

SUMMARY REPORT

C-40, C-50, C-70, and Lower C-Line
REHABILITATION UNIT 85-4

Resource Management Division
Redwood National Park

by
Daniel Vann

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INTRODUCTION

Unit Description

Rehabilitation unit 85-4 addressed the removal of the C-40, C-50, C-70 and a portion of the lower C-Line haul roads. (See map 1 & 2). These roads spanned two distinct watersheds; 1.) The Miller Creek Drainage (C-40), and 2.) The Emerald Creek Drainage (C-50, C-70, and L. C-Line). The unit roughly lies on the western side of Redwood Creek from Cloguet Creek to Emerald Creek and extends upslope to the C-Line, C-20 and the C-30 roads. Total relief within the rehabilitation unit is 1,350 feet from Redwood Creek (100 ft elevations) to the upslope boundary on the C-30 (1450 ft. elevation). Slopes within the unit are gentle to moderate averaging 30 to 50 percent. Hillslopes are composed of two distinct lithologic units divided by the Grogan Fault (See map 2). On the eastern side of the fault rocks are derived from the Franciscan formation (graywacke, siltstone, mudstone, chert, with some ultramafics and meta volcanics) where as; on the western side the rocks are of the south fork mountain schist (s.f.m.s.) assemblage quartz muscovite feldspar schist with some cobble and pebble conglomerate, with some ultramafics and meta-volcanics.) Since this is the first rehabilitation unit to span the Grogan Fault there are more types of soils than is most rehabilitation units.

Trailhead soils predominate west of the fault (derived from the s.f.m.s.) particularly on the upper and middle slopes. Copper Creek, Devils Creek, and Lacks Creek soils occur on the steeper schist slopes, and near Miller and Emerald Creeks (see map 2).

Atwell soils predominate east of the fault (derived from the Franciscan sedimentary rocks) especially in hollows near drainages. Copper Creek and Slide Creek soils are common on higher, better drained slopes. Prior to logging, the vegetation was forest type 111 with redwood, douglas-fir, western hemlock and tan oak in the overstory and a rhododendron - huckleberry - tanoak shrub understory. The cutovers now have mostly rhododendron, huckleberry ceanothus and baccharis -whipplea seral types with a low to moderate density of red alder.

