

Summary Report
WATERSHED RESTORATION UNIT 97-1
C-LINE SOUTH

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TABLE OF CONTENTS

INTRODUCTION	4
BACKGROUND	4
SITE DESCRIPTION	4
GEOLOGY	8
TIMBER HARVEST HISTORY	8
EROSIONAL FEATURES	10
THREATENED AND ENDANGERED SPECIES CONCERNS AND WORK SCHEDULE	10
RESTORATION WORK.....	11
PROJECT IMPLEMENTATION	11
HEAVY EQUIPMENT PHASE	11
<i>Stream Crossings</i>	13
<i>Export Outsloping</i>	16
<i>Outsloping</i>	17
<i>Miscellaneous Bid Items</i>	17
<i>Non-Bid Items</i>	17
LABOR INTENSIVE PHASE	18
DOCUMENTATION PHASE	18
DISCUSSION	19
REFERENCES	24

LIST OF FIGURES

1. Location of Project Area	5
2. Timber Harvest History and Recent Mass Movement Features	9
3. Location of Treatment Types in the Project Area	12

LIST OF TABLES

1. Restoration Work Cost Summary for Unit 97-1, C-Line South Road	7
2. Stream Crossing Excavation Costs and Production Rates for Unit 97-1, C-Line South Road	20
3. Export Outslope Excavation Costs and Production Rates for Unit 97-1, C-Line South Road	21
4. Outslope Excavation Costs and Production Rates for Unit 97-1, C-Line South Road	21
5. Miscellaneous Bid Item Costs for Unit 97-1, C-Line South Road	22
6. Non-bid Item Costs for Unit 97-1, C-Line South Road	23

INTRODUCTION

Background

Redwood Creek drains a 280-square-mile watershed in the mountainous, coastal region of northwestern California. The watershed is characterized by high relief, steep unstable slopes, and narrow valley bottoms. Redwood Creek and its tributary streams are subject to frequent flooding from winter storms, and basin soils are naturally unstable and highly erodible. Landslides and earthflows are widespread, and even under natural conditions streams swelled by winter rains transport large volumes of sediment. With over 90% of the forests in the basin harvested, and 2/3 of the basin in active timber management, sediment levels in Redwood Creek are twice the mean annual erosion rates for the north coast (U.S. Congress, House, Committee on Government Operations 1976). Redwood National Park (RNP) is located in the lower 1/3 of the Redwood Creek watershed.

Public Law 95-250 (March 27, 1978) directed that a watershed restoration program be developed for lands that had been timber harvested prior to becoming part of Redwood National Park. Timber harvesting and road construction that occurred on these lands before they were added to the park had adversely influenced erosion rates, sediment deposition, and water quality within the entire basin. These problems are being addressed in the restoration program. The purpose of the restoration program is to minimize human-induced erosion within Redwood National and State Parks, encourage the return of a natural pattern of vegetation, and protect redwood groves and aquatic communities. Ultimately, these efforts should result in the restoration of natural ecosystems to conditions similar to what would have existed without disturbance by humans. (Redwood National Park, Watershed Rehabilitation Plan, 1981)

It is National Park Service policy to "actively seek to understand and preserve the soil resources of parks and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources..." It is also Park Service policy that "Terrain and plants may be manipulated where necessary to restore natural conditions on lands altered by human activity. Management activities may include, but will not be restricted to, removing constructed features, restoring natural gradients, and revegetating with native park species..." (National Park Service Management Policies, 1988). Management objectives of Redwood National Park are "to restore and/or maintain the natural ecosystems of the park" and "to continue with biological and physical restoration of park lands severely impacted by past land-use practices" (Redwood National Park, Statement for Management, 1992). These policies and objectives provided the guidance and direction for the removal of this portion of the C-Line South Road.

Site Description

The project area is located approximately sixteen miles south of Orick at an elevation of approximately 1500 feet above sea level (Figure 1). The C-Line was a major haul road

