

Minor Creek Watershed Inventory
and Restoration Planning
Summary Report

Road Assessment Project
Contract # P0610549



Prepared for:
Pacific Coast Fish, Wildlife and Wetlands Restoration Association and
California Department of Fish and Game Fishery Restoration Grant Program

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INTRODUCTION

This report presents results of the Minor Creek Watershed Inventory and Restoration Planning Project. The project was funded by Department of Fish and Game (DFG) Fisheries Restoration Grant Program under grant agreement number P0610549 dated September 4, 2007. The grant was awarded to Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA) for \$92,292. Resources Legacy Fund Foundation provided additional funding. Redwood National and State Parks (RNSP) contributed in-kind services by providing maps and aerial photographs, geologists for GIS and database development, GIS technical support, data analysis and report preparation.

The report also presents more detailed results of PCFWWRA assessments for all of Minor Creek and a comparison of those results with the 1999-2000 Minor Creek road assessment performed by Natural Resource Management Corp (NRM).

The project was comprised of a road assessment and is part of a watershed-wide effort in Redwood Creek to assess roads and identify potential sediment sources on lands upstream of RNSP and prepare plans that prioritize erosion control and prevention treatments. Since 1996, eleven road assessments in upper Redwood Creek have been completed on about 723 miles of road or about 65% of the 1,116 miles of road in upper Redwood Creek watershed (Bundros, 2004). For data management, the assessments were assigned project numbers by RNSP, which are referred to below.

Four road assessments have been completed in Minor Creek in the past 10 years and are shown in Table 1. The first assessment was implemented in 1999-2000 by NRM as part of a larger project in Redwood Creek and assessed about 48 miles of privately owned roads in Minor Creek (Project 4). In 2000, the Five Counties Salmonid Conservation Program (SCP) completed an assessment of Bair Road, which is owned and maintained by Humboldt County (Project 6). In 2003, PCFWWRA assessed six miles of road in Minor Creek watershed as part of a larger project in Redwood Creek (Project 7). These six miles had been previously assessed by NRM. The fourth project was implemented in 2007-2008 by PCFWWRA (Project 8) and targeted completing the remainder of all privately owned roads in the Minor Creek watershed and is the subject of this report.

Table 1. Completed road assessments in Minor Creek watershed.

Project Name	Investigator	Assessment Dates	Miles Assessed	Number of Sites
Project 4 (portion of)	NRM	1999-2000	48.0	251
Project 6 (portion of)	Five Counties SCP	2000	5.4	40
Project 7 (portion of)	PCFWWRA	2003	6.0	107
Project 8 (this project)	PCFWWRA	2007-2008	59.6	524

Table note: Projects 4, 6 and 7 covered larger areas of Redwood Creek watershed. Data shown are for only the Minor Creek portion of each project.

The 2003 PCFWWRA assessment was implemented when landowners in an adjacent project in Redwood Creek changed their minds about participating and decided to not allow access to their roads after the grant had been awarded. DFG allowed the unspent funds from the adjacent project to be expended on a small portion of Minor Creek roads. This allowed for an objective comparison of road assessment results on the same six miles of roads by two different assessment groups. The comparison revealed a substantial difference in the number of potential erosion sites identified and the estimated erosion volumes at each site. The differences are described in Bundros, 2004.

Because the results of the two assessments differed significantly, and the later assessment was considered more consistent with existing data, the NRM data were not included in analyses for all upper Redwood Creek watershed assessments in previous reports. Field observations and the results of the 2003 PCFWWRA assessment in Minor Creek suggested that treatable sediment sites in Minor Creek are numerous and should be prioritized along with all other areas within the upper watershed. For this reason we pursued funding for a full re-assessment of key areas of the Redwood Creek watershed, particularly Minor Creek, for inclusion in treatment prioritizations.

PROJECT AREA DESCRIPTION

Minor Creek is a large tributary to Redwood Creek in northwestern California (Figure 1). The watershed drains about 8,250 acres (12.9 square miles). Elevations range from 720 feet at the confluence with Redwood Creek to about 4,075 feet on the eastern watershed divide. The watershed is underlain by predominantly mudstones and sandstones of Franciscan Assemblage with schist bedrock along the eastern side of the watershed.

The watershed has been managed for timber production and ranching since the mid-1900s. The watershed contains about 76.6 miles of roads. About 71.2 miles of roads are privately owned. A county maintained road (Bair Road) traverses the northern side of the watershed for 5.4 miles from near Redwood Creek to the watershed divide with Trinity River on the east side. These data are shown in Table 2.

Table 2. Public and private road ownership in Minor Creek.

Road ownership	Road miles
County	5.4
Private	71.2
Total	76.6

Watershed ownership is presently held by ten different landowners. Two landowners are industrial timber companies which, combined, own approximately 82% of the watershed. Six smaller landowners that participated in this road assessment collectively own about 13% of the watershed. Two smaller landowners that did not participate own about 5% of the watershed.

