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INTRODUCTION

Redwood National Park is located in the lower third of the 280-square-mile Redwood Creek watershed. Redwood National Park was established "in order to preserve significant examples of the primeval coastal redwood (*Sequoia sempervirens*) forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study" (Public Law 90-545). Original boundaries protected a ½-mile wide corridor of forest along the lower third of Redwood Creek. Land located upslope and upstream of the boundaries remained in private ownership.

In 1978 Congress enacted Public Law 95-250, legislation which expanded the boundaries of Redwood National Park by approximately 48,000 to include land up to the watershed divide in the lower third of the Redwood Creek basin. At the same time, Congress authorized the establishment of a watershed rehabilitation program in Redwood National Park (RNP) for lands added to the park. The primary goal of this program was to minimize man-induced erosion and speed the natural revegetation process by restoring the hillslope hydrology to conditions that existed prior to man's influences.

Redwood Creek and its tributary streams are subject to frequent flooding from winter storms, and basin soils are naturally unstable and highly erosive. Even under natural conditions landslides and earthflows are widespread. Until purchase by RNP, the additional 48,000 acres and lands upstream of RNP were the site of intense timber harvest practices and related road construction. These activities adversely influenced erosion rates, sediment deposition and water quality within the entire basin. Studies indicate these activities caused unnatural and excessive erosion that resulted in adverse impacts to riparian habitat, anadromous fisheries, and amphibian species (Narver, 1971). The existence of several hundred miles of major logging haul roads and thousands of miles of tractor skid trails intensely disrupted hydrologic regimes and caused severe erosion problems.

Watershed restoration project Unit 99-5 was part of the program designed to restore disturbed lands (FIGURE 1). The purpose of the project was to remove roads in order to reduce future erosion problems and restore the natural landscape along the road corridor, as near as possible, to original topography. This was accomplished mainly by using heavy equipment to excavate road fill from stream channels and pulling back side-cast road fill to recreate original land configurations such as ridges, valleys and swales. Heavy equipment work was done under Watershed Restoration IDIQ contract awarded to Lambert's Excavating of Arcata, California. The contract was for watershed restoration on the L-2-2-1 road in McArthur Creek.

In January 1997, an eleven-year storm event occurred within the Redwood Creek basin, following several months of above-average precipitation in the basin. Heavy precipitation in combination with intensely disrupted hydrologic patterns caused numerous erosion problems. The most obvious and dramatic erosion events were numerous mass failures and debris flows, most of which originated from saturated sidecast fill material on major haul roads in Redwood National Park. Four mass failures originated from the L-2-2-1. The two largest failures moved an estimated 3,000-10,000 cubic yards of soil downslope. Because of the road prism failures, the L-2-2-1 road was evaluated and approved for removal under 1997 Storm Damage funding.

Location

The unit is located in Redwood National and State Parks (RNSP) approximately 1.5 miles due south of the Orick bridge over Redwood Creek (FIGURE 1). It is in Township 10 North, Range 1 East, Section 10.

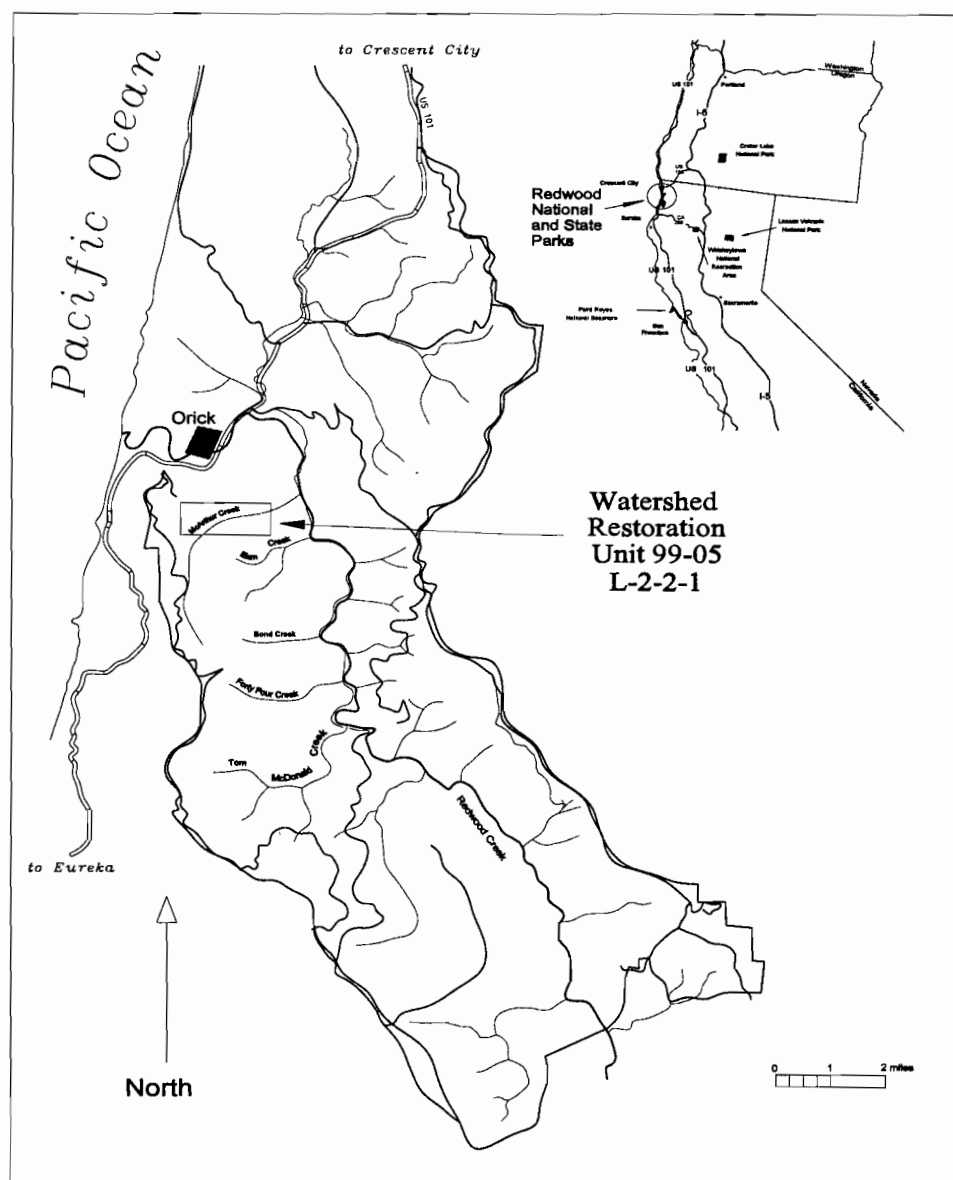
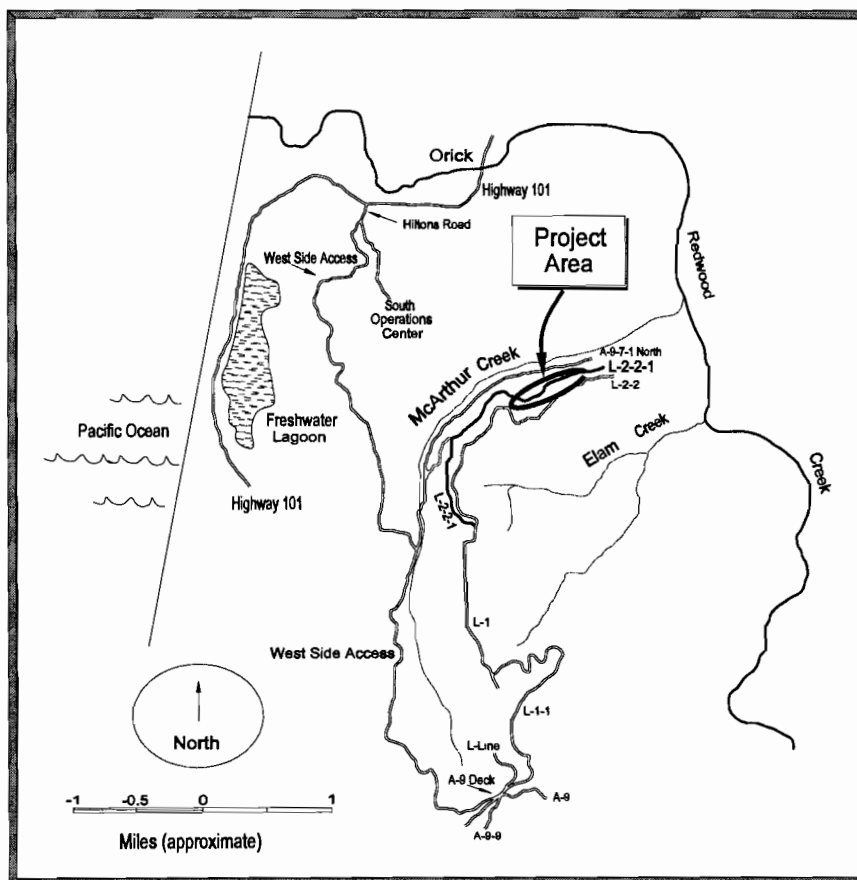