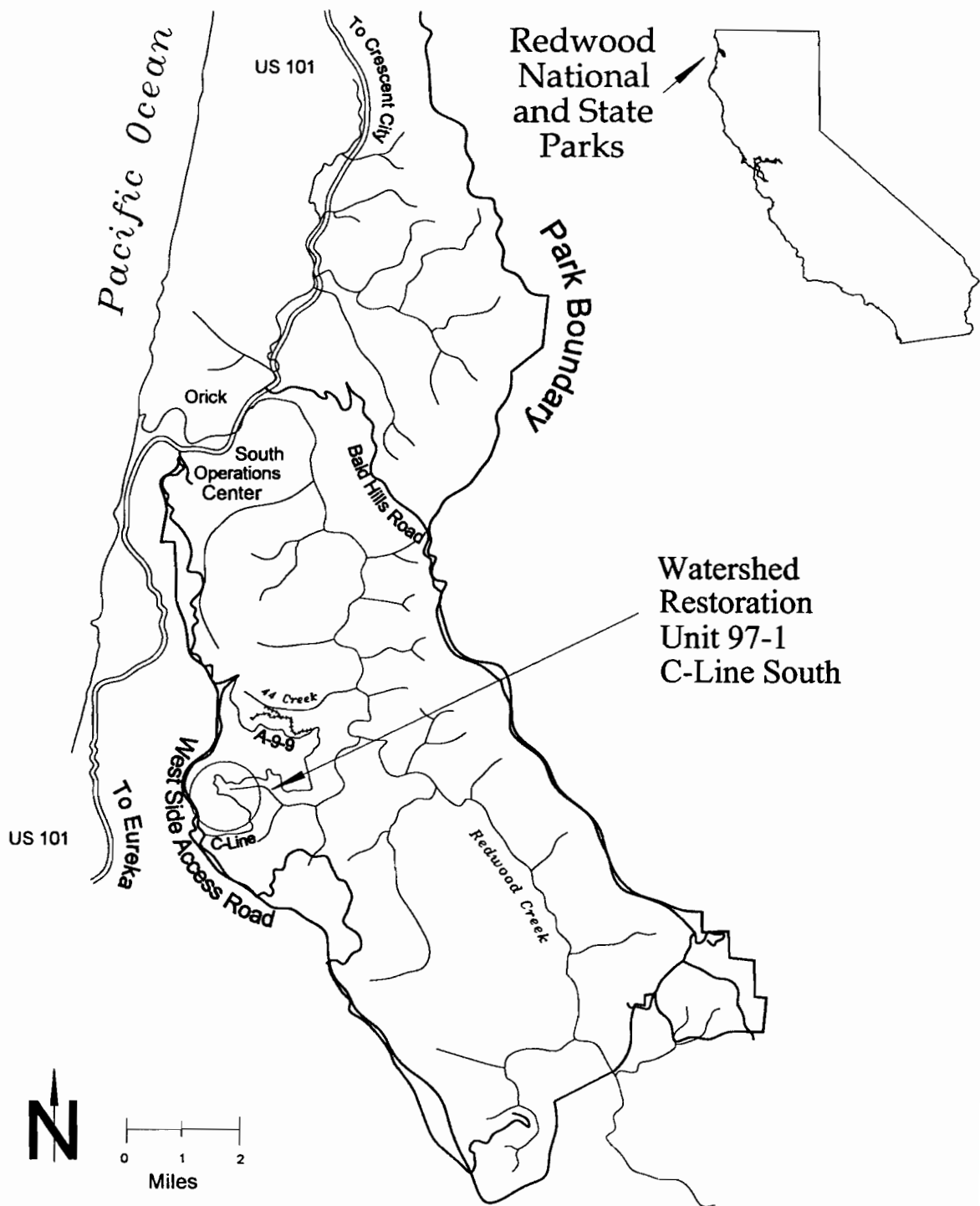


Figure 1. Location of Project Area

constructed in approximately 1950. It is located on the west side of the Redwood Creek basin and ran, within the park boundaries, from the West Side Access Road near MP 9 to the A-9-9. A large stream crossing (C-Line Pond) was excavated in 1993, severing the C-Line into two sections - the C-Line North and the C-Line South.

In 1996, a small portion of the C-Line South was prioritized for removal because of the large volume of fill material in the stream crossings, the high quality of Tom McDonald Creek for aquatic life, and the availability of funding from the National Park Service Dam Safety Program.

On January 1, 1997, an eleven-year storm hit northern California, including the Redwood Creek basin, after three months of above average precipitation. This storm caused numerous failures, predominately mass movements along the roads in Redwood National Park. A portion of the road fill and hillslope on the C-Line South slumped, causing the road bench to drop approximately five feet. Redwood National Park received \$7.5 million from the Emergency Supplemental Appropriations Act for Recovery from Natural Disasters (PL 105-18) and \$0.5 million from the Federal Highway Administration's Emergency Relief for Federally Owned Roads (ERFO) to remove roads that had been damaged during the storm. Other roads that were public access or long term administrative access roads also received funds for repair. The C-Line South was one of the roads to be removed.

Due to this increase of funding to remove 1997 storm damaged roads, a longer portion of the C-Line could be removed. The total cost for this project was \$360,413 (see Table 1 for cost summary). The heavy equipment cost of \$306,744 was funded as follows: \$25,000 from the Dam Safety Program; \$75,000 from RNP's base operating funds; and \$206,744 from the Emergency Supplemental Appropriations Act. The salary cost of \$53,669 for implementation was funded by RNP's base operating funds and the Emergency Supplemental Appropriations Act.

Watershed Restoration Unit 97-1 constitutes the first phase of a three-year strategy to remove the C-Line South. This project removed 0.7 mile of the C-Line that included four stream crossings and one skid-road stream crossing. Stream crossing RX-4 was the largest stream crossing excavated to date (42,000 yd³) in Redwood National Park and had water impounded on the upstream side of the road fill to a depth of 13 feet. This project involved the excavation of a total of 89,450 yds³ of fill material, including 63,700 yds³ associated with four stream crossings and a skid-road stream crossing.

Restoration focused on the removal of the stream crossing fill and unstable side cast fill, and placement of this fill against the cutbanks on stable road reaches in order to restore more natural hillslope topography and drainage patterns interrupted by the C-Line South. The excavation of the stream crossing fill uncovered the natural channel bed and banks, and excavated fill was used to re-create the natural topography. Buried organic and nutrient rich material was returned to the surface in order to help speed recovery of native vegetation. Trees removed during excavation were stockpiled and dispersed along the finished surface in order to provide habitat and simulate natural forest litter.

TABLE 1							
RESTORATION WORK COST SUMMARY FOR UNIT 97-1, C-LINE SOUTH ROAD							
Treatment	Quantity	# of Jobs	Total Costs		% of Grand Total using Actual	Average Unit Costs	
			Actual ^a	H.E.R.E. ^b		Actual	H.E.R.E. ^b
Heavy Equipment							
Stream Crossings	63,700 yds ³	5	\$210,809	\$217,403	58	\$3.31	\$3.41
Export Outslope	9,600 yds ³	2	\$20,295	\$23,400	6	\$2.11	\$2.44
Outslope	16,150 yds ³	7	\$34,747	\$34,938	10	\$2.15	\$2.16
Misc. Bid Items		4	\$21,168	\$17,013	6		
Misc. Non-Bid Items			\$19,725	\$28,797	5		
Subtotal	89,450 yds ³		\$306,744	\$321,551	85		
Project Implementation ^c							
Planning	8 hrs	NA	\$168		0		
Mapping	154.5 hrs	NA	\$3,109		1		
Prescriptions and Layout	135.25 hrs	NA	\$2,700		1		
Surveying	513 hrs	NA	\$10,152		3		
Environmental Compliance	81.5 hrs	NA	\$1,666		0		
Contract Preparation	93 hrs	NA	\$1,901		1		
Heavy Equipment Supervision	1245.75 hrs	NA	\$29,563		8		
Check and Install Additional Silt Fences	65 hrs	NA	\$1,340		0		
Photo Documentation	55.5 hrs	NA	\$1,027		0		
Report Writing	95 hrs	NA	\$2,043		1		
Subtotal	2446.5 hrs	NA	\$53,669		15		
Grand Total			\$360,413	\$375,220	100		

^a Actual costs include \$292,083 paid to the contractor as contract costs and \$14,661 as materials and labor provided by Redwood National Park for winterizing RX-4. See Table 6 for winterizing costs.

^b Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: Komatsu 220 hydraulic excavator @ \$150/hr; Caterpillar D8L dozer @ \$200/hr; Komatsu 400 hydraulic excavator @ \$200/hr; and Caterpillar D8H dozer @ \$165/hr.

^c Project implementation costs are the total number of hours that Redwood National Park employees worked on the project multiplied by their hourly rates. Several employees making different hourly rates worked on this project, so the total hourly rate is not consistent.