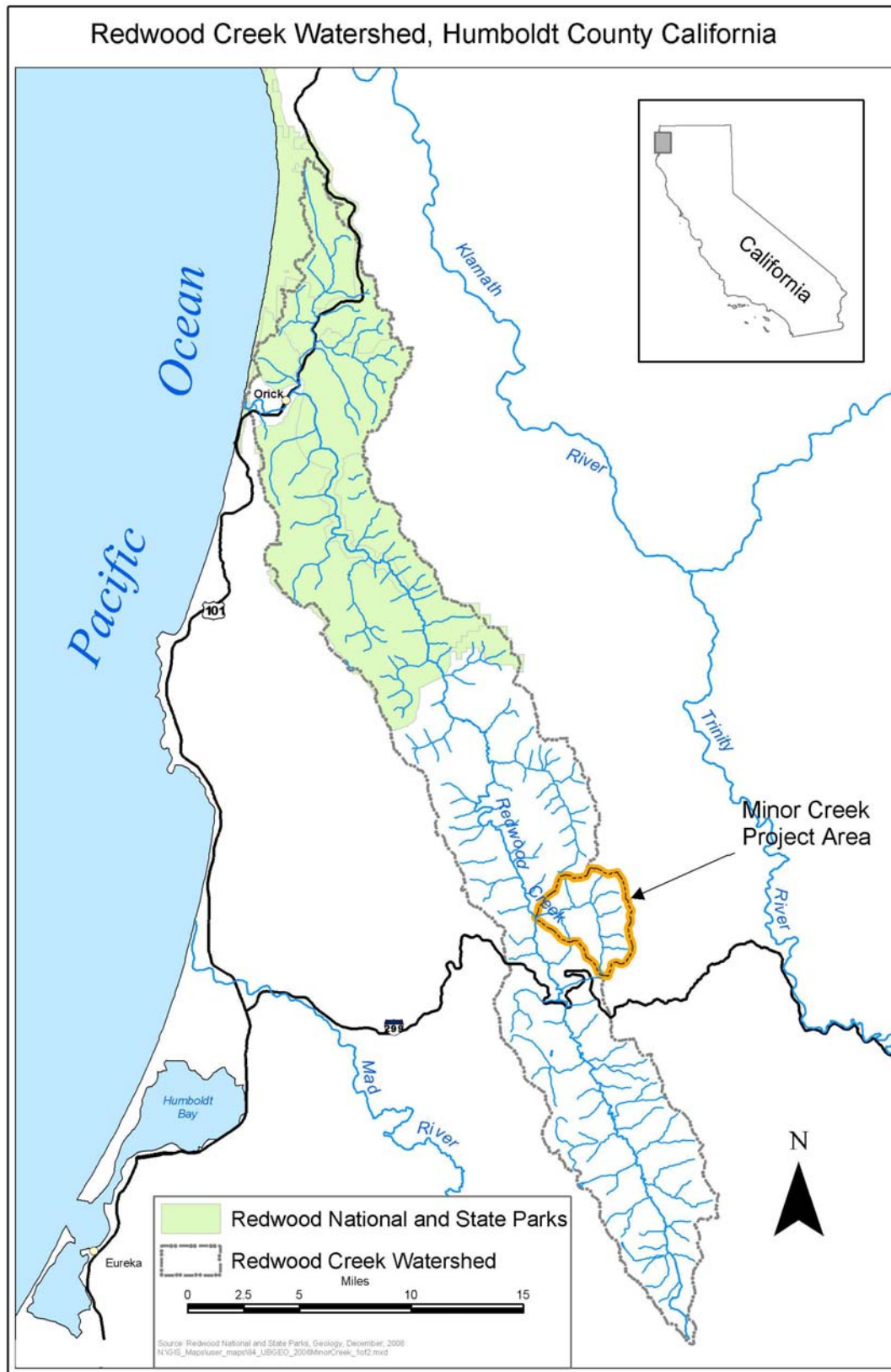


Figure 1. Location of Minor Creek in Redwood Creek watershed, Humboldt County, California.

As a part of the current assessment field crews mapped and evaluated potential erosion sites along 65.6 miles of roads (Figure 2). Road assessment fieldwork began in July 2007 and concluded in August 2008. Bair Road, maintained by Humboldt County, was previously assessed as part of the Five Counties Salmonid Conservation Program in 2000 and was not re-assessed as part of this project.

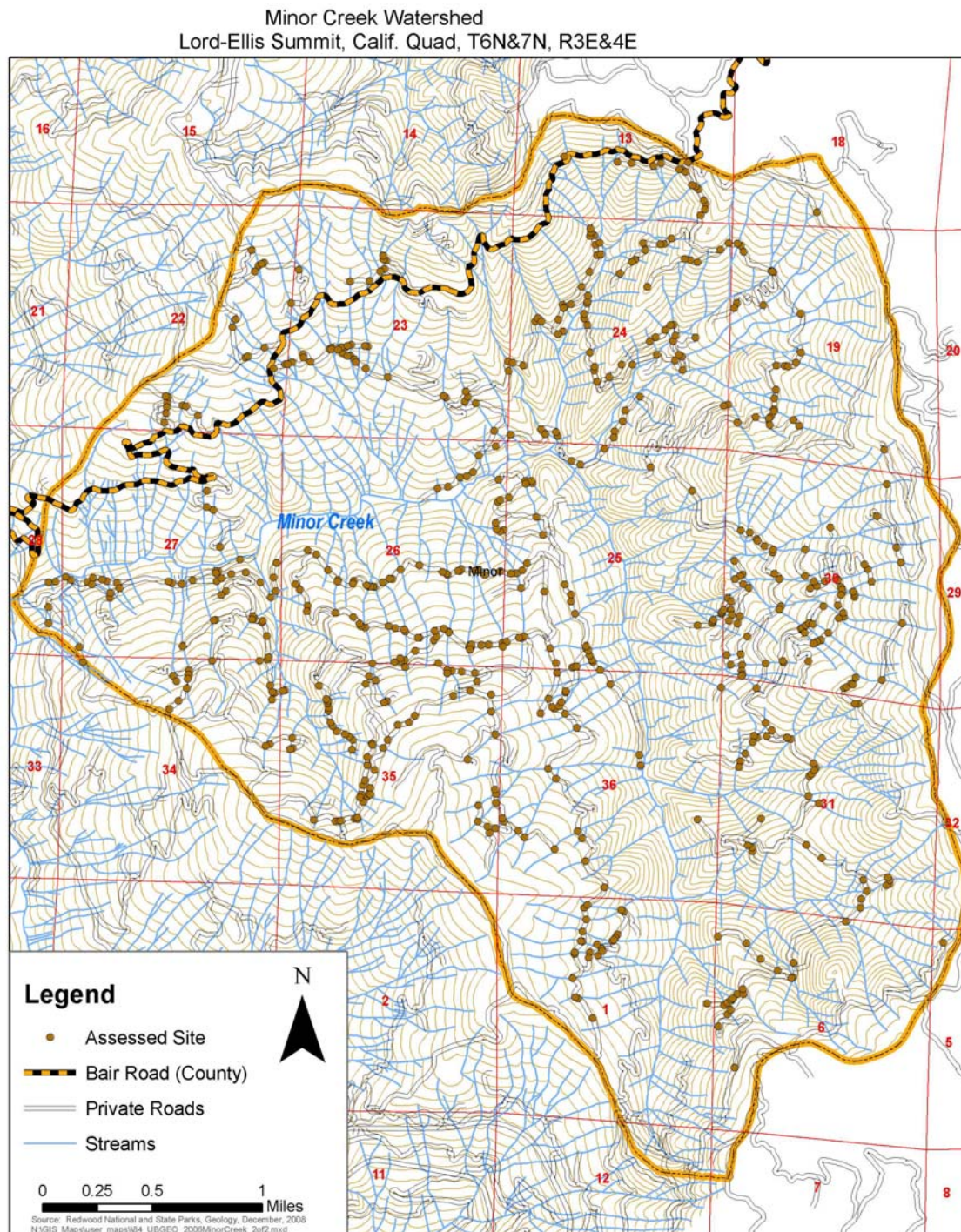


Figure 2. Map of Minor Creek watershed showing all sites assessed in Projects 7 and 8.

METHODS

Assessment Fieldwork

Field crews, in teams of two, evaluated each road for existing and potential erosion sites. Sites included all stream crossings, over-steep landings, and other sites where sediment would likely be delivered to a stream channel. All ditch relief culverts (DRC) were mapped and assessed including those that would not deliver sediment to a channel¹.

A data form was completed for each site and the site was located and mapped on a mylar overlay of a 1:6,000 scale 1997 aerial photograph. Each site was flagged and marked in the field with an aluminum tag for locating it in the future.

The field data form (Appendix A), when completed, contained basic information about the type, nature, and location of each potential erosion site on a road. The form was logically organized to guide the field crew as they recorded the critical information needed to describe the potential erosion site. The crew then prescribed needed erosion control or prevention treatments, and surveyed the sites to quantify sediment volumes.

The assessment method included a tape and clinometer survey of each stream crossing that was evaluated. The survey was used to estimate potential erosion volumes and excavation volumes necessary for treatments (e.g., excavation volumes for decommissions, culvert replacements, etc.). Recommended treatments, equipment, labor and material needs were also recorded. The crew also provided a written description and simple sketch of each site on the data form.

All field crew members were previously trained by Pacific Watershed Associates (PWA) and had completed numerous road assessments in Redwood Creek prior to starting this assessment. Two crews worked in Minor Creek in teams of two. For quality control, each assessment site was field reviewed by an experienced geologist from PWA.

All field forms and mylar overlays are stored at the RNSP office in Arcata.

Volume Calculations and Limitations

As used in this report, “site potential yield” and “site potential erosion” are synonymous with “future yield” and “future erosion” (respectively) found on the assessment form. Site potential yield is the amount of sediment that is reasonably expected to be delivered to a watercourse if site failure occurs.