FIGURE 1. SITE LOCATION MAP.

Unit 99-5 encompassed approximately 40 acres in the McArthur Creek watershed. These acres included a 1.0 mile corridor of the main L-2-2-1 haul road plus 13 skid road excavations adjacent to the main road corridor. The unit is located mid-slope, approximately 800 feet elevation, on the south ridge of McArthur Creek drainage. The L-2-2-1 road is on a northwest and northeast facing slope. Only one mile of the proposed 1.6 miles of road corridor was removed during the project. The project began three weeks into the equipment season partially due to contract negotiations continuing up until the contract start date, and contractor difficulties in obtaining the required equipment at the last minute. In addition, wildlife restrictions were in place until September 15. These restrictions protected marbled murrelets during the nesting season and prohibited work two hours after sunrise and two hours prior to sunset.

The project occurred between August 27 and November 9, 1999. November brought heavy seasonal rains which began to inhibit heavy equipment work and the work itself was threatening to produce sedimentation to tributary streams. The date of October 15 is the accepted standard for halting heavy equipment work, as it is a common date for the onset of heavy seasonal rains. During the time between October 15 and November 9, our Watershed Restoration Program was in close communication with National Marine Fisheries Service (NMFS) in Arcata, CA. Our communications allowed us to continue work into November due to the absence of inclement



weather during that time.

FIGURE 2. PROJECT AREA AND ACCESS.

Road and Logging History

Watershed restoration Unit 99-5 had been quickly and intensely harvested for timber beginning in 1971 and ending in 1976 just prior to RNSP expansion (FIGURE 3). Clearcut tractor yarding was the primary method of timber harvest. The goal of the clearcut was most likely to extract as many healthy conifer trees as possible, as quickly as possible, with the understanding that the land would soon be converted to National Park land. Although timber operators followed what were the best practices at that time, they left very few trees standing on this unit.

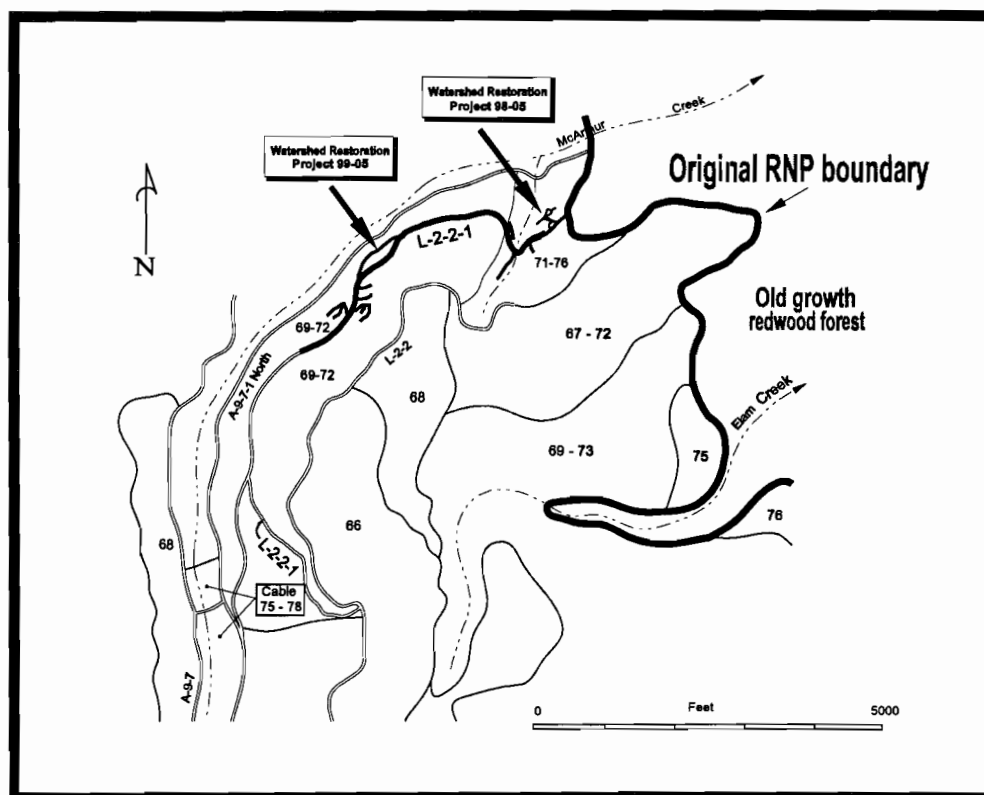


FIGURE 3. LOGGING HISTORY. THE EASTERNMOST END OF THE L-2-2-1 BEGINS CLOSE TO THE ORIGINAL 1968 PARK BOUNDARY, WHERE UNCUT OLD GROWTH CONIFEROUS FOREST CONTINUES FOR A MILE AND A QUARTER BEFORE REACHING THE REDWOOD CREEK FLOODPLAIN.

Tractor yarding employed large bulldozers to build roads directly to trees. This type of access created a dense network of skid roads that crisscrossed the entire hillslope. As a result, there was very little hillslope surface area above and below the L-2-2-1 that was not disturbed (FIGURE 4). Tractor yarding also resulted in major disruption of natural hydrologic conditions. Hydrologic disruption along the L-2-2-1 road corridor is evidenced by large debris flows, gullies, and slope failures due to interception of ground water and diversions of surface flow.

Timber operators built bridges called "Humboldt crossings" which enabled them to cross small stream channels with their equipment. These Humboldt crossings were constructed by placing logs lengthwise in the stream channel and packing soil around them to build a road surface. There are numerous Humboldt crossings of varying size in Unit 99-5. The packed soil in virtually all of the crossings have completely or partially eroded downstream. This soil, and the soil from debris flows, gullies and slope failures, travels down McArthur Creek and eventually reaches the Redwood Creek floodplain. Increased sedimentation in Redwood Creek and its tributaries jeopardizes the habitat and therefore the continued existence of the threatened Southern Oregon/Northern California Coast coho salmon, and the Southern Oregon and California Coastal chinook salmon.