Geology

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 pervasive shearing. Fractures seem to have resulted from deformation from tectonic emplacement, likely by subduction, and from brecciation along high angle faults. The intensity and style of this disruption seems to be the rock characteristic that most influences differences in the erosion rates and landforms (Janda, unknown). The Grogan fault, which has a surface trace roughly coincident with the valley of Redwood Creek, separates two major lithologies of the Franciscan formation. In general, rocks on the west side of the basin consist of quartz-mica schist, whereas unmetamorphosed sedimentary rocks are found on the east side. The Grogan fault is more linear than other major NNW trending faults in the region which suggests a near vertical dip (Hardin et al., 1982).

The north-northwest trend of these units and the younger faults that cut them is a signature of the overall tectonic structure of the northwest. This structure is dominated by north-north west trending, imbricated thrust faults that dip to the east and accounts for the prominent north-northwest trend of many of the ridges and rivers in the northern Coast Ranges as well as the obvious shearing. The overall amount of shearing in the major units can usually be predicted by the topography because the amount of shearing strongly influences both type and abundance of landslides.

The project area is situated on the west side of the Redwood Creek basin, and is underlain by the schist of Redwood Creek. The most common rock type within this unit is metamorphosed mudstone. Metamorphosed sandstones which locally display graded bedding are also present. Another major lithologic component is metamorphosed basalt and tuff. Large metabasalt outcrops form prominent knobs on the landscape. Considerable variations in mineralogy, texture, lithology, and structure are evident but intense shearing and complex folding and faulting preclude mapping subunits.

Timber Harvest History

The 1948 air photos covering Tom McDonald Creek show that no road construction or timber harvest had begun in the area. By 1954, the C-Line had been constructed and limited timber harvesting had begun. All the areas that were cut in the project area prior to 1954 were harvested using cable yarding techniques. By 1962, most of the project area had been cut except for three parcels which were cut in the 1970s. (Figure 2) Before the 1970s, areas below the C-Line were harvested by cable yarding and areas above the C-Line were harvested by tractor yarding. The harvesting done in the 1970s was by tractor yarding. Clearcutting and seed-tree leave were the silvicultural practices used in the 1950s. Between 1962 and 1968, no large-scale harvesting was done in the project area, but some of the seed trees left during earlier logging were harvested. Between 1973 and 1976 three old-growth patches were clearcut. No additional timber harvesting was performed after 1976 and Redwood National Park acquired the land in 1978.

