future sediment delivery, Indian Creek assessment area, Mendocino County, California.

Treatment Immediacy	Site (#)	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Grader (hrs)	Dump truck (hrs)	Backhoe (hrs)	Labor (hrs)
High, High/Moderate	16	2,006	90	110	1	0	6	56
Moderate, Low/Moderate	54	4,955	218	297	3	30	7	111
Low	10	214	22	34	0	1	0	7
Total	**80**	**7,175**	**330**	**441**	**4**	**31**	**13**	**174**

Estimated costs for erosion prevention treatments Prescribed treatments are divided into two components: a) site specific erosion prevention work identified during the road inventory, and b) control of persistent sources of road surface, ditch and cutbank erosion and associated sediment delivery to streams. The total costs for road-related erosion control at sites with future sediment delivery is estimated at approximately $234,353 for an average cost-effectiveness value of approximately $12.17 per cubic yard of sediment prevented from entering Indian 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 Tables 4 and 5, as direct excavation times, in hours, to treat all sites. These hourly estimates include only the time needed to treat each of the sites, and do not include travel time between work sites, times for basic road surface treatments that are not associated with a specific "site," or the time needed for work conferences at each site. These additional times are accumulated as "logistics" and must be added to the work times shown in Table 4 to determine total equipment costs as shown in Table 5. The estimate includes costs for seed and mulch, rock armor, culvert materials, downspouts, filter fabric, as well as rock necessary for rip-rap and road surfacing at rolling dips and other specific locations.

The costs in Table 5 are based on a number of assumptions and estimates, and many of these are included as footnotes to the table. The costs provided are assumed reasonable if work is performed by outside contractors, with no added overhead for contract administration and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road upgrading 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. Costs in Table 5 assume that the work in the watershed will be accomplished during one summers work period using one equipment team. Table 5 lists approximately $42,215 for “supervision” time for detailed pre-work layout, project planning (coordinating and securing equipment and obtaining plant and mulch materials), on-site equipment operator instruction and supervision, establishing effectiveness monitoring measures, and post-project cost effectiveness analysis and reporting.

Conclusion

The expected benefit of completing the erosion control and erosion prevention planning work lies in the reduction of long term sediment delivery to Indian Creek and its tributaries, an important salmonid stream system. For this assessment, 11.7 miles of roads on the Addison and Clow properties were considered for upgrading. Road upgrading consists of a variety of techniques employed to “storm-proof” a road and prevent unnecessary future erosion and sedimentation. Storm-proofing typically consists of stabilizing slopes and upgrading drainage structures so that the road is capable of withstanding both annual winter rainfall and runoff, as well as a large storm event without failing or delivering excessive sediment to the stream system. The goal of road upgrading is to strictly minimize the chronic contributions of fine sediment from the road bed, cutbanks and ditches in the Indian Creek assessment area, as well as to minimize the risk of serious erosion and sediment yield when large magnitude, infrequent storms and floods occur.

Table 5. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on all inventoried sites with future sediment delivery in the Indian Creek assessment area, Mendocino County, California.

Cost Category		Cost Rate[1] ($/hr)	Estimated Project Times: Treatment[2] (hours)	Logistics[3] (hours)	Total (hours)	Total Estimated Costs[4] ($)
Move-in; move-out[5] (Low Boy expenses)	Excavator	80	4	-	4	320
	D-5 tractor	80	4	-	4	320
	Grader[7]	80	4	-	4	320
Road opening costs	Excavator	120	55	-	55	6,600
Heavy Equipment requirements for site specific treatments	Excavator	120	318	95	413	49,560
	D-5 tractor	90	261	78	339	30,510
	Dump truck	70	31	9	40	2,800
	Backhoe	70	13	4	17	1,190
	Water truck[6]	70	35	11	46	3,220
Heavy Equipment requirements for road drainage treatments	Excavator	120	12	4	16	1,920
	D-5 tractor	90	180	54	234	21,060
	Grader[7]	80	22	7	29	2,320
	Water truck[6]	70	45	14	59	4,130
Laborers[8]		35	242	73	315	11,025
Rock Costs: (includes trucking for 394 yds^3 of road rock and 233 yds^3 of rip-rap sized rock)						18,810
Culvert materials costs (150' of 18", 1,080' of 24", 260' of 30", and 300' of 48"; Costs included for couplers and elbows)						36,004
Mulch, seed and planting materials for 4.3 acres of disturbed ground[9]						2,341
Layout, Coordination, Supervision, and Reporting[10]						42,215
Total Estimated Costs						**$234,665**
Potential sediment savings: 19,261 yds^3						
Overall project cost-effectiveness: $12.18 spent per cubic yard saved						