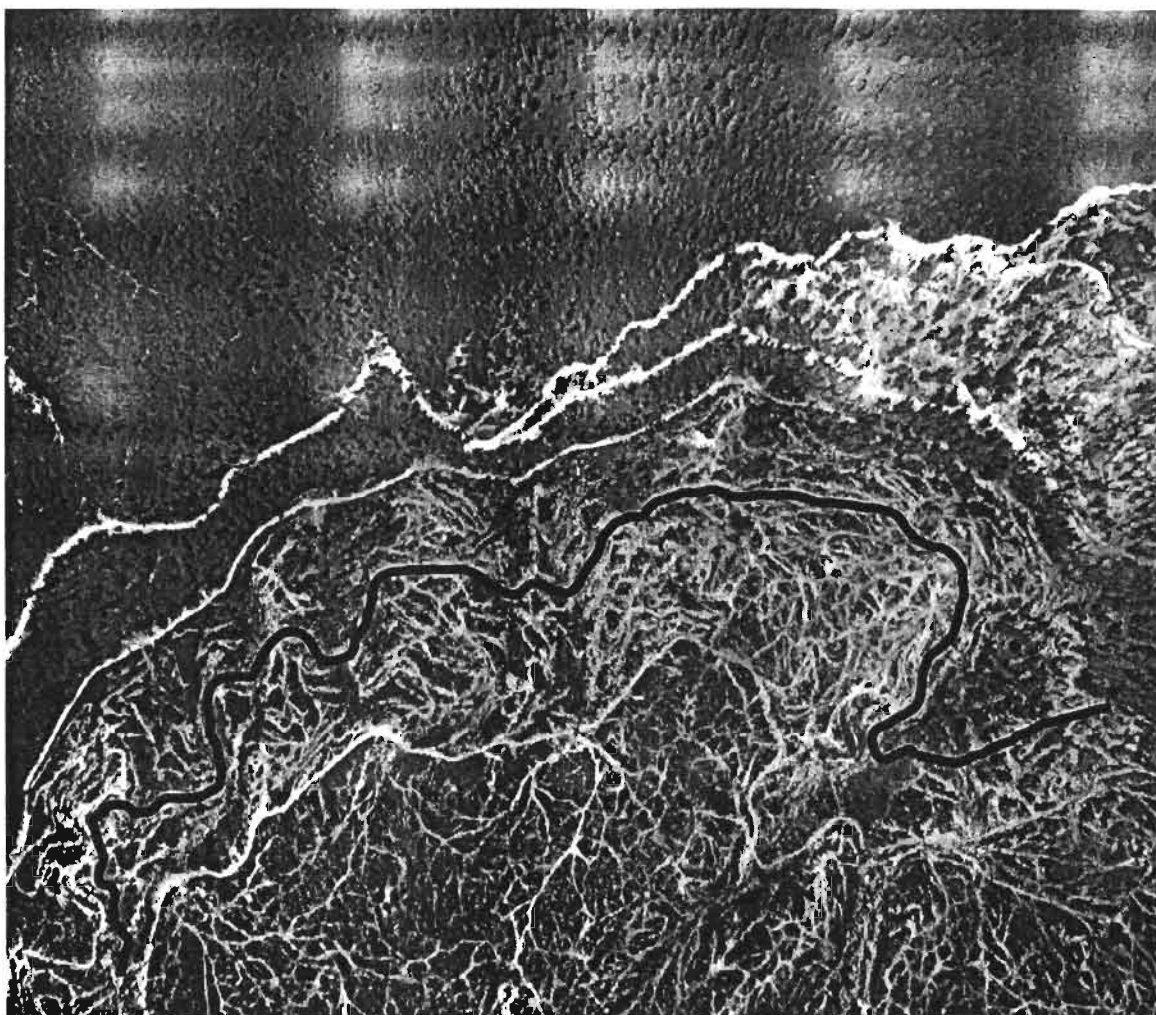


FIGURE 4. AERIAL PHOTOGRAPH SHOWING EXTENT OF LOGGING AND RELATED ROAD CONSTRUCTION BY 1974 NEAR THE L-2-2-1. ALL WHITE LINES ARE EITHER HAUL ROADS OR SKID TRAILS. THE L-2-2-1 ROAD IS SHOWN IN ITS ENTIRETY AS A THICK BLACK LINE. OLD GROWTH REDWOOD FOREST OCCUPIES THE UPPER THIRD OF THE PHOTOGRAPH, WHERE INDIVIDUAL TREES AND THEIR SHADOWS ARE VISIBLE.

GEOLOGY AND PHYSIOGRAPHY

The Redwood Creek basin is almost entirely underlain by the Jurassic-Cretaceous Franciscan formation. Exposures of these rocks typically show closely spaced fractures and/or shearing. Fractures seem to have resulted from deformation from tectonic activity, likely by subduction, and from brecciation along high angle faults.

Unit 99-5 is underlain by quartz-mica Redwood Creek schist unit of Franciscan assemblage (Harden et al., 1982). The schist in this unit is sheared, with complex folding and faulting, and is prone to mass wasting and fluvial erosion. However, in local areas, more competent schist forms resistant ridges between sub-basins and maintains more stable slopes to 70% or greater.

This unit drains into McArthur Creek, a tributary on the west side of Redwood Creek. McArthur Creek is separated from the ocean by its western ridge, which parallels the north-south coastline in the upper watershed (Figure 2). In the lower watershed, however, McArthur Creek swings east to join Redwood Creek. This drainage morphology is unusual for tributaries of Redwood Creek.

The flat-topped ridges east and west of McArthur Creek are the only ones of their kind in the Redwood Creek basin (Popenoe and Bevis, 1990) (FIGURE 5). They are topped by uplifted marine terraces containing sediments largely from the Klamath province (Harden et al, 1982). The marine sediments contain a high proportion of granitics, cherts, and other silicious metamorphic rocks. Slopes drop off steeply below the flat-topped ridges. It is not uncommon to find stable slopes approaching angles greater than 70% in the project unit.

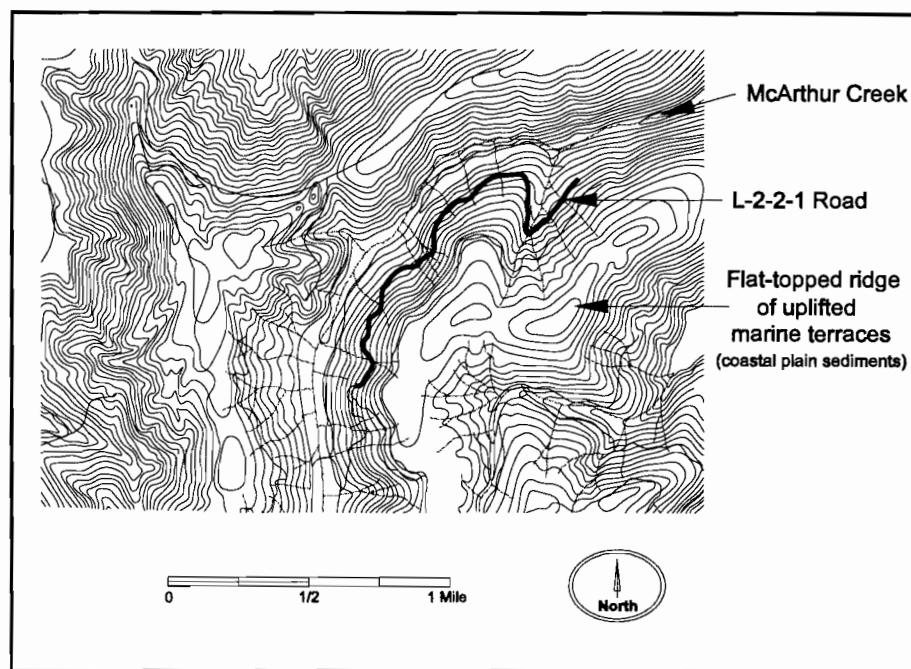


FIGURE 5. TOPOGRAPHIC MAP OF MCARTHUR CREEK.