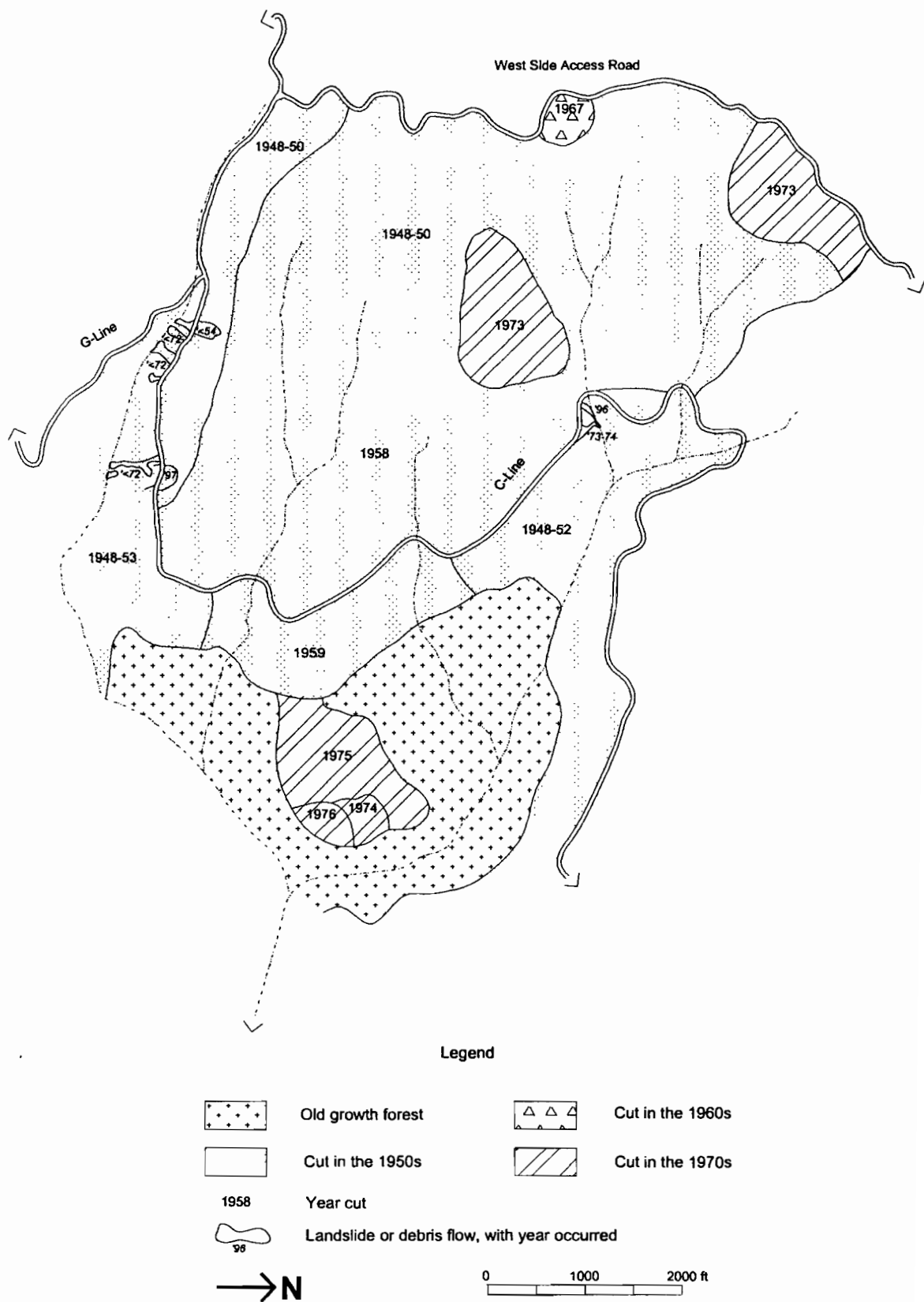


Figure 2. Timber Harvest History and Recent Mass Movement Features

Erosional Features

The most dominant erosional features are landslides and debris flows (Figure 2). The 1954 air photos show one recent slide originating above the C-Line in a cable yarded unit just east of the intersection of the G-Line. The 1972 photos show four recent land slides/debris flows that originated on the outboard edge of the C-Line and terminated at the creek, east of the intersection with the G-Line. Between 1972 and 1973, immediately following clearcutting of an old-growth patch and construction of very large skid roads above the C-Line, a debris flow occurred originating on the outboard edge of the C-Line and terminated in the creek below RX-1 and RX-2. Between December 5 and 9, 1996, the outboard edge of the road at RX-2 failed and debris flowed into the creek. During the New Year's storm on January 1, 1997, a section of the C-Line east of the G-Line intersection slumped, dropping the road bed approximately five feet. In addition, the soils below the C-Line are very prone to gulleying. A ditch relief pipe at station 73+80 discharged water onto the hillslope at a ridge. This water created a gully with dimensions up to 5' wide by 3' deep running all the way down to the creek.

Threatened and Endangered Species Concerns and Work Schedule

Two bird species that are listed as threatened under the Endangered Species Act occupy areas in or near the project area: the northern spotted owl and the marbled murrelet. On May 6, 1997, coho salmon were also listed as a threatened species. Because old-growth forests serve as critical habitat for these species, Redwood National and State Parks is considered a critical conservation area for their survival.

The U.S. Fish & Wildlife Service (USFWS), as administrator of the Endangered Species Act for northern spotted owl and marbled murrelet, has set noise and habitat modification restriction guidelines designed to reduce human impact, especially to nesting sites during the breeding season. Murrelets occupy old-growth habitat below the C-Line, some of which is within ¼ mile of the C-Line. The old growth is at least 1/8 mile downslope from the C-Line and is separated from the C-Line by a dense stand of 45 to 55 year-old second growth. Equipment noise is reduced to ambient levels by the time it reaches the old growth. The entire project area is assumed to be used by spotted owls, at least for foraging habitat. In order to avoid adverse impacts to spotted owls, the project was planned to start on August 1 at the end of the spotted owl breeding season.

The National Marine Fisheries Service (NMFS) is responsible for administering the Endangered Species Act for protection of the coho salmon. Listing of the coho salmon after the contract had gone out to bid, development of guidelines by NMFS to protect the coho salmon, and working with a different agency resulted in a lot of last minute consultation and consternation. The bid opening was delayed for two weeks while awaiting concurrence from NMFS. Concurrence was received on August 27, 1997 and the heavy equipment work began on August 30.

RESTORATION WORK

Project Implementation

Restoration work focused on restoring the land to a condition similar to what would have existed without disturbance by humans. This included complete excavation of road fill out of stream crossings and swales, complete outslowing of the road, and rebuilding of ridges resulting in the road fill being shaped to mimic the natural hillslope topography above and below the road (Figure 3). Recontouring provides a solid, beneficial foundation morphologically, hydrologically, and aesthetically for landscape evolution.

The project geologist, Becca Smith, mapped geomorphic and hydrologic features, prescribed restoration treatments, surveyed the volumes of all worksites before and after excavation, prepared the contract, oversaw heavy equipment operations as the contracting officer's technical representative (COTR), photo documented the work, and wrote the final report. Geologists Phil Freiberg and Meredith Manning served as site inspectors when the project geologist was not on site.

Heavy Equipment Phase

The heavy equipment phase included completion of all primary restoration treatments. A total of 0.7 mile of the C-Line South and 0.15 mile of skid roads was removed at a total heavy equipment cost of \$306,744. A total of 89,450 yds³ of material was excavated from 4 haul road stream crossings (62,100 yds³), 1 skid-road crossing (1,600 yds³), 676 feet of haul road export outslope (9,600 yds³), 1552 feet of haul road outslope (14,300 yds³), and 797 feet of skid-road outslope (1,850 yds³). The haul road surface was ripped prior to placement of fill on fillsites.

The heavy equipment phase was done by "invitation for bid" contract, split into a base bid and one additive bid, containing RX-4 and two outslopes. The bid opening was scheduled for July 28, 1997 (with work beginning around Aug. 1), but concurrence from National Marine Fisheries Service was not received by that date, so the bid opening was delayed until August 13, 1997. A large number of bids were received covering a wide range in prices. The following is a summary of the bids received.

Cross Country Construction	\$247,108
Barber Construction Inc.	\$289,180
Lambert's Excavating Service	\$301,477
Churn Creek Construction	\$304,552
Butte Construction Inc.	\$334,540
Trinity River Construction	\$344,719
Carl M. Kjer & Sons	\$375,065
Clemens Construction	\$494,620
John Peterson Inc.	\$660,100
Bud's Equipment	\$698,768