Fluvial sites

Site potential yield at a stream crossing was estimated from tape and clinometer surveys of the crossing fill. The field crew surveyed a profile through the stream crossing that followed a straight line and approximated the center of the stream valley. The profile began in the

¹ A form was completed for all DRC sites, including DRCs that had no potential erosion. CDFG generally does not provide funding for mapping and assessing DRCs. However, it is important to identify and locate these sites as they are integral to proper road drainage and require regular maintenance.

undisturbed or stable channel above the crossing, extended downstream across the roadway and down the fillslope to the natural channel below the crossing. When plotted, an accurate profile survey reveals the original channel grade through the crossing. The site potential yield was estimated by assuming that, on average, a stream will eventually erode the crossing to its original channel depth, grade and width, and will erode sideslopes to a 1:1 (100%) slope.

For stream crossings that were proposed for decommissioning, the profile was used in combination with cross-section surveys to determine the fill volume in the crossing. The estimated excavation volume is the fill volume that would be removed from the crossing to expose the original or near original stream bed, with a channel width similar to the channel and valley width above and below the crossing. The default design used 2:1 sideslopes (50%) for calculating the estimated excavation volume. The actual crossing excavation will be influenced by bedrock and stumps, which guide the final excavation and reveal original, pre-road topographic conditions.

For stream crossings that were proposed for upgrading, the surveyed profile provides a means for determining proper culvert placement on channel grade, length of culvert needed and, where appropriate, the length of downspout needed. The volume of fill that must be excavated and replaced during a culvert upgrade can also be determined from the surveys.

Fluvial erosion at ditch relief culvert outlets, springs and along road reaches was estimated by assuming reasonable dimensions of a gully that could potentially form or enlarge at the site.

Stream diversions – Site potential yield from potential stream diversions was not estimated during the assessments. Stream diversions can cause substantial erosion and sedimentation, but estimating the potential yield from future, hillslope gully erosion would be speculative and most likely inaccurate.

Landslide sites

Estimates for site potential yield at a landslide site was determined by delineating the boundaries of the future landslide, calculating the volume of the material, and then estimating the percent of the volume that was expected to reach a stream. The site potential yield generally includes only the erosion volume directly associated with the road prism. For most landslide sites, the yield does not include the volume of material that can erode downslope from a road when road failures occur, or the volume associated with larger landslide features that can extend far upslope or downslope from the road. Field crews measured only that portion of the landslide mass that could be directly associated with the road prism. There were two situations where the future sediment yield included more than just the road prism. These sites were: 1) deep seated landslides where the road mass likely initiated a failure that was incorporating native ground, and; 2) landslide sites where the potential for ‘extreme erosion’ had been identified and quantified. Other than these two exceptions, the total volume associated with a large landslide that may or may not be exacerbated by a road was not quantified as part of this assessment. Because volume calculations for most landslide sites are based only on the road prism, volume, and yield estimates for potential landslide erosion are likely conservative.

Culvert diameter

Recommended culvert diameters were determined using two methods and choosing the larger of the two results. The first method used field evidence including natural channel cross-sectional area and existing culvert rust line. The second method used standard published runoff equations and a culvert sizing nomograph.

In the first method, the estimated channel cross-sectional area occupied by the 100-year flood flow (average channel width x average channel depth, as determined from the natural undisturbed stream channel upstream from the crossing site) was estimated in the field and reported on the data form. The inventory crew then made a field decision on the adequacy of the existing culvert diameter by comparing the 100-year channel cross-sectional area to the existing culvert inlet area. If determined undersized, the field crew recommended a larger culvert diameter at least equal to the 100-year channel cross-sectional area. The culvert rust line was also used to determine if an existing culvert was properly sized. A rust line that exceeded 50 percent of the circumference was used as a criterion indicating an undersized culvert.

The second culvert sizing method was an office exercise that estimated the 100-year peak discharge based on the USGS method (Waanenen and Crippen, 1977) for drainage areas 80 acres and greater, and the Rational Method (Dunne and Leopold, 1978) for drainage areas less than 80 acres.

There are inherent limitations with both the field methods and the office methods when sizing culvert diameters. In the field, errors occur when estimating the channel dimensions of the 100-year storm discharge. In the office, errors occur when delineating drainage areas from topographic maps. A 10-meter digital elevation model (DEM) produced by RNSP was used as a base for delineating drainage areas used in the office calculations.

During project level planning, the recommended culvert diameter should again be evaluated in the field prior to finalizing a culvert replacement. Results from both the initial field call and the office determination should be used in combination with other field evidence to correctly determine final culvert size.

Database and GIS

All data collected as part of the Minor Creek road assessment are contained in a relational database using Microsoft Access™. The database contains the data from all assessments performed in Redwood Creek for which data are available. All GIS data are maintained in ESRI ArcInfo™ coverages.

CURRENT ROAD ASSESSMENT – PROJECT 8 RESULTS

The current road assessment, Project 8, covered approximately 66 miles of roads, assessing erosion potential at 524 sites. Field crews spent 120 days (240 person-days) in the field on the assessment. Additional time was spent in the field by a geologist to review the sites and in the

office to calculate survey volumes and organize field products. Office crews entered data into the Redwood Creek watershed roads database and into RNSP's GIS.

Since Project 8 (this assessment) did not encompass the entire Minor Creek watershed, we are reporting only selected data specific to the project in Table 3 below. For other data reporting, we have chosen to compile Project 8 data with the previous road assessment data (Project 7) for Minor Creek by PCFWWRA and summarize the data for the entire watershed. All data were collected by the same field crews using the same field forms and methods with the only difference between the assessments being the separation in time from 2003 to 2007-08.

Table 3. Selected data for Project 8 road assessment.

	No. of Sites	Erosion Volume ¹ (yds ³)	Site Potential Yield (yds ³)	Extreme Potential Yield (yds ³)	Potential Sediment Yield ² (yds ³)	% of No. of Sites	% of Pot. Sediment Yield
Sites Inventoried ³	524	208,866	107,387	18,250	118,032	100%	100%
All Sites with no yield	22	0	0	0	0	4%	0%
All Sites, Yield > 0	502	208,866	107,387	18,250	118,032	96%	100%
M-H Sites, Yield > 0	136	55,847	35,505	12,750	41,960	26%	36%
All Fluvial Sites	373	84,145	83,909	5,500	87,405	71%	74%
All Landslide Sites	151	124,721	23,478	12,750	30,627	29%	26%
Field Prescriptions							
Decommission	193	104,564	50,702	10,000	56,136	37%	47%
Upgrade	303	99,722	54,756	8,250	59,967	58%	51%
Maintain	28	4,580	1,929	0	1,929	5%	2%

Table notes:

¹ Erosion Volume is that amount of sediment that can potentially erode from a site. Not all sediment eroded will be delivered to a stream.

² Potential Sediment Yield is the greater of the site potential yield and the extreme potential yield for each site then summed for all sites. It is not the sum of the two columns "Site Potential Yield" and "Extreme Potential Yield".

³ All sites, including DRCs with no potential sediment yield.

RESULTS FOR MINOR CREEK WATERSHED (PROJECT 7 AND PROJECT 8)

Project 7 (2003), and Project 8 (2007-08) together provide a nearly complete assessment of potential road-related erosion and sediment delivery in Minor Creek. Combined, the two projects identified and assessed 631 sites including DRCs with no potential sediment yield. The location of all sites is shown in Figure 2.

About 77 miles of roads have been identified in Minor Creek through analysis of historic aerial photography and field verification. For the recent assessment, permission to assess roads was

granted by all but two landowners which excluded assessment of about 6 miles of road (7.9% of Minor Creek privately owned roads or about 5% of watershed area). These data are shown in Table 4.