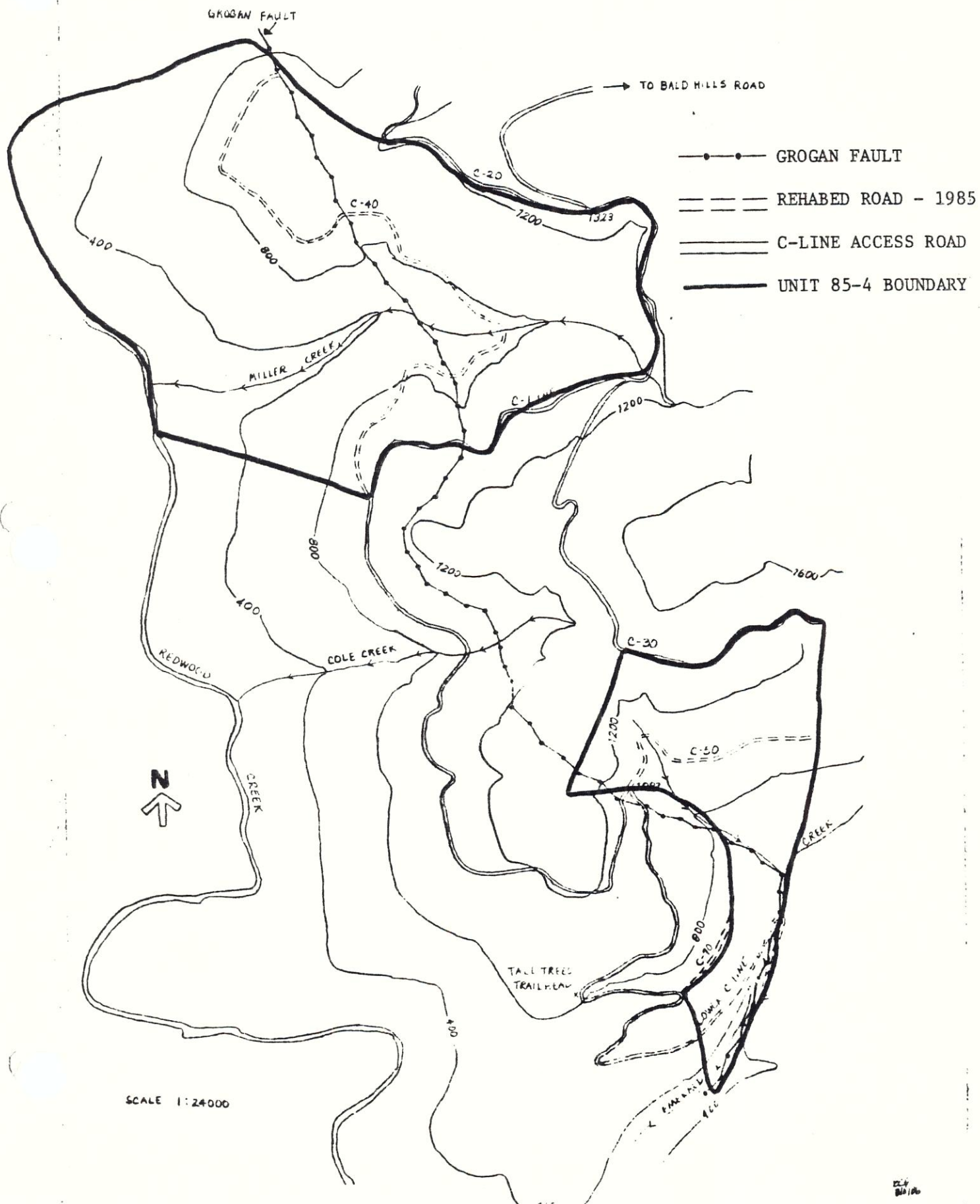
Erosion Features

The following section describes the recent erosional history of the unit. The information was obtained from aerial photographs taken in 1968, 1972, 1973, 1974, 1976, 1978, & 1982. The appendix has photo copies of aerial photos taken in 1972, 1973, 1974, and 1976. On site mapping occurred during 1984 and 1985. A reconnaissance in 1985 was performed to insure the validity of the previous years work and to establish if any new erosional problems had developed.

MAP 1. REHABILITATION UNIT 85-4 : SITE LOCATION



MAP 2. REHABILITATION UNIT 85-4 : ROAD SYSTEMS.



Erosion Features 1968

The 1968 photographs indicate that the unit supported a pristine, predominately old growth redwood/Douglas-fir forest. The old growth canopy inhibits analysis of surficial erosion and does not suggest recent mass movement features.

Erosion Features 1972

By 1972, the C-Line was under construction and had been completed approximately one-half mile south of the C-40/C-Line junction. Timber was being tractor logged only above the C-Line continuing upslope to the Bald Hill Road (see map 2). Timber harvest units were predominately clear-cuts with a few, minor, selective cuts.

The C-30, at this time, has been completely constructed but the C-40, C-50, and the C-70 had not yet been started.

A small translational, shallow seated landslide had occurred along the right bank of Miller Creek in the old growth forest. It was located several hundred feet, downstream from the C-40 bridge (as yet unbuilt). In the photos, the landslide is fresh and probably occurred during the 1972 winter storm.

Erosion Features 1973

Renewed construction of the C-Line had progressed to about 1500 feet beyond the C-50/C-Line intersection. The initial construction of the C-50 was underway and the road had been completed up to R-7 (see map 4). Due to the steepness of the hillslopes, adjacent to the stream channel at RX-52, the road had to be deeply cut into the slope. As a consequence, a large amount of sidecast earth was lost directly into the stream channel in building the road's fill prism. This condition was particularly amiss below R-7 and the landing on R-8 (see map 4). In addition, during the pioneering of the C-50 large amounts of excess logging slash had been pushed into the stream channel below RX-52.