Soils and Vegetation

The L-2-2-1 road is located predominantly in soils with brown clay loam B horizons (Coppercreek, Ahpah, Tectah, and Lacks creek). Wet soils with gray, mottled Cg horizons (Devils creek) are found in some streams and hollows (Popenoe and Bevin, 1990). Soils on slopes below the uplifted marine terraces, including the L-2-2-1, contain mostly schist fragments (metamorphosed mudstone) mixed with a small percentage of terrace material (Popenoe and Bevis, 1990).

Soils of this unit support vegetation that thrives in the cool shade of north-facing slopes. Old-growth redwood, douglas-fir, western hemlock and western red cedar historically grew in these soils, and remnants of old-growth forest remain on the unit. Red alder now grows in dense stands wherever soil was disturbed by logging, especially along road corridors, and the twenty-year old trees are approximately 50-70 feet tall. Understory vegetation includes salal, rhododendron, huckleberry, salmonberry, and oregon grape. Swordfern reach head height in some of the shadiest areas, and water cress is found in some of the wettest.

Erosion Processes and Hydrology

In the McArthur Creek watershed a combination of sheared schist bedrock and uplifted marine terrace geology allows water to readily infiltrate and percolate through cracks and fissures in the ground. Often this flow emerges in places contrary to normal expectations (for example, at the base of a cutbank on a ridge, which normally would be dry). The crisscrossing road network in this unit has intercepted groundwater flow in many locations, causing it to emerge on the ground surface sooner than it normally would under undisturbed conditions.

Emergent groundwater is common on the slope, and it is not surprising to find water at any elevation. Valley incision develops immediately downslope of the springs, and there is no trace of valley geomorphology above the springs. Seeps are especially common along the L-2-2-1 road, where road construction intersected groundwater flow and caused it to emerge higher on the slope than it would naturally. Large pools of water have established along the L-2-2-1 road in the twenty-two years since the road was last used. During that time bog ecosystems have developed along the road corridor, complete with soft, spongy ground, hydrophilic vegetation, and methane production. Springs are evident even during the driest months of the year.

Roads in this unit commonly divert, pond, and channel water away from its natural drainage, discharging concentrated flow onto normally dry hillslopes and causing ponded water to seep through road fill. I stated in the preceding section that these soils "hold up" to precipitation well following complete road removal, and so far, this appears to be true. Conversely, where water is unnaturally concentrated or ponded, or perched road fill is saturated, these soils move under gravity. Movement of these saturated soils cause massive debris flows continuing hundreds or thousands of feet downslope, evidenced by the mass soil movements of January 1997. During this time a total of five debris flows originated from the L-2-2-1 or the hillslope immediately above it. Two of the five debris flows were treated in 1998 as part of Unit 98-5. These occurred near stations 07+50 and 09+00, and are shown on the treatment map in the project report for that unit. Another was treated in 1999 near station 48+00. One more will be treated during 2000 work, near station 89+00. The last debris flow will not be treated because it occurred on the Six-Hour Loop Horse Trail and there is still enough road bench left for horse passage.

Figure 6 is a treatment map for Unit 99-5. Long arrows perpendicular to the road are stream channels. Work progressed from lower to higher bid items (BI's), or from right to left on the map. Initial access to the first bid item at the far end of the road was a time consuming process. This was partly due to the length of road necessary to open to four-wheel-drive truck access, and partially because we installed five culverts along the way. We installed these semi-permanent culverts in live stream channels and permanent springs to reduce creek sedimentation during daily access to and from the work site.

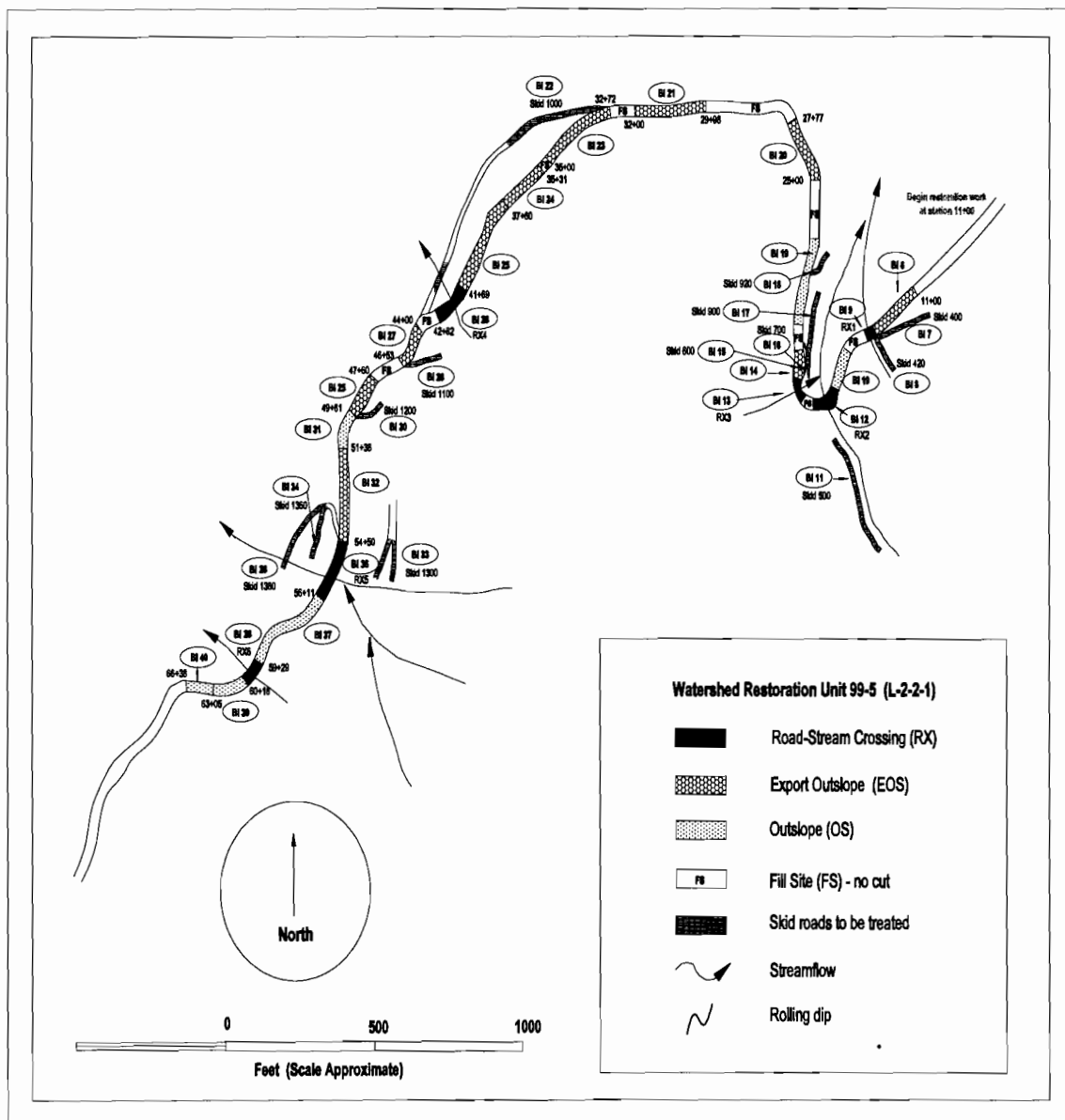


FIGURE 6. TREATMENT MAP FOR UNIT 99-5.