Table 4. Status of roads assessed in Minor Creek.

Assessment status	Miles	% of all road length in watershed	% of private road length in watershed
Assessed private roads (Projects 7 and 8)	65.6	85.7	92.1
Non-assessed private roads	5.6	7.3	7.9
Assessed county road (Bair Road) (Project 6)	5.4	7.0	-
Total length of road	76.6	100.0	-

Driveability and maintenance status

Crews recorded the driveability of road reaches while assessing roads. Of the 66 miles of roads assessed, about 38 miles of road were found to be driveable by a standard 4WD vehicle and about 28 miles were not driveable. Road driveability is summarized in Table 5.

Table 5. Driveability of all assessed roads in Minor Creek in Projects 7 and 8.

Driveability	Miles	% of Total Assessed Miles
Driveable	37.5	57%
Not Driveable	28.1	43%
Total Assessed in Projects 7 and 8	65.6	100%

Table notes: Driveability is listed as documented at the time of the assessment.

The road maintenance level of each road was also documented during the assessment. Field crews described roads as maintained, unmaintained, or decommissioned. Maintained roads showed evidence of recent maintenance, including cleaning of culvert inlets, trash racks, and inboard ditches; grading; rolling dip or waterbar reconstruction; brushing; culvert replacement; or reconstruction of fills. Roads identified as unmaintained lacked obvious maintenance to culverts and ditches, and vegetation was encroaching on the road and road surface. The road may or may not have been driveable. There were about 33 miles of maintained roads and about 33 miles of unmaintained roads. The status was not documented for about 0.5-mile of road. Table 6 summarizes these data.

Table 6. Maintenance status of all assessed roads in Minor Creek in Projects 7 and 8.

Maintenance Status	Miles	% of Total Assessed Miles
Maintained	32.6	49.7%
Unmaintained	32.5	49.5%
Unknown Status	0.5	0.8%
Total assessed Projects 7 and 8	65.6	100%

Prescribed road treatments

Field crews proposed the general category for treatment for each site, based largely on the stability, erosional condition and maintenance status of the road. Sites were prescribed one of three treatment types: decommission, upgrade or maintain. Decommission was typically prescribed for sites where the field conditions clearly showed the road was on unstable terrain, the sites were highly prone to erosion and the road was abandoned. Approximately 18 miles of road were prescribed for decommissioning, about 41 miles for upgrading and about 4 miles prescribed for maintenance. Table 7 summarizes these data.

Table 7. Road treatments prescribed for Minor Creek in Projects 7 and 8.

Prescribed Treatment	Miles Prescribed for Treatment	% of Total
Decommission	18.0	28.4
Upgrade	41.4	65.4
Maintain	3.9	6.2
Unassigned ¹	2.2	3.5
Totals	65.6	100%

Table Note:

¹ Field crews failed to identify prescribed treatment for 2.2 miles of roads.

The treatment type assigned to each site by the field crews was purely an educated ‘call’ that guided the type of information collected at the site. It was not meant to reflect a commitment or obligation by the landowner to treat the road as prescribed. While we encourage road decommissioning to reduce the road density in the upper Redwood Creek watershed, the landowner will ultimately decide how a road will be treated.

Regardless of the prescription assigned at the time of the assessment, the basic information gathered during the assessment can still be used if prescriptions change. For example, if the landowner decides they would like to upgrade a road that had been prescribed as decommission, the basic information gathered during the assessment can be adjusted to provide an estimate of the needed work and project costs. Similarly, for roads that had been prescribed as upgrade, the data can be re-worked for decommission treatments. This second scenario requires additional time in the field to determine such things as: where to store spoils, how to move spoils, what are estimated equipment production rates for more complex excavations, etc. In both cases, the information from the original road assessment must be ground-truthed and a budget developed for the specific project.

Potential sediment yield

In this report, *potential sediment yield* is always the larger of *site potential yield* or the *extreme potential yield* for each site. The site potential yield was measured for each site in the field during the assessment. It is the volume of material that can potentially erode and be delivered to a stream during a large storm. An extreme potential yield was also estimated in the field, but only where the potential for an extreme erosional event (e.g., a debris torrent initiating at a stream crossing) was clearly identified at a site. Sites with extreme potential yields were not common.

A total of 631 sites were evaluated in the field. Sites were categorized into two groups based on the dominant erosional process at the site. Fluvial sites generally include stream crossings on either haul roads or skid trails, DRCs, road reaches, springs and swales. Landslide sites generally include debris slides and deep-seated features related to the road system. There were 456 fluvial erosion sites and 175 potential landslide sites. Site locations are shown in Figure 2. General site information is summarized in Table 8.

Table 8. Potential sediment yield in Minor Creek watershed within Projects 7 and 8.

	No. of Sites	Erosion Volume ¹ (yds ³)	Site Potential Yield (yds ³)	Extreme Potential Yield (yds ³)	Potential Sediment Yield ² (yds ³)	% of No. of Sites	% of Pot. Sediment Yield
Sites Inventoried	631	241,538	127,609	19,750	138,847	100%	100%
All Sites with no yield	30	0	0	0	0	5%	0%
All Sites, Yield > 0	601	241,538	127,609	19,750	138,847	95%	100%
M-H Sites, Yield > 0	193	73,447	48,156	14,250	55,204	31%	40%
All Fluvial Sites	456	101,554	101,318	7,000	105,407	72%	76%
All Landslide Sites	175	139,984	26,291	12,750	33,440	28%	24%
Field Prescriptions							
Decommission	202	105,563	51,653	10,500	57,159	32%	41%
Upgrade	37	4,605	1,954	0	1,954	6%	1%
Maintain	392	131,370	74,002	9,250	79,734	62%	57%

Table notes:

¹ Erosion Volume is that amount of sediment that can potentially erode from a site. Not all sediment eroded will be delivered to a stream.

² Potential Sediment Yield is the greater of the site potential yield and the extreme potential yield for each site then summed for all sites. It is not the sum of the two columns "Site Potential Yield" and "Extreme Potential Yield".

Fluvial erosion sites

Of the 456 fluvial erosion sites identified in the road assessment, 332 were haul road stream crossings. Of these, 130 had treatment urgencies of medium or higher with the potential to yield about 39,898 cubic yards of sediment to streams. This is about 94% of the potential sediment yield of all medium and higher urgency fluvial erosion sites. Skid trail crossings accounted for the next largest volume of potential sediment yield with an estimated 1,915 cubic yards possible sediment delivery from 13 sites with medium or higher treatment urgency. Selected data for fluvial erosion sites in Minor Creek are shown in Table 9.

Table 9. Selected information for fluvial erosion sites in Minor Creek within Projects 7 and 8.

Fluvial Features, Yield>0	All Urgency Sites		Medium to High Urgency Sites			
	No. of Sites	Potential Sediment Yield (yds ³)	No. of Sites	Potential Sediment Yield (yds ³)	% of No. of Medium + Sites	% of Pot. Sediment Yield
Stream Crossings on haul roads	332	96,042	130	39,898	87%	94%
DRC	29	322	5	114	1%	0%
DRC, no sediment delivery	28	0	0	0	0%	0%
Road Reaches	22	1,058	2	504	3%	1%
Stream Crossings on skid trails	43	7,917	13	1,915	9%	5%
Swales	2	68	0	0	0	0
Totals	456	105,407	150	42,431	100%	100%

Fish passage at stream crossings - In Projects 7 and 8 there were three Class I (fish bearing) stream crossings identified. None of the crossings appeared to be barriers to fish at any life stage at the time of the assessment. Two of the crossings were on the TP1300 road which was built sometime before 1958 in very steep terrain. Both crossings had been washed-out long ago. The third crossing is a flat car bridge on a main access road into the watershed that crosses the mainstem of Minor Creek. Improvements prescribed at the crossings for erosion control are low to low-medium urgency. These data are summarized in Table 10.