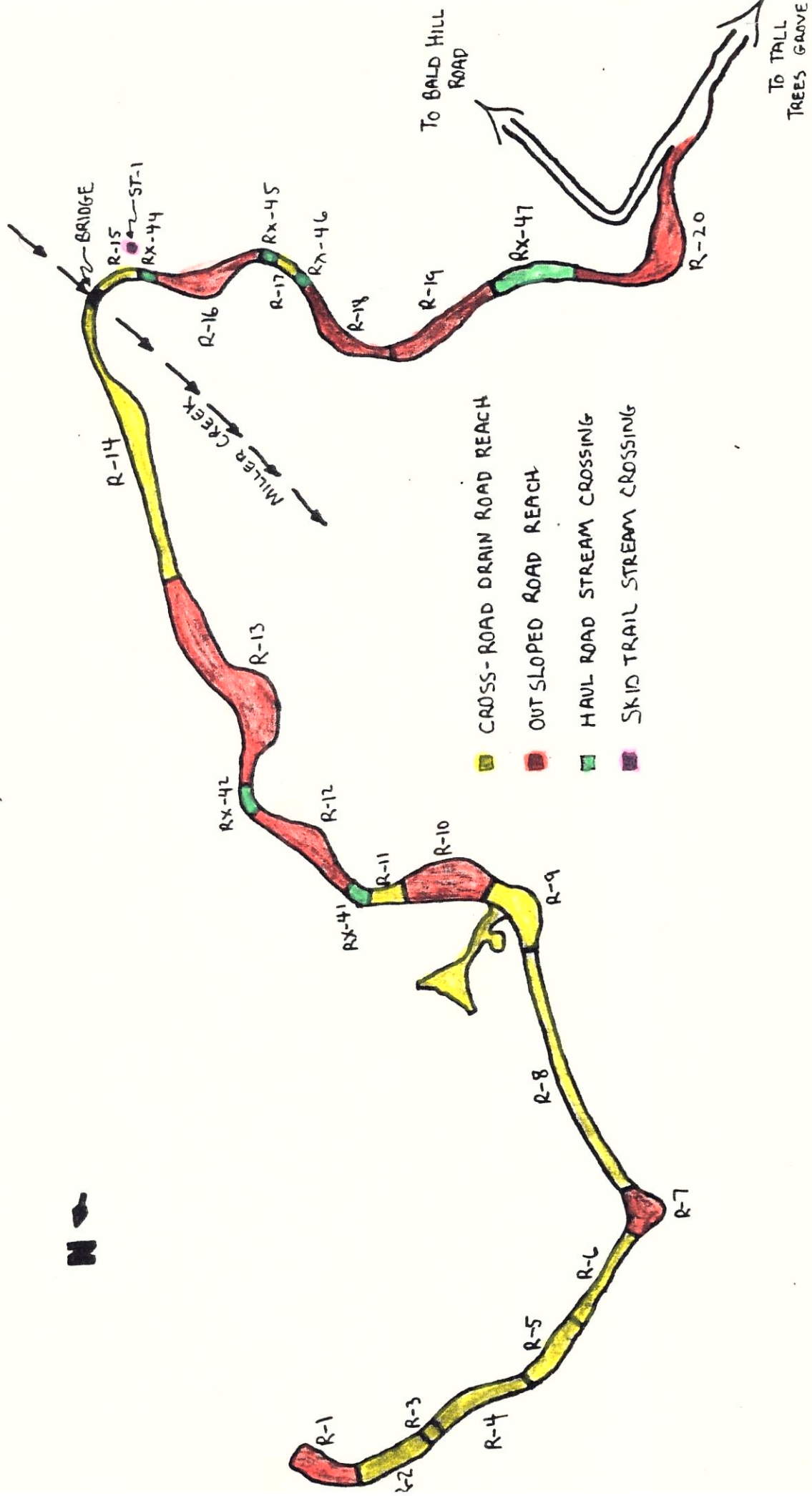
Timber harvest in the C-50 area was progressing downslope from the C-30, towards the yet to be completed C-50. Timber had been cut along the C-50 roadway up to R-5 and a small patch above R-7 had been cut on the hillslope

Erosion Features 1974

Road construction had accelerated in 1974 with the completion of the C-Line to it's termination point at the Emerald Creek Bridge. The C-50 and C-70 had also been completed. The construction of the C-40 had begun with work being completed up to RX-42.