Wildlife Concerns and Work Schedule

The U.S. Fish and Wildlife Service (FWS), as administrator of the Endangered Species Act, has set noise restriction guidelines for management projects that do not remove or degrade suitable habitat for both the northern spotted owl and the marbled murrelet. These management projects require consultation with FWS prior to project implementation. In joint cooperation, RNSP, FWS, and the National Marine Fisheries Service (NMFS) created a Biological Assessment followed by biological and conference opinions, adopted July 1998. This document outlines specific guidelines such that RNSP may continue watershed restoration work without adversely affecting critical habitat of the wildlife in question. These guidelines are designed to reduce human impact on nesting sites during the breeding season. Specifically, project areas where heavy equipment operates during the breeding season within ¼ mile of suitable marbled murrelet nesting habitat require a noise restriction period.

Watershed restoration Unit 99-5 was partially within the ¼-mile radius for suitable habitat (Figure 7); therefore, a time restriction was imposed on the project. Work was allowed to begin after July 10, which is outside the early part of the murrelet breeding season. Additionally, no equipment could be operated prior to two hours after sunrise or after two hours before sunset between July 11 and September 15. These hours are prime feeding times for murrelets. These restrictions were a result of consultations with FWS, who agreed to let RNSP perform the heavy equipment restoration work during the breeding season if and only if RNSP complied with these terms. A certain amount of "incidental take", or acres of habitat disturbed by project noise greater than ambient level, is associated with each planned work project. This amount depends primarily upon proximity to suitable nesting habitat. RNSP reports annually in writing to identify the amount of work accomplished under this programmatic consultation and provides information that quantifies actual acres of affected marbled murrelet habitat disturbed by noise greater than ambient level.

Project 99-5 was allowed 138 acres of incidental take for marbled murrelets and 138 acres for northern spotted owl. The numbers are identical because all the habitat is suitable for both species. This year's project (99-5) began on August 27 and ended on November 9, and during that time, I reported 66 acres of incidental take. This number is low because the project is not yet complete, and in the year 2000 I will be affecting additional acres.

Project 99-5 work was targeted for completion by November 1. This ending date was specified in order to minimize impacts to threatened fish species by protecting the aquatic habitat from sediment pollution following the onset of winter rains. The National Marine Fisheries Service allowed for additional small work items to be implemented during November only if periods of dry weather were expected, and the work items could be completed within the window of predicted dry weather. We took advantage of this offer and with permission from NMFS were able to complete several small work items during dry weather before the project ended on November 9, 1999.

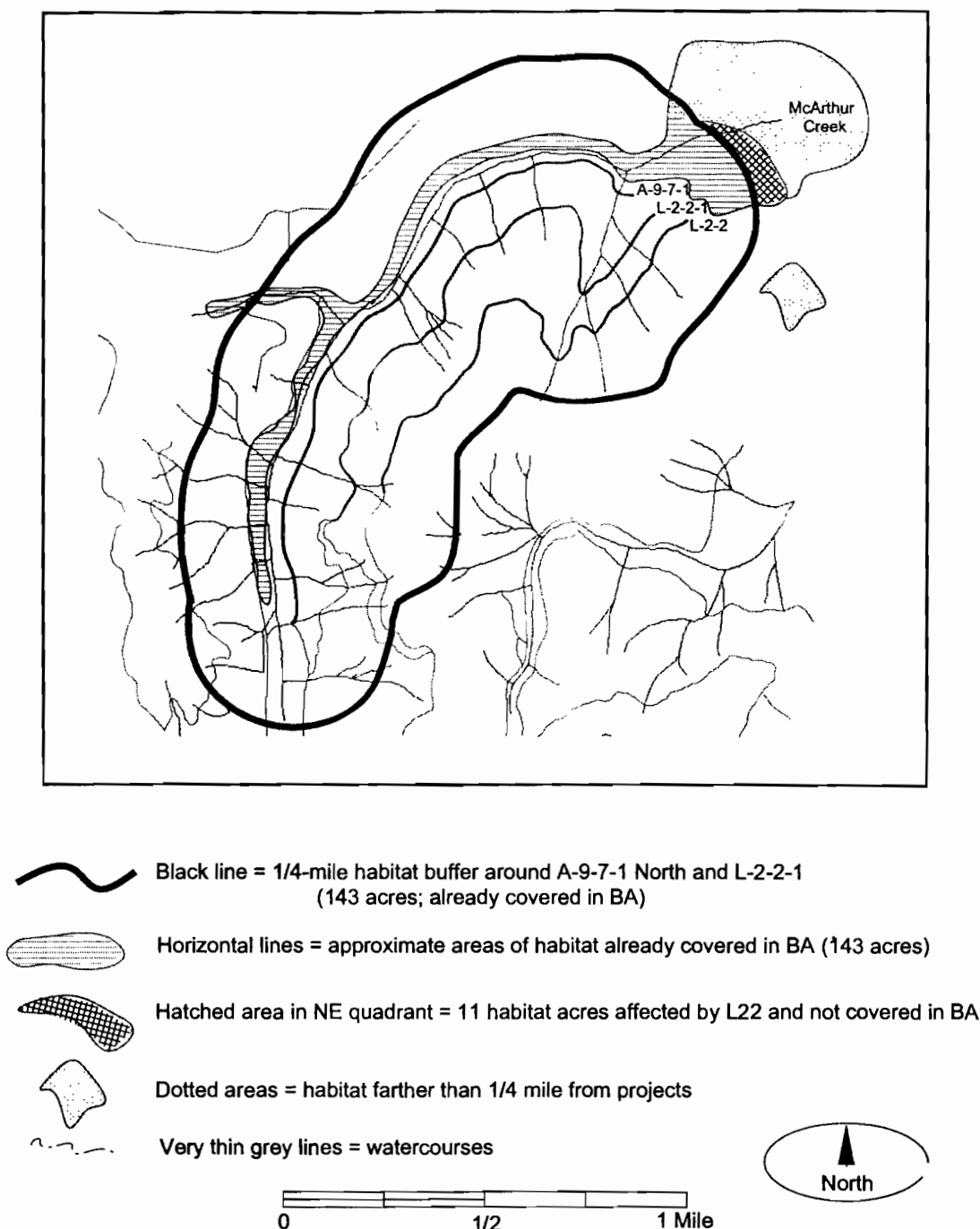


FIGURE 7. THICK BLACK LINE REPRESENTS A 1/4-MILE AREA AROUND THE L-2-2-1 AND A-9-7-1 NORTH PROJECTS IN THE MCARTHUR CREEK WATERSHED. WITHIN THIS AREA ARE 143 ACRES OF NORTHERN SPOTTED OWL AND MARBELED MURRELET HABITAT POTENTIALLY AFFECTED BY THESE PROJECTS. THE ACREAGE IN QUESTION IS SHOWN IN HORIZONTAL LINES AND REPRESENTS OLD-GROWTH RESIDUAL OR SUITABLE SECOND-GROWTH REDWOOD STANDS.

RESTORATION WORK

Heavy equipment work was done under Invitation for Bid contract awarded to Larry Lambert of Lambert's Excavating of Arcata, California, for \$232,363 (TABLE 1). Two pieces of equipment were used to complete the contract: a Hitachi EX310H hydraulic excavator, and a Caterpillar D8H bulldozer, both owned by the contractor. The contractor, Larry Lambert, operated the excavator, and the bulldozer was operated by Paul Curtwright of Palm Desert, California. Heavy equipment typically operated 10-11 hours daily, six days a week. The bulldozer had many breakdowns which slowed progress tremendously. Excavation rates in Tables 2, 3, and 4 reflect earth moving hours only, and do not reflect time that the equipment was broken down or otherwise unemployed.