[1] Costs listed for heavy equipment include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.
[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.
[3] 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.
[4] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.
[5] Lowboy hauling for tractor and excavator, approximately 4 hours round trip for two (2) crews to work areas on the Indian Creek assessment area. Costs assume 2 hauls each for two pieces of equipment over the time of the project.
[6] Water truck hours include 100% of the excavator hours (100 yds^3/hr) during backfill of stream crossing culvert installations and replacements and 25% of the dozer hours for rolling dips and critical dips on all roads.
[7] An additional 18 hours of grader time is added to resurface roads post-treatment.
[8] An additional 68 hours of labor time is added for straw mulch and seeding activities.
[9] Seed costs equal $6/pound for erosion control seed. Seed costs based on 50 lbs. of native seed per acre. Straw costs include 50 bales required per acre at $5 per bale. Sixteen hours of labor are required per acre of straw mulching. Does not include additional seed and mulch required on decommissioned road surfaces within the Water/Lake Protection Zones.
[10] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, training of equipment operators, supervision during equipment operations, supervision of labor work, transportation, lodging, per diem, supplies, and post-project documentation and reporting

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Appendix A

Road Erosion Inventory Data Form Used in the Indian Creek Upslope Road Sediment Reduction Project

ASAP CHECK ***PWA* ROAD INVENTORY**
DATA FORM (3/03 version) Front______ Back_______

GENERAL	Site No:_______	Watershed:	Subwatershed:		Sketch (Y)
	Photo:_________	Road :	Mileage:____________	Landowner:	

	Inspectors:_______	Date:_____	Year Built:____	Surface - rocked, native, paved, chip seal (R, N, P, C):________					
	Maintained	Abandoned	Decomissioned	Road use (Year round, Seasonal, no use):_________		Driveable, quad, walk (D,Q,W):_______			
PROBLEM	Stream xing	Landslide	Roadbed (bed, ditch, cut)	DR-CMP	Spring	Channel scour	Bank erosion	Other	
	Road related? (Y, N)	Geomorphic Association: SS, IG, ST, SW, HD, BIS, Other							
ROAD/ DITCH INFO	Left road/ditch length (ft):		Right road/ditch length (ft):			Left rd grade%:	Right rd grade%:		
LANDSLIDE	Road fill	Landing fill	Cutbank slide	Hillslope debris slide (>50% original ground)	Deep seated, slow	Past failure	Potential failure		
	Slope shape: (convergent, divergent, planar, hummocky)		Natural slope %:____________		Distance from toe to stream (ft):_______				
STREAM	CMP	Bridge	Humboldt	Fill	Ford	Armored Fill	Pulled xing	% pulled:______	
	CMP diam (in):	Culvert type (P, S, A, C)	Inlet (O, C, P, R)	Outlet (O, C, P, R)	Bottom (O, C, P, R)	Separated (Y)	Check CMP size (Y)		
	Plug potential (H, M, L)	Headwall (in)_____	CMP slope % _____	Rust/silt line (in):____	CMP appears undersized (Y, M, N):____				
	Stream class (1, 2, 3)	Sed trans (H,M,L)	Ch grade (%)_____	Ch width (ft): _______	Ch depth (ft):_______				
	Diversion Pot?(Y):	Currently dvted? (Y):	Past dvted? (Y):	Fish barrier? (Y):					
EROSION	E.P. (H, M, L):	Potential for extreme erosion? (Y):	Volume of extreme erosion (yds^3): <500, 500-1000, 1-2K, 2-5K, >5K						
Past Erosion..	Is the stream crossing washed out? __________%	Past stream crossing erosion (yds^3):							
Future Erosion..	Total Future Erosion (yds^3):	Future delivery %:	Total Future Yield (yds^3):						
	Future width (ft):	Future depth (ft):	Future length (ft):						
TREATMENT	Treat (Y N)	Immed. (H, M, L)	Complexity (H, M, L)	Upgrade	Decommission				
	Excavate soil	Critical dip	Trash Rack	Install bridge	Other treatment? (Y)	Mulch (ft^2):			
	Wet crossing (ford or armored fill)	armored fill hgt (ft)__	armored fill/ford width (ft) __	Armor size range (ft):	Armor vol (yds^3) :				