Table 10. Status of Class I stream crossings in Minor Creek within Projects 7 and 8.

Site ID	Road	Type	Urgency	Comment
3059046.3	MC1000	Flat car bridge	Low	Mainstem Minor Ck crossing
3165007	TP1300	Washed out	Low	On large tributary, ~ 650 feet from mainstem
3165009	TP1300	Washed out	Low-Medium	On large tributary, ~ 500 feet from mainstem

Landslide sites

There were 175 landslide sites identified in the assessment. Of these, 137 sites were associated with road reaches with 33 having treatment urgencies of medium or higher and potential sediment yield of about 7,360 cubic yards. This was about 58% of total potential sediment yield from landslide sites. Selected data for landslide sites in Minor Creek are shown in Table 11.

Costs for implementing treatments

Costs were calculated for all work prescribed by PCFWRA during the field assessments in Minor Creek (Table 12). Costs have been determined separately for road decommission and upgrade treatments. Costs represent a preliminary estimate; final estimated costs will vary based upon a detailed field evaluation at the project level when projects are planned, and the landowner's decision to upgrade or decommission a road is finalized. Of the 65.6 miles

assessed, treatments were prescribed for 63.3 miles. Treatments were not identified for 2.2 miles of road.

Table 11. Selected information for landslide sites in Minor Creek within Projects 7 and 8.

Landslide Features, Yield>0	All-Urgency Sites		Medium to-High Urgency Sites			
	No. of Sites	Potential Sediment Yield (yds ³)	No. of Sites	Potential Sediment Yield (yds ³)	% of No. of Sites	% of Potential Sediment Yield
Road	137	21,851	33	7,358	77	58
Landing	22	4,586	4	2,198	9	17
Hillslope	1	750	0	0	0	0
Road-Landing	11	3,531	5	2,717	12	21
Road-Hillslope	3	1,222	1	500	2	4
Landing-Hillslope	1	1,500	0	0	0	0
Totals	175	33,440	43	12,773	100%	100%

Table 12. Estimated road treatment costs for all evaluated sites in Minor Creek within Projects 7 and 8 (Bair Road not included).

Item	Decommission	Upgrade	Totals
Miles prescribed for treatment	18.0 mi	41.4 mi	59.4 ¹
Site specific treatments	\$265,920	\$661,637	\$927,557
Equipment and labor logistics	132,960	330,819	463,778
Road opening and rebuilding	279,216	668,253	947,469
Road drainage	25,247	96,893	122,140
Culvert materials	0	256,473	256,473
Mulch	14,626	13,233	27,858
Mobilization	10,637	26,465	37,102
Layout, coordination, supervision and reporting (30% of above costs)	218,582	616,132	834,714
Totals	\$947,187	\$2,669,905	\$3,617,092
Average treatment cost per mile	\$52,622	\$64,490	\$57,142 / mi

Table note:

¹ A total of 59.4 miles of roads were prescribed for Decommission or upgrade treatments and the estimated costs for those roads are shown in the table. Estimated costs were not calculated for an additional 6.1 miles prescribed for maintenance work where road treatment was not identified.

Site specific treatment costs were calculated first for each evaluated site based on equipment and labor needs recorded on the field form. Other costs associated with treatments, such as equipment mobilization, road opening and rebuilding, road drainage treatments, culvert materials, and mulching were summed for the entire assessment area. Additional costs for

equipment and labor logistics; and layout, coordinating, supervision and reporting were added as an aggregate amount to the total project cost.

The specific details and assumptions for calculating costs are shown in Appendix B.

Excluding routine road maintenance, the total estimated cost to decommission roads identified as such in Minor Creek is about \$947,187, averaging about \$52,622 per mile of road (Table 12). For decommission roads, costs are calculated for all sites and all treatment urgency levels. It is assumed that all sites along a decommissioned road would be treated, because the road would be inaccessible after treatment, and untreated sites could not be maintained.

For roads prescribed as upgrade, the total estimated treatment cost is about \$2.7 million, averaging about \$64,490 per mile of road (Table 12). Costs for upgrade sites are only calculated for medium to high urgency sites. Treatments at lower urgency sites are likely not critical, so limited funds would be spent most effectively treating higher urgency sites. Landowners would be expected to treat the low urgency sites during routine maintenance operations.

COMPARISON OF TWO ROAD ASSESSMENTS IN THE SAME WATERSHED BY TWO DIFFERENT METHODS

Roads in the Minor Creek watershed were assessed for potential erosion by two groups - the first in 1999-2000 by NRM Corp. and the second in 2003 and 2007-2008 by PCFWWRA. Both road assessments had the same stated goals – to assess all roads within the watershed, identifying all sites with potential sediment delivery and to develop treatments for reducing that potential. These projects, implemented by two separate groups, provide an opportunity to compare results and assess the merits and hazards of combining work utilizing different methodologies in a watershed-wide or regional data set for ranking purposes.

Field time for assessment

A large difference between the two projects that likely had strong influence on data results is the amount of time spent in the field performing the assessment. We used the date recorded on each field form to count each unique date in the field. We also counted the number of unique individuals in the field each day based on information recorded on the forms to determine number of person-days spent in the field. The length of road assessed and field time for each assessment crew is shown in Table 13.

The 1999 NRM assessment covered 48 miles of roads in Minor Creek or about 67% of all private roads in the watershed. The later assessments covered about 65.6 miles or 92% of all private roads. The 1999 assessment forms show that 22 days were spent in the field assessing roads in Minor Creek with either one or two crew members each day. This summed to 38 person days in the field. In contrast, the later surveys spent 135 days in the field, consistently using a two-person crew each day for a total of 270 person-days to complete the road assessments.

Table 13. Comparison of miles assessed and field time spent performing road assessments in Minor Creek between two different crews using differing methodologies but with the same objectives. Both projects were to have inventoried all privately owned roads in the watershed.

	NRM	PCFWWRA	Difference factor from PCFWWRA to NRM
Dates of field work	10/13/1999 - 8/11/2000	9/8/2003 - 11/19/2003 and 7/30/2007 - 8/4/2008	
Miles assessed	48.0	65.6	1.4
Number of field days	22	135	6.1
Number of person-days in field	38	270 ¹	7.1
Average number of sites assessed per day	11.4	4.7	0.4
Average number of sites per person day	6.6	2.3	0.3
Average miles assessed per person day	1.26	0.24	0.2

Table Notes:

¹ Number of person-days in field for PCFWWRA does not include geologist review time

Results and comparison of two assessments

Assessment results varied greatly between the two assessments. This can be attributed to a few obvious underlying factors.

The first factor is the difference in funding for the two projects. Available funding to cover the cost of a project influences the amount of time that can be spent on the project which affects the amount of information that can be collected at each site. The NRM project, which included more area than just Minor Creek, was funded by DFG for \$50,510 in 1999. The entire project assessed about 96 miles for an average funded cost of \$527 per mile. During the same year PCFWWRA was implementing an assessment, also in Redwood Creek, with funding from multiple sources totaling \$231,328. PCFWWRA assessed 187 miles for an average cost of about \$1,238 per mile. This is roughly 2.4 times the cost per mile than what NRM was funded during the same year of assessments. Higher funding allows for more thorough site identification and assessment, more detailed volumetric surveys and less likelihood for errors in all phases of the project.