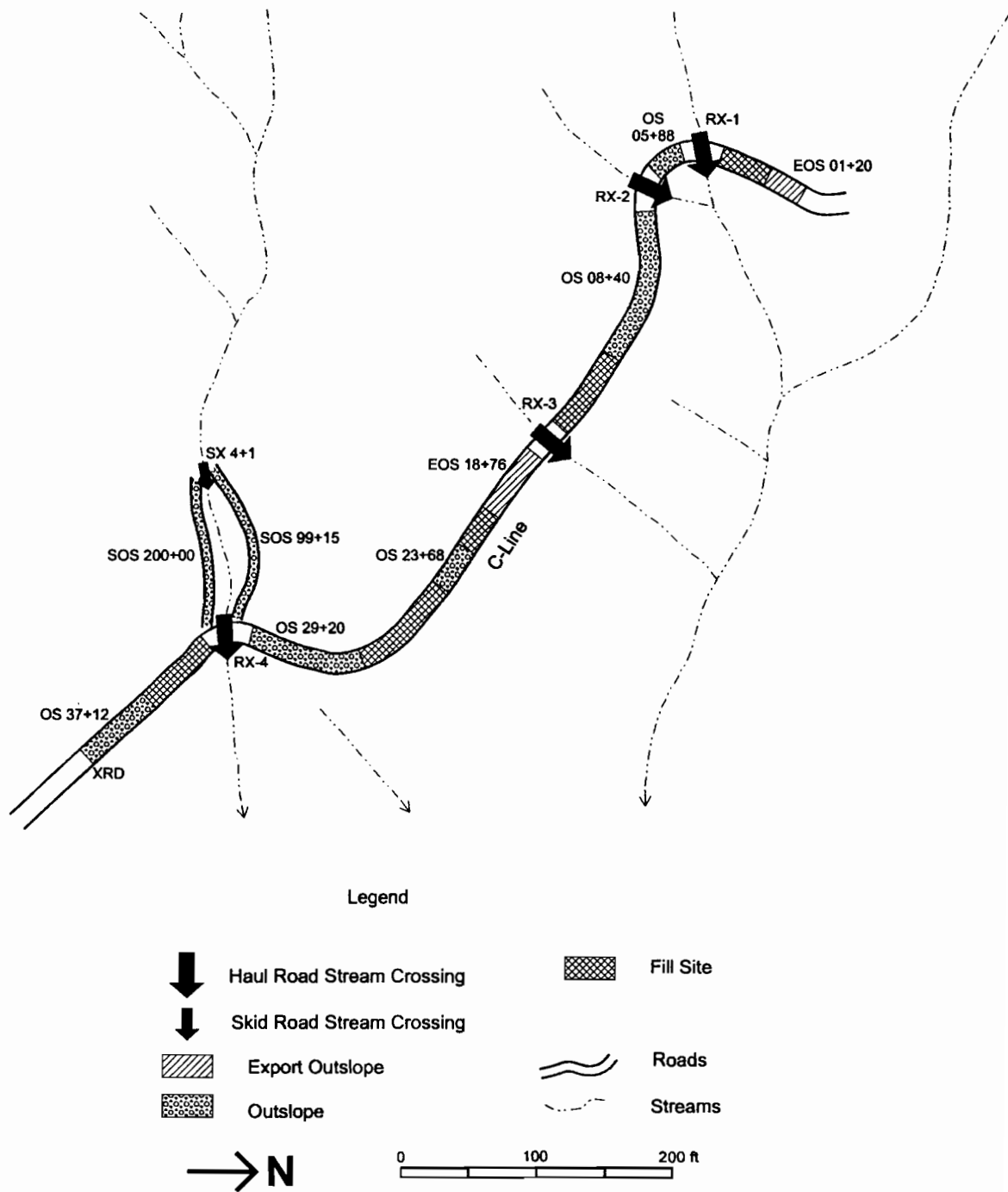


Figure 3. Location of Treatment Types in the Project Area

The contract was awarded to the lowest, responsive bidder, Cross Country Construction on August 21, 1997 for both the base bid and the additive bid. Concurrence from NMFS was finally received on August 27, 1997 and the notice to proceed was issued on that date.

The heavy equipment work began on August 30, 1997 and was suspended for the winter season on November 12, 1997. Heavy equipment work was resumed on July 31, 1998 and completed on August 21, 1998. The following equipment was used: a Komatsu PC 220 LC-6 excavator, a Komatsu PC 400 LC-3 excavator, a Caterpillar D8L bulldozer with winch, and a Caterpillar D8H bulldozer with winch. In 1997, Chris Cross and Pat Williams were full-time operators with Chris running the excavators and Pat running the D8L. Chris' sons, Forrest and Byran were occasionally on site working as laborers or running one of the excavators. When work was suspended in 1997, the contract was slightly behind schedule, so Chris hired another full time excavator operator, Bruce Gutenberger for the 1998 work season. The D8H was brought in part of the time in 1998 to work on one of the RX-4 fillsites. The D8H was run by John Jackson.

Stream Crossings

A summary of stream crossing excavation costs and production rates is shown in Table 2. A narrative of the excavation of each of the crossings follows.

RX-1

This crossing was fairly steep, narrow, and long. It also ended up being the wettest job on the entire contract. They were not able to dish down very far before hitting saturated fill. Most of the fill had to be lifted up to the haul road with the excavators. The dozer could then push the fill to the fillsite. The push was about 600 feet and the fill was wet so the D8L couldn't push a full blade full (5 minute turnaround). Therefore, the excavators often had to wait for the dozer.

The channel from RX-2 joins the channel from RX-1 at the bottom of RX-1. The outboard edge of the road fill in RX-2 had failed in December 1996 and debris flowed down the channel. A pile of material had been deposited at the bottom of RX-1. This pile was to be excavated as part of RX-1. This pile had been saturated after the failure of RX-2, but it had dried out over the summer so that a person could walk on it on foot. Chris took the 220 down to the bottom of RX-1 to start working on this pile. The 220 immediately got stuck. Chris tried three times to get on top of this pile by putting logs underneath his tracks. However, the material was still saturated and the excavator would sink as he tried to swing. There was no other feasible way to get this material out of the channel, so we ended up digging a channel around the left side of the pile and leaving the pile at the bottom.

Despite the fact that the surface water coming into the crossing was diverted around the excavation, a large amount of water continued to flow through the fill and emerge in the excavation area. Most of the fill remained saturated throughout excavation. The 220 would scoop a bucket full out of the channel and more mud would flow down to fill the hole. The material was so fluid that it wouldn't stack in a pile. The 220 sometimes had to scoop to the 400 one scoop at a time.

The wettest material was poured from the 220 bucket directly into the 400 bucket and then dumped onto the push road.

The left side of this crossing was steep bedrock. The right side was less steep with several springs. This configuration may be due to the dip direction of the underlying schist bedrock. A small bedrock cliff on the middle right side of RX-1 was exposed during excavation. A few feet down-slope of this bedrock was a small stump about 6 feet tall. It looks like this is an old scarp.

The production rate was slow because of the wet conditions, but eventually it was completed!

RX-2

As mentioned above, the outboard edge of the road fill in this crossing failed as a debris flow in December 1996. This caused the surface of the failure area to be wet, but the fill was not wet all the way through as RX-1 was. Chris built a corduroy road across the mid-right part of RX-2. Chris walked the 400 out on this road and the whole platform started sliding down hill. He took the 400 out, and brought the 220 onto the road. The road held up better with the lighter-weight 220 on it, but after working awhile, parts of the road started slipping. Because of the sliding road problem, a thin layer of fill was left in the bottom of RX-2.

When the excavation was completed, it was apparent that the boundary between the right edge of RX-2 and OS 08+40 was within the RX-2 stream valley. During post-excavation surveys, this boundary was moved up road to the edge of the valley, thereby increasing the volume of RX-2 over the design volume.