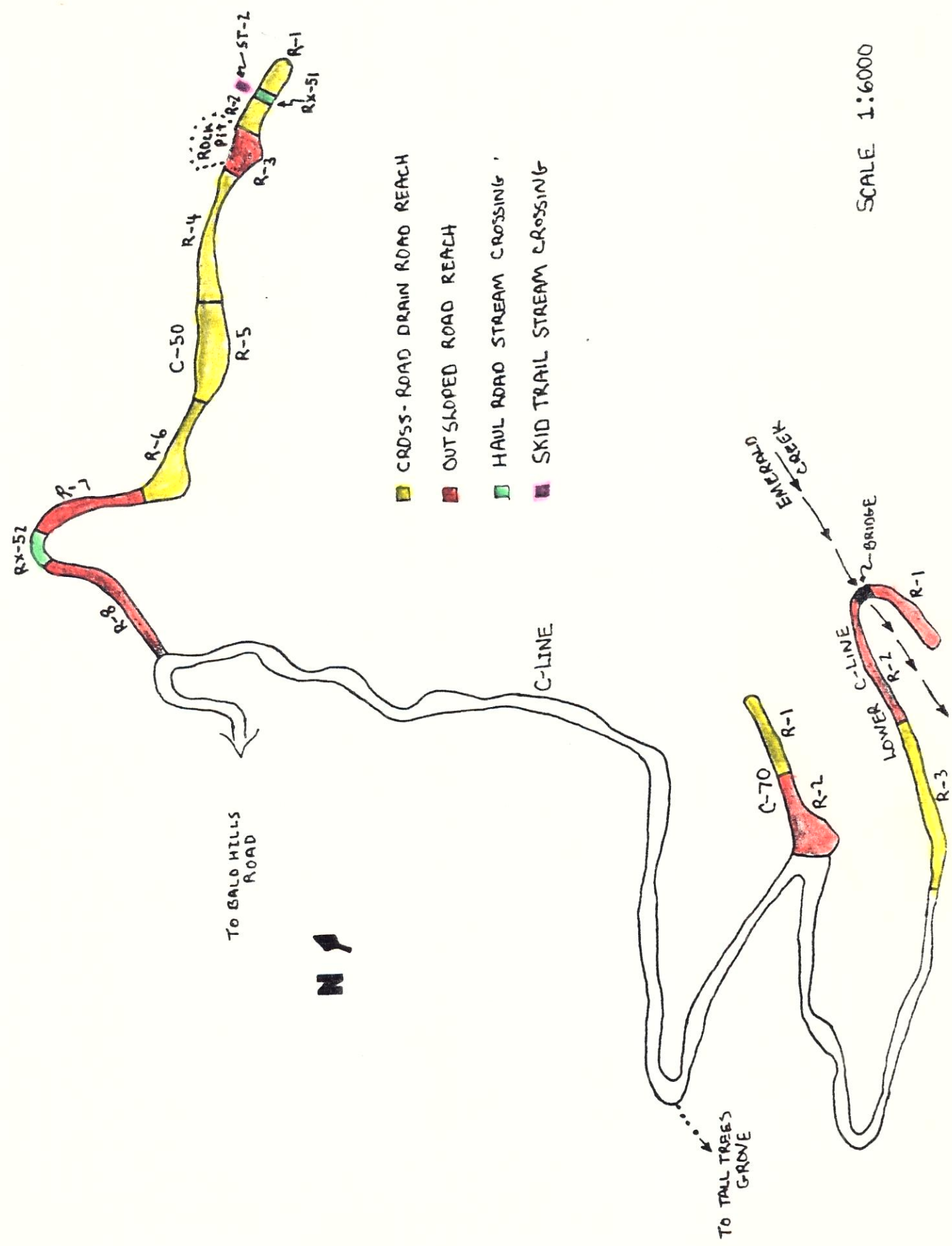
Timber harvest on the C-40 had progressed to R-15 (see map 3). Timber had been tractor clear-cut from the C-40, upslope, to the C-line. The stream channel passing thru RX-44, between the C-40 and C-line, had undergone