A second factor that influences results is assessment methods. PCFWWRA uses teams of two to perform an initial assessment of the road, which identifies and maps all sites, and evaluates and performs volumetric surveys of the sites. This is followed by a geologist's field review of all forms and sites. The geologist is often a registered Professional Geologist. NRM visited each site once. The completed field forms indicated that for most sites a team of two assessed the site and for some sites only one person evaluated and surveyed a site. The NRM survey methods

utilized a quicker, simpler survey that uses coarser measurements and simpler geometry to calculate volumes.

Field forms differed between the NRM and PCFWWRA assessment. The NRM form collected less information at each site, but included the most commonly used information. The NRM form is shown in Appendix C.

Selected results from each assessment group are shown in Table 14 for comparison.

Table 14. Comparison of selected data from two different assessment crews.

	NRM 1999-2000	PCFWWRA 2003, 2007- 2008	Difference factor from PCFWWRA to NRM
Miles assessed	48.0	65.6	1.4
Number of sites assessed	251	631	2.5
Number of sites per mile	5.2	9.6	1.8
Number of sites with potential yield > 0	157	601	3.8
Urgency = medium and above	50	193	3.8
Fluvial sites - count	244	456	1.9
Stream crossings on haul roads	168	332	2.0
DRC	64	55	0.9
Road reach	12	22	1.8
Stream crossings on skid trails	0	43	∞
Swales	0	2	∞
Critical crossings - count	12	37	3.1
Landslide sites - count	7	175	25.0
Road	6	137	22.8
Landing	0	33	∞
Hillslope	1	5	5.0
Potential sediment yield – cubic yards (cy)			
Fluvial sites	14,215 cy	105,407 cy	7.4
Landslide sites	1,189 cy	33,440 cy	28.1
Total	15,404 cy	138,847 cy	9.0
Avg. potential sediment yield / fluvial site	58 cy	231 cy	4.0
Avg. potential sediment yield / landslide site	170 cy	191 cy	1.1
Avg. potential sediment yield / stream crossing	84 cy	289 cy	3.4

CONCLUSIONS AND DISCUSSION

Project 8 assessment (current project)

The Project 8 assessment in Minor Creek watershed covered 524 erosion sites on about 58 miles of roads. The assessment identified about 118,000 cubic yards of potential sediment yield that

can be delivered to streams. About 74% of the volume is from fluvial sites and about 29% from landslide sites.

Minor Creek assessment

About 90% of all private roads in Minor Creek have been assessed for erosion potential by two projects implemented in 2003 and 2007-2008 using the same methods and crew. About 138,800 cubic yards of potential sediment yield was identified at 631 sites. Of these sites, 193 sites have treatment urgencies of medium or higher and have potential sediment yield of about 55,000 cubic yards.

There were 456 fluvial erosion sites with 150 fluvial sites identified with a treatment urgency of medium or higher and having potential sediment yield of about 42,000 cubic yards. Landslide sites accounted for 175 sites with 43 of those sites having treatment urgency of medium or higher and a total potential sediment yield of about 13,000 cubic yards.

There were three Class I stream crossings identified. One is at a well maintained bridge crossing near the mouth of Minor Creek. The other two are on an abandoned road and are nearly completely washed out. None of the crossings are fish barriers.

Costs to treat all evaluated sites on private roads in Minor Creek are estimated at \$3,617,000. Treatment cost for all decommission sites is estimated at about \$947,000. For upgrade sites, costs to treat all sites with treatment urgencies of medium and higher is estimated at about \$2.7 million.

Comparison of two road assessments in Minor Creek

As part of the early road assessments in Redwood Creek, RNSP geologists field-reviewed approximately 20% of PCFWWRA assessed sites across the field areas. This was done to evaluate comparability of RNSP assessments with PCFWWRA assessments. The results of these two groups proved comparable in both volume estimates and site characterizations for erosion potential and treatment needs. A smaller percentage of sites assessed by NRM were visited by RNSP geologists and, while much of the data were similar to those RNSP would have collected, the volume data differed. Since most of the road data collected in Redwood Creek was collected by PCFWWRA and RNSP using comparable methods and results we felt we couldn't include NRM data in watershed-wide analyses of road assessments. When we tried including the data we found that areas covered by NRM 'appeared' as lower volume threats to resources. We knew from our field experience that many of these low threat areas should show up higher.

Using the NRM data sets alone and ranking within the area covered by NRM is likely valid. It would be a comparison of "apples to apples". However, the results of the two Minor Creek assessments by two different groups over the same area with presumably the same goals, demonstrate that using two different methods or differently trained crews for an assessment renders the data incomparable and the results should not be used together in prioritizing areas for treatments. This would be a comparison of "apples to oranges".

In 1999, both NRM and PCFWWRA implemented road assessments in adjacent areas in Redwood Creek with the same stated goals. Funding for the projects differed by a factor of 2.4

per mile. NRM received about \$525 per mile and PCFWWRA received about \$1,238 per mile. In the current Minor Creek road assessment, PCFWWRA used the same methods as for all assessment they have completed in Redwood Creek since 1999. This suggests that, if both NRM and PCFWWRA performed the Minor Creek assessments in the same year, using their respective methods, PCFWWRA would complete the work for about 2.4 times the cost of that of NRM. We feel that this accounts for much of the difference in the results of the two assessments.

Road assessment projects must be funded sufficiently to complete the work satisfactorily. In large watersheds such as Redwood Creek it is often necessary to perform assessments over the course of multiple funding opportunities and time, while at the same time keeping methods consistent to allow for comparisons across the watershed. Absent adequate funding and consistent methods across a watershed or planning area, road assessments have limited value.

REFERENCES

- Bundros, G.J., Short, D., Hare, V.C. 2004. Upper Redwood Creek watershed road assessment: updated summary report. Redwood National and State Parks report to the Pacific Coast Fish, Wildlife and Wetlands Restoration Association, unpublished, 129 pp.
- Redwood Creek Watershed Group. 2006. Integrated watershed strategy for Redwood Creek. Available at Redwood National and State Parks, Arcata, Ca. 102 pp.

Appendix A.

Road Assessment Form used by PCFWWRA in Redwood Creek.

Reviewed by : _____

REDWOOD CREEK BASIN ROAD INVENTORY FORM

Check _____

ID No.: _____

Redwood National and State Parks

ASAP _____

Version 4/9/03

SECTION I: GENERAL SITE INFORMATION

Road Name: _____ Site # _____ Date: _____ By: _____

Watershed: _____ Ownership _____ Year built: _____

Quad ID: _____ Photo# _____ Photo date: _____

Current road condition: Drivable [Maintained Abandoned Decommissioned]

The road surface is: [Native Rocked Paved]

Proposed Treatment: [Maintain Upgrade Decommission]

SECTION II: FLUVIAL SITE (CROSSINGS, RELIEF CULVERTS, GULLY, ETC.)

FEATURE: [RXing STXing Swale *Ditch/road relief Road reach] Spring

PROCESS: None Gully Streambank/channel eros. Collapsing Fill failure

Will it debris torrent? **Y N M**

DRAINAGE STRUCTURE: Bridge *Culvert: *metal *concrete *plastic

Humboldt Fill Ford Armored fill None

Critical dip@xing? **Y N** Left ditch/road length _____ ft. Right ditch/road length _____ ft.