Project Implementation

The geologist responsible for this project was Meredith Manning. It was my responsibility to perform the following tasks: evaluate and formulate rehabilitation prescriptions, survey and photo-document the project, generate plansheets and technical specifications for contracting, oversee heavy equipment operations as the contracting officer's technical representative (COTR), and complete the final documentation. I will plan, develop, and oversee the continuation of the L-2-2-1 road removal project in 2000. Additional geologists at RNSP were designated as site inspectors, and Phil Freiberg was called upon to oversee the heavy equipment work. Phil acted as COTR for several weeks at the end of the project while I was working on fire restoration work on the Big Bar Fire in Trinity County. The Supervisory Geologist for this project was Terry Spreiter. The Storm Damage Coordinator was Darci Short, Sherri Romanini managed the budget, and Kris Swofford from Point Reyes National Seashore was the Contracting Officer for the project.

The following table shows primary treatments for Project 99-5. Categories are listed in descending order by percent volume of total excavation.

Treatment	Number	Linear Feet	% Total by Length of Road	% Total by Volume
Haul Road-Stream Crossings	6	636	10%	48%
Haul Road Export Outslope	10	2,436	36%	27%
Skid Road Export Outslope	8	1,463	22%	14%
Haul Road Outslope	6	1,429	22%	10%
Skid Road Outslope	3	553	8%	1%
Skid Road-Stream Crossings	2	76	1%	>1%

Table 1. Restoration Work Cost Summary for Unit 99-05, L-2-2-1 Road

Treatment	Quantity (cubic yards)	Equipment Hours	Number of Sites	Total Cost		Percent of Grand Total (Actual cost)	Average Unit Cost	
				Actual	H.E.R.E. (a)		Actual	H.E.R.E. (a)
Heavy Equipment								
Haul Road Stream Crossings	27,054	304.50	6	\$ 114,032	\$ 52,760	49	\$ 4.21	\$ 1.95
Skid Road Stream Crossings	266	8.00	2	\$ 1,064	\$ 1,342	0	\$ 4.00	\$ 5.05
Haul Road Export Outslope	15,188	166.50	10	\$ 51,941	\$ 29,512	22	\$ 3.42	\$ 1.94
Skid Road Export Outslope	7,875	71.75	8	\$ 25,913	\$ 11,891	11	\$ 3.29	\$ 1.51
Haul Road Outslope	5,498	57.00	6	\$ 12,813	\$ 9,506	6	\$ 2.33	\$ 1.73
Skid Road Outslope	925	22.00	3	\$ 2,150.00	\$ 2,055.77	1	\$ 2.32	\$ 2.22
Non-Bid Item	---	136.25	---	\$ 24,450.00	\$ 22,119	11	---	---
Subtotal or Weighted Average	56,806	766	35	\$ 232,363	\$ 129,187	100	\$ 4.09	\$ 2.27

Project Implementation (b)	COTR hours			Personnel hrs		Cost	Percent of Grand Total (Actual cost)
	COTR hours	COTR OT hrs					
Mapping	55					\$ 1,197	0
Prescriptions and Layout	78					\$ 1,697	1
Aerial Photo Interpretation	3					65	0
Brushing	30		30			\$ 1,253	0
Surveying & DesignCAD	185		202			\$ 6,504	2
Contract Preparation	210	33				\$ 5,417	2
COTR Training							0
Contract Administration/ Heavy Equipment Supervision	375	91	9			\$ 10,671	4
Photo Documentation	48		10			\$ 1,374	1
Report Writing	130	3				\$ 2,908	1
Subtotal	1,114	127	251			\$ 31,087	12
Grand Total						\$ 263,450	

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on actual hours worked. Costs are calculated from Cal-Trans 1999 Labor and Rental plus 40% profit and overhead, and include the cost of the operator for: Caterpillar D8H dozer @ \$152.66/hr and Hitachi EX310H excavator @ 176.86/hr.
- (b) Costs are based on the salary and benefits of a GS-9 employee @ \$21.76/hr plus those for a GS-5 employee @ \$12/hr where applicable (i.e. for surveying and photo documentation assistance).

As previously indicated, we installed five culverts during the road opening procedure. Road opening consisted mainly of clearing dense stands of 22-25 year old alder trees (50-60 feet tall). Their presence slowed down production considerably. The bulldozer was required to "clear" them from the area and stockpile them in an "out of the way" location, so that the excavator could place them on the finished slope later in the process. During last year's work (Unit 98-5), work was performed on narrow skid roads; the L-2-2-1 itself was not very wide; and the piles of alder trees were constantly in the way. They also were responsible for ripping numerous hydraulic lines and getting caught in the bulldozer tracks. A few unruly alders caused major dents in the excavator and shattered the glass of the cab more than once, which is extremely unnerving to the operator. The remaining alder stands outside the area of excavation confined the excavator swing, which also slowed production considerably.

This year's project on Unit 99-5 took place more on the main haul road, and alders inhibited production slightly less. However, they still contributed significantly to low production rates. Although the alder trees are becoming prolific and difficult to manage due to their density and height, they are still required to be spread over the finished slope with other large organic material rather than buried. There is a good reason for this. Buried trees may "pipe" or funnel water through fill material, and will eventually break down, causing fill material to settle and pond water. Unnaturally ponded water or any concentrated flow outside of the normal channel creates a potentially unstable hillslope and is contrary to RNSP's watershed restoration goals.

Another cause of low production on haul road-stream crossings (RX's) was the amount of large woody material buried in or at the bottom of the fill material, which had to be separated from the fill material. This large woody "debris" came from old growth redwood trees, and were typically 5-10 feet in diameter, and could be 30-40 feet long. During road construction these giant logs were thrown in the bottom of the channel and then covered with fill material. They were used to fill space in the channel so less material would need to be imported to create a road bench. These logs acted as culverts, albeit semi-permanent ones, as water flowed subsurface, following along the buried logs.

During road-stream crossing excavations, particularly in RX2 and RX3, we uncovered large amounts of these intertwined logs at the bottom of the fill material. Some of these monsters were too large to be moved, even with the combined power of both bulldozer and excavator. The moveable logs had to be separated from the fill material, stockpiled out of the way of excavation work, and placed on top of the finished slope. It was a tedious process. Twenty percent of the total excavation time was spent separating large woody debris from fill material on each crossing, which significantly reduced production rates for each.

On the following page, Figure 8 shows "before, during and after" photographs of RX5, with the aforementioned woody debris placed on top of the finished slope.



FIGURE 8. BEFORE, DURING AND AFTER PHOTOGRAPHS OF THE EXCAVATION OF RX5.

Exported Outsloping (EOS)

Export outslope (EOS) treatments are performed where sufficient fill space does not exist directly onsite so fill material needs to be moved to a more distant, stable fillsite. All material moved in this manner was performed by bulldozer; that is, all material was pushed to the fillsite instead of transported by dump truck or loader.

Along the main haul road, export outslope was the most common treatment, accounting for 36% of the total length of road treated. In terms of total volume, haul road export outslope accounted for 27% of total sediment excavated, while skid road export outslope accounted for 14% of total. See note in section above regarding a sediment slide which occurred following the first rainy season. Excavation rates for EOS treatments are summarized in Table 3 (Appendix).

The L-2-2-1 cuts across many headwater swales. Headwater swale excavations commonly became EOS treatments, due to lack of fill storage onsite. Many of these EOS treatments became wide, shallow bowls upon completion of excavation, because there were many small side channels that fed the swale which had been buried during road construction.

Outsloping (OS)

Outsloping (OS) treatments involve the removal of fill from the outboard edge of a road and placing it along a stable section of cutbank, usually directly on-site. Recontouring in this manner restores natural drainage patterns and results in the recovery of original sidecast soil. Original topsoil is the first soil layer to be sidecast downslope during road construction. Long buried under fill material, the topsoil is the last to be retrieved during outsloping. This material rich in organic matter gets distributed over the finished slope, and enhances the revegetation process dramatically (Popenoe and Martin, 1990).