MAP 3 REHABILITATION UNIT 85-4 : C-40 ROAD WORKSITE LOCATIONS



SCALE 1:6000

MAP 4 REHABILITATION UNIT 85-4 : C-50, C-70, AND LOWER C-LINE ROADS WORKSITE LOCATIONS.



severe disruption. Large amounts of logging debris was pushed into the channel and at one point (skid trail crossing #1) the channel had been completely filled in obstructing passage of water into the lower section of the channel. The streams above RX-45 and RX-46 were left basically intact with minor amounts of logging debris in their channels. Skid trail crossings were not constructed across the stream channel above RX-45 and it appears that for the most part heavy equipment stayed out of the channel. The stream channel above RX-46 had sustained a minor amount of disturbance. Heavy equipment had been in the channel with minor impact, however, at one point it appears the channel was filled in for a crossing.

Timber harvest along the C-50 had resumed with timber being tractor clear cut between the C-30 and C-50 roads. The stream channel above RX-51 had large amounts of logging debris in its channel with numerous skid trail crossings along its entire length up to the C-30. The stream channel at RX-51 was completely filled in without a culvert being provided and water was flowing in many directions across the C-50. Directly above RX-51, at skid trail crossing #2, the channel is undefined being completely filled in by heavy equipment. Water was partially diverting down a skid trail, creating a gully, and was emerging out on the C-50 at R-1. Here, the water braided out across the landing and was saturating the ground. The stream channels above RX-52 sustained minor impact due to logging. Slash and fill in the channels was kept to a minimum.

Timber harvest around the lower end of the C-Line was very limited at this time. A small section of timber was removed above R-2 and the ground was beginning to show signs of instability such as, mudflows, debrisflows, and numerous springs.

Erosion Features 1976

By 1976, all the present road systems and timber harvest cuts had been completed with the exception of the cable yard unit on the C-50 below R-5 that was cut between 1976 and 1978. There was only three cable yard cut units on this rehabilitation site. The other two were on the C-40 below R-1 and R-8/9. The remainder of the rehabilitation unit was tractor-logged.

The area surrounding the stream channel entering RX-42 was logged in the intervening period from 1974 to 1976. Initially these stream channels felt little impact due to logging. The headwaters of the streams were disturbed by heavy equipment and a few skid trail crossings were constructed across their channels.

Unlike most logged hillslopes within the Redwood Creek drainage, this unit's hillslopes had relatively few, man induced erosion features. The reasons for the lower degree of erosion in this area were: relatively high infiltration rates on the slopes; low concentrations of emergent ground water; few skid trail crossings of perennial and intermittent streams; rapid revegetation; and most of the logged hillslopes have undergone only one major storm. Stream gradients and channel sidebanks are steep but pore pressures of the bank materials must remain relatively low due to the low

occurrence of stream bank failures. Gully and hill development is very low west of the Grogan Fault due to the high clay content of the soils derived from the south fork mountain schist. East of the fault the soils are more prone to gulling, but as stated before, the infiltration is good and very few gully systems developed.

Erosion Features 1978 - 1984

During this time period drainage patterns within the unit chiefly remained unchanged. Some diversion courses occurred with partial deflection of water out of their channels. Skid trail crossings #1 and #2 were the two major diversions that received treatment.

Primarily, two major areas of instability worth noting evolved on this rehabilitation unit. A large earthflow developed or was reactivated apparently as a result of deforesting the hillslopes on the C-40 above R-14. The toe of the earthflow progressed across the C-40 and heavy equipment was necessary to clear earth from the roadway.