DIVERSION POTENTIAL: DP? **Y N** Now diverted Past diverted Rd grade _____ %

CONDITION OF FILL: Intact removed _____ % washed-out _____ %

CULVERT INLET INFORMATION: *Diameter _____ in. Headwall height _____ in.

Rust line: width _____ in. depth _____ in. Upstream chan: width _____ ft; depth _____ ft grade _____ %

Stream class: **I, II, III, or IV** Sediment transport: **H M L**

Does culvert look undersized? **Y M N** Plug potential: **H M L**

*Inlet condition: OK Rust/holes Band separation Trash rack Drop inlet

*crushed _____ % *plugged _____ %

CULVERT OUTLET INFORMATION:

*Condition: OK Rust/holes Functional downspout %crushed _____ % Shotgun

Fish-outlet drop: now _____ ft. @bankfull _____ ft. Culvert grade _____ %

Pool dim.: length _____ ft. depth _____ ft. @bankfull: length _____ ft. depth _____ ft.

Comments:

SECTION III: LANDSLIDE SITE

FEATURE: Road reach Landing Cutbank Hillslope

PROCESS: [Slow, deep seated Fast, shallow debris slide] Will it debris torrent? **Y M N**

SETTING: Streamside: <55% or >55% Swale Headwall Break-in-slope Hillslope

Distance to stream _____ ft. Slope _____ %

ACTIVITY: Failed in past? : **Y N** %failed _____ %

ASSOCIATION(S): Road related Water onto feature Spring Stream undercutting

SECTION IV: TREATMENTS (Circle all that apply)

Critical dip@xing Install culvert Replace culvert New culv: dia. _____ in. len _____ ft.

Drop inlet Flared inlet Trash rack Remove sed@CMP inlet Brush inlet

Reconstruct fill Excavate fill Ford Bridge Other None

Armor fillslope: @inlet _____ ft²; Downstream face _____ ft² Downspout _____ ft.

Armored fill: sill height _____ ft. sill width _____ ft. Check culvert size

***** URGENCY: **H M L** COMPLEXITY: **H M L** *****

ROAD REACH TREATMENTS

Clear/est. IBD _____ ft. Remove IBD _____ ft. Rock road _____ ft². Remove berm _____ ft.

Rolling dips: # _____ OS w/out IBD _____ ft. OS w/IBD _____ ft. Inslope road _____ ft.

Cross-road drains # _____ Ditch relief culvert # _____, _____ ft.

SECTION V: FILL AND FUTURE EROSION VOLUMES

Dimensions of landslide or gully: length: _____ ft. width: _____ ft. depth: _____ ft.
(Use Comment Section below to record dimensions of complex features)

Potential erosion vol: _____ yd³ %delivery: _____ % Site potential yield: _____ yds³

Erosion Potential: **H M L** Potential for Extreme Erosion? **Y N**

Is the treatment likely to control or prevent erosion?: **Y M N**

Extreme potential yield (yds³): [<500, 500-1000, 1K-2K, 2K-5K, >5K]

	EXCAVATION VOLUMES		EQUIPMENT HOURS	COMMENT ON TREATMENT:
	Total excavated (yds ³):		Excavator (hrs):	
	Vol. put back in (yds ³):		Dozer (hrs):	
	Vol. removed (yds ³):		Dump truck (hrs):	
	Vol. stockpiled (yds ³):		Grader (hrs):	
	Vol. endhauling (yds ³):		Backhoe (hrs):	
	Dist. endhauling (ft):		Labor (hrs):	
	Exca. prod. rate (yds ³ /hr):		Other:	

Stream Profile through Crossing (begin at top of crossing)				Xing type: 1, 2, 3, 4 (circle one)
Angle (deg) (up+, dn-)	Distance (feet)	Code (UES, TOP, IBR, OBR, BOT, XS1, XS2 LES)	Comments	
0	0	UES, TRN	in natural channel	

Cross Section(s) (begin on left side of crossing)				
XS#	Angle (deg)	Distance (feet)	Code (LRP, LEC, CLP, REC, RRP)	Comments
1	0	0	LRP, TRN	Base of cutbank

Site sketch - Site No. : _____.

Design Results	
Decommission vol. (2:1)	
Erosion vol. (1:1)	
Culvert add/repl. vol. (1:1)	
Humboldt crossing (1:1)	
Culvert length needed	

APPENDIX B

DETAILS AND ASSUMPTIONS FOR CALCULATING COSTS.

As part of the road assessment in Project 8, information necessary to estimate treatments costs were recorded on the field forms. These data were used as described below to calculate overall treatment costs.

Site specific treatment costs

Site specific costs are calculated in the database using formulas that assign specific equipment and labor hourly rates multiplied by the equipment and labor times recorded on the field form. Equipment and labor hours were estimated by first calculating volume of fill to be moved, production rate of equipment (cubic yards moved per hour), the need for support equipment such as dump trucks to endhaul fill to stable sites, and labor needs for installing culverts, downspouts, trash racks or other labor treatments. For upgrade sites, we use only the medium to high urgency sites, since those are the sites that must be treated. Low urgency sites, are sites that have deficiencies, but would likely survive a large storm. For decommission sites, we use the costs to treat all sites because after decommissioning a road, potential erosion sites along the road would remain unmaintained and inaccessible. Therefore, all sites on decommission roads should be treated unless it is shown it would not be cost-effective to do so.

Equipment and labor logistics

The costs for site specific treatments do not include logistical costs. Logistical costs include equipment travel between specific work sites, discussion time between the equipment operators and the project geologist regarding treatment prescription and approach, and labor time for travel and set up at project sites. Our experience with road treatment projects has shown that equipment costs are generally 20 percent of the site specific treatment costs and labor costs are about 30 percent of the site specific treatment costs.

Road opening and rebuilding costs

Many roads proposed for treatments in Redwood Creek require equipment to re-open roads before the equipment can begin decommissioning or upgrading a road. Many roads are abandoned (unmaintained) and overgrown with dense vegetation and trees. Some may have blown-out crossings and failed road prisms. Road opening and rebuilding costs can be a substantial part of road decommissioning projects, but are usually less for road upgrade projects. Generally, roads targeted for decommission are in substantially poor condition requiring more work. Roads targeted for upgrade are often currently driveable requiring less work to open.

While recognizing costs to open and rebuild roads are highly variable, we calculate a rough estimate based on past projects in the region. Generally, decommission projects can incur road opening and rebuilding costs that average about 5 percent of total equipment costs for the project. Upgrade projects have road opening and rebuilding costs that average about 1 percent of equipment costs. Again, these costs will vary from project to project, but our estimates provide a 'ball park' cost for all work identified in the project.

Road drainage treatment costs

Road drainage treatment costs were not calculated for each individual site. These costs are generally best calculated at the project level when a scale of economy can be realized by prescribing treatments for a whole project or road reach. Road drainage treatment costs that are calculated at the project level are: install rolling dips, cross-road drains (XRD), and ditch relief culverts (DRC); road outslowing or inslowing; inboard-ditch treatments (IBD); removing outboard berms, and; road rocking.

During the field assessment, sites not requiring treatments were identified as “maintain” sites. However, when an adjacent road reach required treatment, those treatments were noted and described on the field form for the nearest site along the road, which in some places was a maintain site.