Haul road outslope accounted for only 10% of the total excavated volume. Excavation rates for outslope treatments are summarized in Table 4 (Appendix). Normally, a road removal project might require a greater percentage of outsloping treatments. In this case, it was a challenge to find dry, stable fillsite locations along the L-2-2-1 road corridor, so most treatments were export outslope.

Non-Bid Items

Non-bid items are categorized as jobs that result in non-recoverable costs on the part of the contractor. These items are distinguished by requiring time that is not directly attributable to any specific bid item. Non-bid item times are recorded to compare the cost of contract with that of hourly rentals. Table 5 (Appendix) provides a cost breakdown for non-bid items.

Discussion time is defined as periods of time where equipment operations were interrupted by discussions lasting more than 15 minutes. Typically the contractors stop work to discuss progress of a particular phase of a bid item or develop strategy for the work. The COTR also interrupts the operators to discuss the current work and develop understanding of the contract specifications while the bid item is in-progress.

Down time occurs when equipment is unable to perform in its expected capacity. On Unit 99-5, down time was most often the result of mechanical failure. Down time also included time equipment was either stuck or assisting in the rescuing of other stuck equipment. Down time was only recorded if the other piece of equipment was still working, as when the bulldozer was getting a new exhaust stack installed while the excavator continued to work on bid items.

Idle time for equipment was recorded as a non-bid item but is markedly different than the previous items. Idle time represents the time a piece of equipment was inactive while work proceeded. Idle time differs from down time in that the equipment is able to be used, but the contractor or operator chooses not to use it. There was significant idle time on this project for the bulldozer on the haul road-stream crossing treatments, when the excavator was separating large woody material from fill material. This occurred because I was not able to find enough local work for the bulldozer to stay busy without opening an unacceptable number of bid items at one time.

Under the Indefinite Quantities (IDIQ) contract, the contractor bids on price per foot of log that RNSP wants to "salvage" for in-park use (usually milled into planks for walkways, etc). Table 5 (Appendix) reflects this cost for Log Salvage during Project 99-5.

DISCUSSION

Project 99-5 met the goals of Redwood National Park's watershed restoration program by removing a portion of the L-2-2-1 road and its associated road network. The work restored natural hydrologic patterns along the road corridor and adjacent hillslopes. Restoration work also restored natural landforms as practically as possible given the extent of damage caused by the tractor logging style of timber harvest. Both goals of restoring hydrology and landforms help minimize human-caused erosion in McArthur Creek.

A total of 56,806 cubic yards of fill material was excavated from potentially unstable locations and moved to stable fill sites. The three-month project heavy equipment cost was \$232,363 with an overall average cost of \$4.09 per cubic yard.

The original goal of the project was to move nearly 76,000 cubic yards of potentially unstable fill material. We fell short because the contractor had difficulty obtaining the required equipment once RNSP awarded him the contract. Another factor was the time restriction placed upon the project, specifically, mandatory down times two hours after sunrise and two hours before sunset until September 16.

Under the new IDIQ contracting, contractors do not bid on individual projects; rather, they indicate their preference for current projects, and RNSP matches contractor to project based primarily on the contractor's equipment and the size of the road to be removed. Therefore, there were no competing bidders on this project as there have been in past years under the Invitation for Bid contracts.

The owner of the contracting company, Larry Lambert, is a longtime advocate of road removal and has worked with RNSP's watershed restoration program for decades. He has honed his ability to recognize when he is nearing original topsoil during excavation work, which is always a blessing for the COTR, who is ultimately responsible when excavation goes below original grade. His able assistant Paul Curtwright had the right energy and drive to learn the new skills involved in road removal on last year's project (98-05) and returned this year to continue the work. Paul has great talent for this work because he can visualize the finished product. Paul only needs a little information to get him started and then successfully finishes the job with very little guidance. He is valuable to have on road removal projects.

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Thanks to the other watershed restoration geologists for technical support from start to finish: Terry Spreiter, Becca Smith, Neal Youngblood, Phil Freiberg, Jim Howard, and Mike Sanders, from whom I borrowed prose for sections of this report.

Also thanks to Darci Short and Sheri Romanini for tackling—with patience and grace—the intricacies of funding the project; Kris Swofford for her sense of contracting humor, and Terry Hofstra for his unconditional support for doing it right the first time. Dick Mayle graciously offers timely assistance in any way possible. Tim Tanno, Darlene Buckskin, Keith Richey ("Harry"), and Doug Smith put a lot of energy into my project site, helping me brush and survey for months at a time. Not enough thanks can be said for Rodney Poole for dropping everything else and helping me every time I asked. To the contractor, Larry Lambert, and his able assistant Paul Curtwright, for conscientious and thoughtful work. You made my job easy.

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APPENDIX

Excavation Cost and Production Rate Tables for Unit 99-5

Table 2. Road-Stream Crossing

Table 3. Export Outslope Excavation

Table 4. Outslope Excavation

Table 5. Non-Bid Item Costs

Table 2. Road-Stream Crossing Excavation Cost and Production Rates for Unit 99-05, L-2-2-1 Road

Bid Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Total Cost		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Excavation Rate Both Equip (cubic yards per hour) (c)
			Hitachi EX310-H	Caterpillar D8H	Actual	H.E.R.E.	Actual (price per cubic yard)	H.E.R.E.			
HAUL ROAD											
9	12+40-12+80	1,453	3.25	11.75	\$ 5,812.00	\$ 2,574.25	\$ 4.00	\$ 1.77	\$ 4.00	<100	97
12	14+70-15+93	8,247	51.75	10.00	\$ 32,988.00	\$ 9,668.76	\$ 4.00	\$ 1.17	\$ 4.00	100	134
12	Fillsite Diff.	6,620		41.75	\$ 1,655.00	\$ 7,383.91	\$ 0.25	\$ 1.12	--	600	159
13	16+42-17+52	5,439	32.75	32.25	\$ 21,756.00	\$ 10,703.35	\$ 4.00	\$ 1.97	\$ 4.00	700	84
26	41+69-42+82	4,632	13.75	33.50	\$ 18,528.00	\$ 8,023.89	\$ 4.00	\$ 1.73	\$ 4.00	100	98
36	54+50-56+11	5,548	13.75	51.75	\$ 22,192.00	\$ 11,251.58	\$ 4.00	\$ 2.03	\$ 4.00	250	85
36	Moisture Diff.	5,548			\$ 4,161.00	-	\$ 0.75	-	--	250	--
38	59+29-60+18	1,735	8.50	10.50	\$ 6,940.00	\$ 3,154.64	\$ 4.00	\$ 1.82	\$ 4.00	200	91
Total or Weighted Avg			123.75	191.50	\$ 114,032.00	\$ 52,760.37	\$ 4.21	\$ 1.95	---	---	86
(Does not include differentials)											
SKID ROADS											
7	Skid 400	151	1.00	1.00	\$ 604.00	\$ 329.52	\$ 4.00	\$ 2.18	\$ 4.00	<100	76
35	Skid 1380	115	2.00	4.00	\$ 460.00	\$ 1,012.76	\$ 4.00	\$ 8.81	\$ 4.00	<100	19
Total or Weighted Avg			3.00	5.00	\$ 1,064.00	\$ 1,342.28	\$ 4.00	\$ 5.05	---	---	33

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on actual hours worked. Costs are calculated from Cal-Trans 1999 Labor and Rental Rates plus 40% profit and overhead, and include the cost of the operator for: Caterpillar D8H dozer @ \$152.66/hr and Hitachi EX310H excavator @ 176.86/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (c) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

Table 3. Export Outslope Excavation Cost and Production Rates for Unit 99-05, L-2-2-1 Road