- There was an old-growth redwood tree on the lower right of RX-2. Fill was excavated from around this tree. During the winter of 1997-98, this tree fell over.

RX-3

This crossing was wider, shallower, and drier than the other crossings. There was a thick layer of black dirt containing black sticks in the bottom of the crossing. Chris dug down through this until he reached what we thought was original ground. Several stumps helped define the boundaries. During the winter of 1997-98 water flowed down from the top of RX-3 and disappeared underground into a hole. This indicated that the middle of the RX-3 channel was underexcavated by 1-2 feet.

As the excavation progressed, it became apparent that the boundary between the right edge of RX-3 and EOS 18+76 was within the RX-3 stream valley. Similar to RX-2, this boundary was moved up road to the edge of the valley during post-excavation surveys which increased the volume of RX-3.

SX-4+1

This skid-road crossing was located upstream of RX-4. The fillsites were steep skid roads adjacent to the crossing. The crossing was larger than designed and there wasn't any extra fill

space, so we pushed about 500 yd³ down skid-road 99+15 and left it on the road bench to be incorporated in the fillsite for skid outslope 99+15.

RX-4

Water was impounded on the upstream side of the road fill at this crossing to a depth of 13 feet. This is the largest crossing excavated in Redwood National Park to date. The design volume was 38,000 yd³ and the actual excavation volume ended up being 42,000 yd³. This large size caused several problems during excavation. We had some concerns about whether we would be able to finish the crossing before it became too wet to work because the volume was large and we were starting it late in the year. On October 4, 1997, we discussed options for starting RX-4 and winterizing it if we had to leave it unfinished over the winter. We decided to start it and leave the existing culvert in as long as possible so that it could function over the winter if we didn't finish excavating the crossing. The D8L began dishing down RX-4 on October 13, 1997.

Work progressed by dishing down the fill from the outside edge of the road bench. The dozer built ramps to push out material mostly to the fill pile on the left side of the crossing. When the dozer got down as far as it could, the 220 began working up from the bottom. There were a lot of logs buried in the bottom section of the channel. Beginning at the bottom stake, the channel excavation ran horizontally for about 40 feet when the original channel bottom (hard layer with black top soil containing roots) was reached. Chris also worked on finishing the left side as he went along so that he wouldn't have to go back and finish it later. This crossing was a lot drier than RX-1, but it contained some wet material and the push distances were long, so excavation was, at times, very slow with just one dozer. On October 30, 1997 the D8L broke down and it was not repaired until November 7. This was very unfortunate because we could not do any work on RX-4 while the D8L was down since it would have been very inefficient and impractical to work with just one excavator.

By early November, rain was occurring more frequently and the site was becoming wetter. On November 7, 1997 work was stopped and the site was winterized for the season. The park decided that enough fill had been excavated from the road bench so that the remaining material might not hold back the ponded water over the winter. The park decided that two parallel 24" culverts needed to be installed from the pond (which was now about 10' lower than it had originally been) to the finished channel bottom. The upper two culvert sections of each pipe were buried and the remainder of the sections were staked to the surface. A bench for the upper sections of pipe to lie on was excavated down as far as the 220 could work before the fill got too wet. Two 30° elbows were installed at the break in slope at the end of this bench and the rest of the culverts were placed from the elbows to the finished channel bottom. Silt fences, consisting of hog wire with filter fabric laid over it and attached and anchored to fence posts, were also installed shingled down the partially excavated fill slope.

During the winter of 1997-98 approximately 160 yd³ failed as a debris flow from the upper right portion of the partially excavated fill slope. This material was caught by the silt fences. Additional silt fences were installed on top of some of the original ones that had filled up with sediment. Silt fences any weaker than those installed probably would not have been able to hold back the material that failed. The culverts remained intact and operable throughout the winter, although they did leak at some of the joints.

When work was resumed in July, 1998, the fill was significantly drier than when work had stopped in the fall of 1997. Even most of the fill that had been caught behind the silt fences was relatively dry.

On August 10, 1998, it was becoming apparent that the only remaining designated fillsite for RX-4 on the right side of the crossing was too small to hold all the rest of the fill that needed to come out of RX-4. There was a long skid road that took off above the C-Line at the end of the job at station 40+29. We decided to push the excess fill up there. Chris brought in the D8H with operator John Jackson solely to push the excess fill from the originally designated fillsite to this new fillsite. We continuously tried to estimate how much fill was left to excavate in RX-4, how much space was left in the designated fillsite, and how much we needed to push to the new fillsite. All these volumes had to be revised numerous times to get everything to balance out.

Throughout excavation, the stream was flowing into the top of the crossing. As much of the water as possible was diverted around the excavation using 4" and 6" plastic pipes. This worked well and was essential for minimizing the amount of water in the fill. Some water continued to flow through the fill and emerged in some areas of the excavation making work slower and more difficult. Water could not be diverted around the excavation when we were finishing out the top of the crossing. This caused the fill to be saturated and very difficult to excavate because it wouldn't stack into a pile, wouldn't hold up the weight of the excavator, and the dozer couldn't push it very effectively.

Export Outsloping

A summary of export outslope excavation costs and production rates is shown in Table 3. Export outslope treatments were done in two road reaches where there was not sufficient space against the cutbank within the bid item to store all the material. The fill was pushed to other fill sites with the dozer.

Typically, export outslope treatments are used to treat headwater swales. However, geomorphically EOS 01+20 was a planer hillslope. It was designated as an export outslope because there was not enough room for the fill to be stored against the cutbank within the bid item and so the fill had to be shifted down the road to a throughcut between this bid item and RX-1. This was the first bid item on the job and thus the first thing excavated. The work was done over a week using the 220 excavator almost exclusively because the other equipment had not yet arrived on the site. Therefore the production rate was slow.

EOS 18+76 was a large, bowl shaped excavation adjacent to RX-3. Some fill from both this EOS and RX-3 had to be moved up and down the road a couple times in order to balance out the excavation volume and the fill space. This slowed the production rate somewhat.

Outsloping

A summary of outslope excavation costs and production rates is shown in Table 4. In general, top soil was not as easy to locate as in the crossings. Clues indicating original ground included some soil color change to dark red or brown soil, schist bedrock, and stumps.

C-Line

Production rates varied considerably for the different outslopes. OS 23+68 was surprising slower than the others. This may be do to the large number and size of trees that had to be dealt with compared to the low volume of dirt excavated. OS 05+88 had the highest production rate. This is probably because the distance from the outboard edge of the road to the “cut-to-here” was shorter than the other outslopes.