The lower section of the earthflow became dormant and multiple toes developed approximately 200 to 300 feet above R-14 and began over-riding the older, dormant toe. The multiple toes began moving at different rates, and in some cases began over-riding the next consecutive lower toe. Multiple cracks and arcuate scarps evolved and incised above the toes in response to the vacated volume of earth moving downslope. Numerous springs and seeps also occurred across the slope and an axial gully system developed down the earthflow. The earthflow is primarily comprised of a non-coherent gray to black mudstone locally referred to as "blue-goo". This "blue goo" is presumably derived from deep oceanic muds.

The other earthflow is located on the lower C-Line above the beginning of R-2. This earthflow also seems to have been activated due to deforesting the hillslope. The hillslope shows bulging in several locations and the few remnant trees on the hillslope are leaning in various directions. The inboard ditch at the bottom of the hillslope has been filled in due to the progression of the toe across the lower C-Line roadway.

All the haul roads in the rehabilitation unit were showing signs of deterioration. Numerous scarps and cracks were developing along many of the road reaches.

On the hillslopes, slumping of skid trail roadways were occurring in areas proximal to the stream channels. In particular, the stream channels above RX-42 had mudflows that occurred in the channels due to skid trail crossings constructed across their headwaters.

Erosion Features 1985

In the spring of 1985, field evaluation of the rehabilitation unit began. Erosion features that were mapped in 1984 and 1985 were rechecked for accuracy and a full reconnaissance was made of the unit to determine if any new erosional problems had arisen.

EROSION CONTROL

Introduction

The rehabilitation work in Redwood National Park can be divided up into five phases: assessment, prescription, heavy equipment, labor intensive (which includes winter maintenance), and evaluation.

Assessment consists of inventorying erosion problems and locating sediment sources. This is accomplished through aerial photo interpretation, reconnaissance, and detailed geomorphic field mapping.

Prescription entails design of appropriate treatments to reduce erosion by correcting disrupted drainage patterns, and to excavate sediment sources adjacent to stream channels. This phase also includes selecting the types of heavy equipment to be used, surveying the worksites, documentation of work (photo points and notes), and generating an overall cost estimate for the project.

The heavy equipment phase involves earth moving equipment used to excavate fill, correct water diversions and to improve the stability of active and potential mass movement features. Heavy equipment is also utilized, at times to distribute and place rock and organics for armoring stream channels. This work is always performed during the summer months primarily due to heavy equipment limitations in wet conditions.

The principal task of the labor intensive phase involves distributing and spreading straw. Straw, used as a mulch, is placed over disturbed ground in order to reduce surface erosion from raindrop impact and to help retain soil moisture. Additional work includes rock repositioning that sometimes is required following the placement with heavy equipment. Winter maintenance at times, is necessary after channel adjustment occur on the site due to runoff from storm events. A team of laborers are used for these efforts.

The last phase to occur is an evaluation of the rehabilitation work. This is used to appraise the effectiveness of the prescribed work in terms of cost and erosion control. The evaluation is summarized in a written report compiled at the end of the year.

Objectives

The overall objective of rehabilitation work is to mitigate hillslope erosion induced by past land use practices. Logging has greatly accelerated erosion on the slopes of the Redwood Creek Basin, predominately due to haul road and skid trail construction. Primary considerations are: removing active and potential sediment sources (with major emphasis on proximal stream environments), returning drainage networks to their original configuration, and dispersing water.

The Rehabilitation Unit 85-5 principally addressed the removal of two major haul roads (C-40, C-50) a portion of a third (lower C-Line) and one secondary haul road (C-70). The total length of the roadways was 3.1 mile.

The area encompassed by the boundary of the rehabilitation unit was 925 acres. Eight haul road stream crossings and fifteen outslope reaches were excavated. The remainder of the road reaches were ripped and cross-road drained. There was some minor hillslope work that involved the channelization of two skid trail crossings due to their high erosion and water diversion potential.