Bid Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Total Cost		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Excavation Rate Both Equip (cubic yards per hour) (c)
			Caterpillar D8H	Hitachi EX310H	Actual	H.E.R.E. (a)	Actual (price per cubic yard)	H.E.R.E. (a)			
HAUL ROAD											
6	11+00-12+40	290	1.00	1.00	\$ 870.00	\$ 329.52	\$ 3.00	\$ 1.14	\$ 3.00	155	145
14	17+52-19+17	222	1.00	6.50	\$ 832.50	\$ 1,302.25	\$ 3.75	\$ 5.87	\$ 3.75	<100	30
20	25+00-27+77	578	1.50	3.25	\$ 1,734.00	\$ 803.79	\$ 3.00	\$ 1.39	\$ 3.00	250	122
21	29+98-32+00	2,201	9.50	12.75	\$ 6,603.00	\$ 3,705.24	\$ 3.00	\$ 1.68	\$ 3.00	135	99
23	32+72-35+00	1,893	12.25	10.00	\$ 7,098.75	\$ 3,638.69	\$ 3.75	\$ 1.92	\$ 3.75	130	85
23	Fillsite Differential	360	3.50		\$ 270.00	\$ 534.31	\$ 0.75	\$ 1.48	--	600	103
24	35+31-37+60	2,755	11.50	11.00	\$ 9,642.50	\$ 3,701.05	\$ 3.50	\$ 1.34	\$ 3.50	130	122
25	37+60-41+69	1,447		3.25	\$ 4,341.00	\$ 1,032.78	\$ 3.00	\$ 0.71	\$ 3.00	450	232
27	44+00-46+53	1,930	5.25	7.00	\$ 5,790.00	\$ 2,039.49	\$ 3.00	\$ 1.06	\$ 3.00	180	158
29	47+60-49+81	1,947	17.00	28.00	\$ 5,841.00	\$ 7,547.30	\$ 3.00	\$ 3.88	\$ 3.00	170	43
29	closure Differential	1,947			\$ 1,947.00	\$ -	\$ 1.00				
32	51+38-54+50	1,925	15.75	6.00	\$ 6,737.50	\$ 3,465.56	\$ 3.50	\$ 1.80	\$ 3.50	240	89
32	Fillsite Differential	935	9.25		\$ 233.75	\$ 1,412.11	\$ 0.25	\$ 1.51	--	300	101
Total or Weighted Avg		17,135	90.50	88.75	\$ 51,941.00	\$ 29,512.06	\$ 3.03	\$ 1.72	--	--	96
(Does not include differentials)											
SKID ROADS											
15	Skid 600	250		1.50	\$ 937.50	\$ 265.29	\$ 3.75	\$ 0.23	\$ 3.75	100	115
16	Skid 700	150		1.00	\$ 562.50	\$ 176.86	\$ 3.75	\$ 1.18	\$ 3.75	220	150
17	Skid 900	802	1.00	2.00	\$ 3,007.50	\$ 506.38	\$ 3.75	\$ 0.63	\$ 3.75	200	267
18	Skid 920	1,966	13.25	4.50	\$ 6,881.00	\$ 2,818.62	\$ 3.50	\$ 1.43	\$ 3.50	200	111
22	Skid 1000	1,210	1.75	10.00	\$ 3,630.00	\$ 2,035.76	\$ 3.00	\$ 1.68	\$ 3.00	<100	103
30	Skid 1200	1,480	10.50	10.25	\$ 4,440.00	\$ 3,415.75	\$ 3.00	\$ 2.31	\$ 3.00	140	71
33	Skid 1300	807	5.25	6.50	\$ 2,824.50	\$ 1,951.06	\$ 3.50	\$ 2.42	\$ 3.50	<100	69
34	Skid 1360	1,210	1.25	3.00	\$ 3,630.00	\$ 7721.41	\$ 3.00	\$ 0.60	\$ 3.00	100	285
Total or Weighted Avg		7,875	33.00	38.75	\$ 25,913.00	\$ 11,891.11	\$ 3.29	\$ 1.51	---	---	110

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on actual hours worked. Costs are calculated from Cal-Trans 1999 Labor and Rental Rates plus 40% profit and overhead, and include the cost of the operator for: Caterpillar D8H dozer @ \$152.66/hr and Hitachi EX10H excavator @ 176.86/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (c) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

Table 4. Outslope Excavation Cost and Production Rates for Unit 99-05, L-2-2-1 Road

Bid Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Total Cost		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Excavation Rate Both Equip (cubic yards per hour) (c)		
			Caterpillar D8H	Hitachi EX310H	Actual	H.E.R.E.	Actual (price per cubic yard)	H.E.R.E. (a)					
HAUL ROAD													
10	13+50-14+70	491		2.25	\$ 1,227.50	\$ 397.94	\$ 2.50	\$ 0.81	\$ 2.50	<100	218		
19	19+80-23+23	1,566	15.75	8.00	\$ 3,523.50	\$ 3,819.28	\$ 2.25	\$ 2.44	\$ 2.25	260	66		
31	49+81-51+38	1,166	1.00	7.50	\$ 2,623.50	\$ 1,479.11	\$ 2.25	\$ 1.27	\$ 2.25	<100	137		
37	56+11-59+29	645		4.75	\$ 1,612.50	\$ 840.09	\$ 2.50	\$ 1.30	\$ 2.50	<100	136		
39	60+18-63+05	634		4.00	\$ 1,585.00	\$ 707.44	\$ 2.50	\$ 1.12	\$ 2.50	<100	159		
40	63+05-66+38	996	7.00	6.75	\$ 2,241.00	\$ 2,262.43	\$ 2.25	\$ 2.27	\$ 2.25	<100	72		
Total or Weighted Avg					5,498	23.75	33.25	\$ 12,813.00	\$ 9,506.27	\$ 2.33	\$ 1.73	--	96
SKID ROAD													
8	Skid 420	176		3.25	\$ 440.00	\$ 574.80	\$ 2.50	\$ 3.27	\$ 2.50	<100	54		
11	Skid 500	650	2.75	4.75	\$ 1,462.50	\$ 1,259.90	\$ 2.25	\$ 1.94	\$ 2.25	<100	87		
28	Skid 1100	99		1.25	\$ 247.50	\$ 221.08	\$ 2.50	\$ 2.23	\$ 2.50	<100	79		
Total or Weighted Avg					925	2.75	9.25	\$ 2,150.00	\$ 2,055.77	\$ 2.32	\$ 2.22	--	77

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on actual hours worked. Costs are calculated from Cal-Trans 1999 Labor and Rental Rates plus 40% profit and overhead, and include the cost of the operator for: Caterpillar D8H dozer @ \$152.66/hr and Hitachi EX310H excavator @ 176.86/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (c) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

Table 5. Non-Bid Item Costs for Unit 99-05

Item	Heavy Equipment Hours		Actual Costs	H.E.R.E. Costs (a)
	Caterpillar D8H	Hitachi EX310H		
Move In	---	---	\$ 6,750.00	---
Move Out	---	---	\$ 2,225.00	---
Start Up	---	---	\$ 12,200.00	---
Culvert Installation	---	---	\$ 1,750.00	---
Log Salvage			\$ 1,525.00	
Discussion (b)	10.75	10.50	---	\$ 3,498.13
Down (c)	45.75	23.75	---	\$ 11,184.62
Fuel & Service (d)	25.25	20.25	---	\$ 7,436.08
Subtotal	81.75	54.50	\$ 24,450.00	\$ 22,118.83
Idle (e)	0.00	0.00	\$ -	-
Total	81.75	54.50	\$ 24,450.00	\$ 22,118.83

(a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on actual hours worked. Costs are calculated from Cal-Trans 1999 Labor and Rental Rates plus 40% profit and overhead, and include the cost of the operator for: Caterpillar D8H dozer @ \$152.66/hr and Hitachi EX310H excavator @ 176.86/hr.