Culvert materials costs for medium to high urgency stream crossings

Culvert materials costs have been calculated for all medium to high urgency stream crossings where either the field or database culvert analysis called for replacing or installing new culverts.

Mulching costs

Straw mulch is recommended at all treated stream crossings at a rate of about 4,000 pounds per acre. Mulch is prescribed for all bare soil slopes within crossing excavations and adjacent fillslopes draining directly to a stream. Mulch is also prescribed for all upgraded stream crossings of medium to high urgency. This includes culvert replacements and other treatments that would leave bare soil draining to the stream. Mulching generally occurs on the upstream and downstream face of upgraded crossings. Tree planting is required on stream crossing excavations for all projects funded by California Department of Fish and Game. These costs have not been included in our estimates, but are a very small portion of the total overall costs of projects. Mulching costs for Minor Creek roads were estimated using cost ratios in past road assessment reports for Redwood Creek where mulching costs were calculated in detail. For decommission sites mulching costs averaged 5.5% of site specific treatments and for upgrade sites mulching costs averaged 2.0% of site specific treatment.

Equipment mobilization costs

Equipment mobilization costs can be highly variable depending on the project. For this discussion, we assume that a typical one-season project completed with two pieces of equipment will cost about \$250,000. We also assumed that mobilization costs for each project would be about \$10,000 for all equipment.

Total costs for all prescribed road treatments

All costs are summed in the final table to calculate the total estimated cost for treating sites identified in Minor Creek (Project 8 and a portion of Project 7).

Appendix C.

Road assessment form used by NRM in 1999 Redwood Creek.

SECTION I: GENERAL SITE INFORMATION

Road Name: MD-1000 Site# X02 Date 11/2/99 By SG/SB Wshd MSC-MNC Ownership Brimm
 Quad ID Lord E Photo# 11C-10 PhotoDate 9/9 Current Road Condition Drivable Maintained Abandoned Decom.
 Road Surface Native Rocked Paved Proposed Treatment Maintain Upgrade Decommission

SECTION II: FLUVIAL SITE INFORMATION (Crossings, Gully, Etc)

Feature: Stream Xing Ditch Relief* Road Reach Spring Erosional Process: None Gully Channel Erosion Collapsing Fill Failure

Drainage Structure: Bridge Culvert: CMP plastic concrete Humboldt Fill Ford Armored Fill Pulled Critical Dip @ Xing? Y N

IBD Length R L 200 Diversion Potential: Y N Now diverted Past Diverted Road Grade 10 %

Condition of Prism: Intact Removed % Washed Out %

Culvert Inlet Information: *Diameter 36 in. Headwall ht 52 in. Rustline > 20% Y N Upstrm Ch. Width 3 ft Depth 1 ft

Stream Class 3 Sediment transport H M L Does Culvert Look Undersized? Y M N Plug Potential: H M L

*Inlet Condition OK Rust/holes Crushed % Plugged % Band Separation Trash Rack Drop Inlet

*Outlet Condition OK Shotgun 4 ft Rust/holes Downspout / Functional? Crushed % Fish/ Drop ft; BF ft; Pool L&D

Volume Msrmts (in feet & degrees):

Upstrm Grade 17 (deg) (38%) S1(deg) 45 sLen1 6 CW1 3 Road Bench 18

Dstrm Grade 8 (deg) S2(deg) 40 sLen2 21 sLenToCulv 14 CW2 4

Measurements from Sketch & CW/D Ratios:

Inlet D1 6 Horizontal L1 4

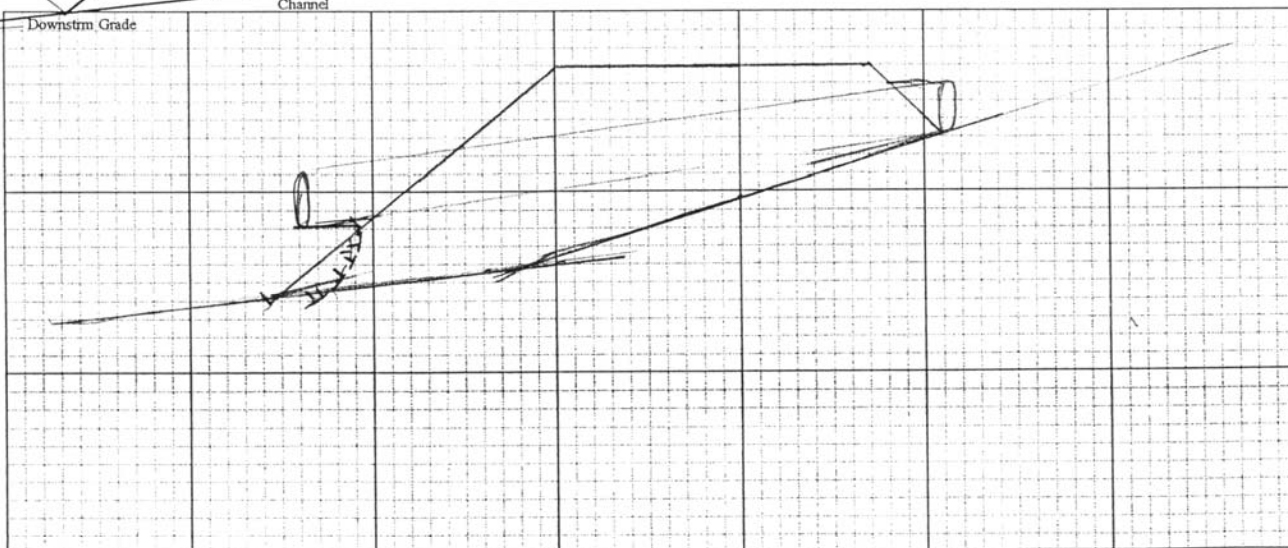
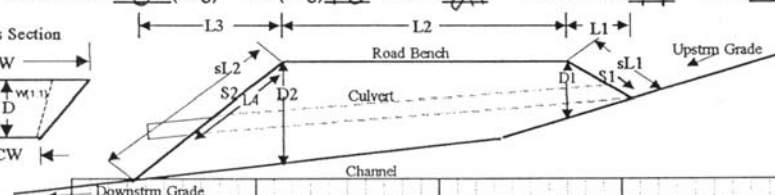
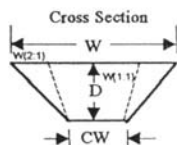
Outlet D2 11 Horizontal L3 15

Inlet Widths: W(2:1) 27 W(1:1) 15

Outlet Widths: W(2:1) 48 W(1:1) 26

W(Culv)

W(Culv)



Section IV: Treatments: Critical Dip Install / Replace: Dia in. Len ft Drop Inlet Trash Rack Excavate Fill

Remove Sediment @ Inlet Brush inlet Reconstruct fill Ford Bridge Armor fill / fillslope: Ht ft W ft None

Downspout ft Check Culvert Size: Y N Urgency: H M L Complexity: H M L

In feet: Clear/est. IBD Remove IBD Rock Road ft² Remove berm Dip OS OS w/IBD

Inslope CrossDrain# Ditch Relief Culvert#

Section V: Fill and Erosion Volumes: Fill Volume (2:1) 194 Erosion Volume (1:1) 113 Culvert Vol (1:1) 100% delivery

Production (cy/hr): 70 or 40 Excavator hrs Dozer hrs 112 Stockpile or Endhaul Endhaul yd³ Endhaul Dist

Erosion Potential H M L Potential for Extreme Erosion? N Y : <500 500-1000 1K-2K 2K-5K >5K

Comments:

Dip is very minor needs improvement