	Install culvert	Replace culvert	CMP diameter (in) _____	CMP length (ft) _______	Clean CMP	Repair CMP
	Install flared inlet	Flared inlet diam (in):	X-ing Downspout diam (in):____	X-ing D.S. length (ft) ___________		
	Armor Ditch / headcut	Armor fill face (in out)	Armor area (ft^2) :	Armor size range (ft) :	Armor vol (yds^3) :	
	Install DR-CMP (#) ___	*Replace DR-CMP (#) ___*	*DR-CMP diam (in):*	*Total DR-CMP length (ft):*	*Cross rd. drain (#) ___*	
	Number of DR-CMP downspouts needed_______	*DR-CMP downspout diam______*	*Total DR-CMP downspout length _______*			
	Outslope & Remove ditch (ft) ________	*Outslope & Retain ditch (ft) ______*	*Inslope road (ft) ____________*			
	Rolling dip (#) ___	*Remove berm (ft) _________*	*Berm width (ft):*	*Berm depth (ft):*	Engineered fill	
	Clean or cut ditch length (ft) _________	Remove ditch (ft) __________	Rock road- ft^2 _______			
Road Opening	*Vegetation: Brush Small trees Large trees*	*Landslides inhibiting access: Cutbank Road fill*	*Other road opening obstacles:*	*no road opening costs*		

COMMENT ON PROBLEM:

EXCAVATION VOLUME	Total excavated (yds^3) _______	Vol put back in (yds^3) _______	Volume removed (yds^3) ________	
	Vol stockpiled (yds^3) _______	Vol endhauled (yds^3) _______	Dist endhauled (ft) ______	Excav prod rate (yds^3/hr) _______
EQUIPMENT HOURS	Excavator (hrs) ________	Dozer (hrs) ________	Dump truck (hrs) ______	Grader (hrs) ________
Exc.______ Inst.______ Bf.______	Loader (hrs) _________	Backhoe (hrs) ________	Labor (hrs) _______	Other (hrs) ________
Road bed post exc.: (lower, raise, same elevation)	Lower/raise (ft):	Road alignment post exc. (move in, out, same location)	Move in/out (ft):	Fill rebuild angle__________

COMMENT ON TREATMENT:

Stream Profile Through Crossing (begin at top of profile) ***Xing type 1, 2, 3, 4*** (Circle) Profile shot As is As was

Angle (deg) (dwn=-)	Distance (feet)	Code (UES, **TOP, IBR, OBR, BOT XS1, XS2...**,LES)	Comment

0	0	UES, TRN	in natural channel

Cross Section(s) (begin on left bank)				
xs#	Angle (deg)	Distance (feet)	Code (LRP, **LEC, CLP, REC,** RRP)	Comment
1	0	0	LRP, TRN	Base of cutbank

Computer volumes-

1. Computer erosion volume (1:1): ____________
2. Culvert excavation vol (add/repl - 1:1): ______________
3. Humboldt excavation volume (1:1): ____________
4. Decommission volume (2:1): _______________

Site Sketch - Site No._______