Skid Roads

Two skid roads that were perched above the creek between RX-4 and SX 4+1 were outsloped. Most of SOS 200+00 simply involved reaching down to the bottom of the fillslope with the small excavator and placing the material against the cutbank. There was not much room and the fill slope was short so the fill and cut volumes were simply matched 1:1 without worrying about trying to find top soil.

SOS 99+15 was at a higher elevation above the creek. The fill slope was longer and there were more trees to deal with. Some of the fill had to be shifted up the road so that it would all fit. This made the production rate slower.

Miscellaneous Bid Items

A summary of miscellaneous bid item costs is shown in Table 5. All miscellaneous bid items were lump sum items. Ripping was done to decompact the remaining road bench and inboard ditch underneath fillsites. Only one dozer was on site for the 1997 season. The contractor chose to have a dozer with a winch, rather than one with rippers, so that the winch could be used to move large woody debris and pull equipment out of the mud when it got stuck. Since the dozer did not have rippers, decompaction was done by digging up the road bed with the excavator buckets. This was effective in terms of decompacting the road, but was much slower than a dozer with ripper teeth.

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 generally not directly attributable to any specific bid item. Non-bid item times were recorded to compare the costs of the contract with that of an hourly rental. Table 6 provides a cost breakdown for non-bid items.

“Discussion time” is defined as periods of time where equipment operations were interrupted by discussions lasting 15 minutes or more. Several shorter discussion periods were sometimes combined into one when they added up to approximately 15 minutes (time was recorded in 15 minute intervals). Typically the contractor would stop to discuss the progress of a particular phase of a bid item or develop a strategy for the work with the other operators or COTR. On occasion, the COTR or site inspector would interrupt the operators to make sure that the specifications of the contract were understood and would be met.

“Stuck” refers to a piece of equipment getting stuck in the mud and needing to be pulled out with another piece of equipment. This includes both the time one piece was stuck and the time another piece spent assisting in rescuing the stuck equipment.

“Down time” occurred when equipment was unable to perform at its expected capacity. Down time was most often the result of mechanical failure.

“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 was able to be used but the contractor or operator choose not to use it. For this contract, there were times when the contractor had 3 pieces of equipment and only 2 operators. The extra equipment allowed the contractor greater flexibility in day to day planning, and in approaching specific worksites. In a rental situation, such flexibility would be prohibitively expensive as shown by the associated H.E.R.E. costs (see Table 6).

Labor Intensive Phase

Labor intensive rehabilitation and erosion control work usually includes all secondary treatments for surface erosion which, in the past, have typically involved the application of straw mulch to critical areas on finished rehabilitation worksites. Straw mulch was not applied on unit 97-1 for several reasons. Logs and topsoil were placed on the surface wherever possible. After restoration work was completed, redwood fronds and alder leaves naturally dropped from the surrounding second-growth forest onto the finished surface, which helped protect it from surface erosion. Natural revegetation, especially alder growth, is expected to be excellent. Previous studies indicate that straw may not be good in forest settings since it alters the soil to be more like that of a grassland and it may also introduce exotic species. The winter of 1997-1998 was moderately wet and erosion over the project area was minimal. Alder seedlings were already beginning to grow by the spring of 1998.

No labor intensive work was done on this project.

Documentation Phase

The final rehabilitation phase is the documentation process. This includes post-heavy equipment volumetric surveys, photo point documentation, cost data compilation, and writing the restoration

project report. This work was done by Becca Smith with essential help by numerous assistants, and was completed in February, 1999.

DISCUSSION

Project 97-1 met the goals of the watershed restoration program by minimizing human-caused potential erosion and sedimentation from roads into creeks and on hillslopes. Road fill was removed from stream crossings, swales, and road benches and natural topography and hydrology were restored. Topsoil was uncovered where possible. Woody debris was also spread on the finished slopes.

The contractor on this project, Chris Cross, is very good at this type of work. He anticipated what needed to be done and where the actual bounds of excavation would be. He knew which characteristics indicated original ground and when he had hit it. The other equipment operators, with the exception of John Jackson, had no prior experience with this type of work, so Chris had to spend time explaining to them what needed to be done and how best to do it. Chris was very conscientious in his work and took extra effort to insure that the excavations were down to original ground and that finished work was of the highest quality. As a result, there were no significant adjustments during the 1997-98 winter.

A total of 89,450 surveyed yds³ were excavated from potentially unstable areas and moved to stable fillsites at a total heavy equipment cost of \$306,744 which equates to an overall average of \$3.43/yds³. Most of the work involved large stream crossings, some of which were very wet.

TABLE 2												
STREAM CROSSING EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 97-1, C-LINE SOUTH ROAD												
Worksite	Volume (yds3)	Heavy Equipment Hours			Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate ^b (yds ³ /hr)	
		Komatsu PC 220 LC	Cat. D8L	Komatsu PC 400 LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/yd ³)				H.E.R.E. ^a (\$/yd ³)
C-LINE												
RX-1	9,600	75.25	99.00	55.25	0.00	\$29,760	\$42,138	\$3.10	\$4.39	\$3.10	400	42
RX-2	3,800	6.75	17.75	20.00	0.00	\$12,350	\$8,563	\$3.25	\$2.25	\$3.25	150	85
RX-3	6,700	11.50	40.75	36.00	0.00	\$20,770	\$17,075	\$3.10	\$2.55	\$3.10	200	76
RX-4 ^c	42,000	215.75	314.50	215.75	38.50	\$142,679	\$144,765	\$3.40	\$3.45	\$2.90	500	54
Total/Ave.	62,100	309.25	472.00	327.00	38.50	\$205,559	\$212,540	\$3.31	\$3.42			54
SKID ROAD												
SX-4+1	1,600	3.75	8.25	13.25	0.00	\$5,250	\$4,863	\$3.28	\$3.04	\$2.50	100	63

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: Komatsu 220 hydraulic excavator @ \$150/hr; Caterpillar D8L dozer @ \$200/hr; Komatsu 400 hydraulic excavator @ \$200/hr; and Caterpillar D8H dozer @ \$165/hr.

^b Excavation Rate = volume excavated divided by the total of all equipment time for each worksite.

^c RX-4 required substantial winterization. See Table 6 for winterization costs.

TABLE 3

EXPORT OUTSLOPE EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 97-1, C-LINE SOUTH ROAD

Worksite	Volume (yds ³)	Heavy Equipment Hours			Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate ^b (yds ³ /hr)
		Komatsu PC 220 LC	Cat. D8L	Komatsu PC 400 LC	Actual	H.E.R.E. ^a	Actual	H.E.R.E. ^a (\$/yd ³)			
EOS 01+20	2,900	38.25	4.25	0.00	\$5,220	\$6,588	\$1.80	\$2.27	\$1.80	120	68
EOS 18+76	6,700	4.75	46.00	34.50	\$15,075	\$16,813	\$2.25	\$2.51	\$2.25	250	79
Total/Ave.	9,600	43.00	50.25	34.50	\$20,295	\$23,400	\$2.11	\$2.44			75

TABLE 4

OUTSLOPE EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 97-1, C-LINE SOUTH ROAD

Worksite	Volume (yds ³)	Heavy Equipment Hours			Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate ^b (yds ³ /hr)	
		Komatsu		Cat.	Actual	H.E.R.E. ^a	Actual (\$/yd ³)	H.E.R.E. ^a (\$/yd ³)				
		PC 220 LC	D8L									
		PC 220 LC	D8L	Komatsu	PC 400 LC	D8H						
C-LINE												
OS 05+88	1,100	0.00	0.00	9.50	0.00	\$2,545	\$1,900	\$2.31	\$1.73	\$1.25	50	116
OS 08+40	5,600	6.50	26.75	28.00	0.00	\$10,360	\$11,925	\$1.85	\$2.13	\$1.85	125	91
OS 23+68	600	6.75	1.75	4.25	0.00	\$1,380	\$2,213	\$2.30	\$3.69	\$1.30	75	47
OS 29+20	3,300	26.75	10.00	5.25	0.00	\$8,451	\$7,063	\$2.56	\$2.14	\$1.60	200	79
OS 37+12	3,700	8.75	0.00	34.00	0.00	\$7,215	\$8,113	\$1.95	\$2.19	\$1.95	100	87
Total/Ave.	14,300	48.75	38.50	81.00	0.00	\$29,951	\$31,213	\$2.09	\$2.18			85

SKID ROADS

SOS 99+15	1,300	8	0	8.25	\$3,289	\$2,850	\$2.53	\$2.19	\$1.90	100	80
SOS 200+0	550	3.5	0	1.75	\$1,507	\$875	\$2.74	\$1.59	\$2.10	30	105
Total/Ave.	1,850	11.5	0	10	\$4,796	\$3,725	\$2.59	\$2.01			86

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: Komatsu 220 hydraulic excavator @ \$150/hr; Caterpillar D8L dozer @ \$200/hr; Komatsu 400 hydraulic excavator @ \$200/hr; and Caterpillar D8H dozer @ \$165/hr.

^b Excavation Rate = volume excavated divided by the total of all equipment time for each worksite.

TABLE 5 MISCELLANEOUS BID ITEM COSTS FOR UNIT 97-1, C-LINE SOUTH ROAD										
Job	Quantity	Heavy Equipment Hours			Total Costs		Unit Costs		Original	
		Komatsu PC 220 LC	Cat. D8L	Komatsu PC 400 LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/unit)	H.E.R.E. ^a (\$/unit)	Bid (\$/unit)
Move In	1					\$10,000	\$7,000	NA	NA	\$10,000
Move Out	1					\$5,000	\$7,000	NA	NA	\$5,000
Ripping	3,077	13.25	0.00	4.75	0.00	\$5,168	\$2,938	\$1.68	\$0.95	\$5,168
XRD	1	0.50	0.00	0.00	0.00	\$1,000	\$75	\$1,000	\$75	\$1,000
Total						\$21,168	\$17,013			\$21,168

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: Komatsu 220 hydraulic excavator @ \$150/hr; Caterpillar D8L dozer @ \$200/hr; Komatsu 400 hydraulic excavator @ \$200/hr; and Caterpillar D8H dozer @ \$165/hr.

TABLE 6 NON-BID ITEM COSTS FOR UNIT-97-1, C-LINE SOUTH ROAD									
Job	Heavy Equipment Hours			Other Costs		Total Costs			
	Komatsu PC 220 LC	Cat. D8L	Komatsu PC 400 LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual	H.E.R.E. ^a	
Discussions	39.75	20.00	20.25	0.75			\$0	\$14,136	
Salvage Log for RNP	0.00	0.50	0.00	0.00			\$0	\$100	
Dig Pit for Fuel Tank	0.25	0.00	0.00	0.00			\$0	\$38	
Walking Equipment	4.00	0.25	0.75	0.00			\$0	\$800	
Stuck	4.50	1.75	2.00	0.00			\$0	\$1,425	
Winterizing (slope and drain)	10.50	2.00	1.00	0.00			\$0	\$2,175	
RX-4 Culvert Installation ^b	13.75	2.25	2.75	0.00	\$12,948.32	\$859.20	\$12,948	\$3,922	
RX-4 Culvert Removal	7.25	0.00	0.25	0.00			\$0	\$1,138	
RX-4 Silt Fence Installation ^c	0.00	0.00	0.00	0.00	\$6,776.75	\$5,063.81	\$6,777	\$5,064	
Subtotal	80.00	26.75	27.00	0.75	\$19,725	\$5,923	\$19,725	\$28,797	
Down	20.50	84.00	73.00	0.00					
Idle	142.50	47.50	90.00	0.00					
Lunch/Breaks	46.75	47.75	44.25	3.75					
Totals	289.75	206.00	234.25	4.50					

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: Komatsu 220 hydraulic excavator @ \$150/hr; Caterpillar D8L dozer @ \$200/hr; Komatsu 400 hydraulic excavator @ \$200/hr, and Caterpillar D8H dozer @ \$165/hr.

^b Winterization of RX-4 involved installation of culverts and silt fences. Actual costs are \$8448.10 for materials (culverts, elbows, collars, fence posts, wire) and \$4500.22 for RNP employee labor. Other H.E.R.E. costs are \$859.20 for contractor employee labor.

^c Winterization of RX-4 involved installation of culverts and silt fences. Actual costs are \$1902.35 for materials (filter fabric, hog wire, fence posts, wire) and \$4874.40 for RNP and contractor employee labor. Other H.E.R.E. costs are \$1902.35 for materials and \$3161.46 for contractor employee labor.

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