Heavy Equipment Phase

Heavy Equipment Application

Rehabilitation work on the unit was carried out by two bulldozers and an excavator. Three dump trucks and the R.N.P. own backhoe were also briefly utilized at site specific locations (See table 1 for equipment specifications). The caterpillar D-8 bulldozer was designated to be the primary piece of excavation equipment. This machine is very competent at moving large volumes of material, providing maneuverability and ground conditions (moisture content) are favorable. Excavations were designed around the D-8 in order that it could remove as much of the volume of fill that was efficiently possible. The D-8 was also used to rip compacted surfaces for easier excavation or to improve the infiltration and aeration of the soil. The case 980 excavator and the caterpillar D-7 bulldozer were employed to act as support equipment to the D-8. They usually worked as a team on completing stream crossing excavations, outsloping, and placing rock armor. The three dumptrucks were used exclusively on the lower C-line (R-2) to facilitate the endhauling of fill to stable fillsite (on R-3), that was not available locally. The R.N.P. backhoe was used to re-locate rock armor stockpiles, at a few haul road stream crossings, in order to improve maneuverability of the heavy equipment during excavation. For further discussion on heavy equipment applications and limitations see R.N.P. Rehabilitation Reports from 1980 to 1984.

Heavy Equipment Sequencing

Heavy equipment was scheduled such that the D-8 worked ahead of the 980-B and D-7 completing as much of the primary rehabilitation work as was possible. Rehabilitation work was initiated by the D-8 at the termination point of the road and work progressed towards the road's intersection with the C-line. Work on the lower C-line involved the removal of its first 1800 feet of roadway from its termination point just past the Emerald Creek Bridge. A primitive access road was left along the upper portion of haul road stream crossings, at the lower perimeter of outslope reaches, and through ripped reaches. The D-8 was able to excavate from 50 to 90 percent of the haul road stream crossings and about 90 percent of the outslope reaches. The 980B and D-7 completed the rehabilitation work on outsloped and stream crossing excavations. They were also responsible for the secondary heavy equipment phase which consisted of placement of rock-armor within stream crossing excavations. Besides assisting the excavator in removing fill, the D-7 was used for touch-up work on sloped areas, feeding rock-armor to the excavator, and was particularly useful at winching logging debris from excavations or rescuing machinery stuck in the mud. Cross-road drains were excavated by different equipment depending on excavation efficiency and/or the logistics of the work schedule.

The D-8 started two weeks ahead of the other equipment doing preliminary work on the C-40. By the third week all the heavy equipment was on the rehabilitation unit. The D-8 was transferred from the C-40 to begin preliminary work on the C-50. The excavator and the three dumptrucks were

TABLE 1 SUMMARY OF EQUIPMENT SPECIFICATIONS

<u>Equipment type</u>	<u>Make/Model</u>	<u>Year</u>	<u>Rate/Hour</u>	<u>Total Hours</u>
Bulldozer	Caterpillar D8-46A W/13 wide 4-way Hydraulic Tilt Straight Blade and 36 Rippers	1972	\$ 95.00	241
Bulldozer	Caterpillar D7-G W/13 wide 4-Way Hydraulic Tilt U-Blade and Winch	1969	\$ 74.00	314
Excavator	Case 980-B W/Standard Toothed Bucket and Triple Grouser Tracks	1981	\$100.00	217
3 Dump Trucks	2-10 yd Bed	1970	\$ 41.50	132
		1975		
	1-12 yd Bed	1977	\$ 41.50	

outsloping R-2 on the lower C-line. The D-7 was outsloping R-1 on the C-line, the C-70 landing (R-3) and working the lower C-line fillsite (R-3) as the dumptrucks filled in the space. The three dumptrucks were released during the fourth week and all the equipment was working on the C-50. It was particularly important at this stage of the project to schedule the 3 pieces of equipment to be able to work on RX-52 together. This was necessary due to the long distance from the excavation site to the fillsite which needed two bulldozers for pushing fill while the 980B excavated the crossing. However, even the best laid plans are subject to fate. The 980B excavator had a terminal break down without another one available in the county. For the fifth and sixth week the two bulldozers were rescheduled to account for the adversity. By the end of the sixth week, all the preliminary work that could be done by bulldozers was completed and the D-8 was released. A new 980B excavator was commandeered on the seventh week and rehabilitation work resumed on the C-40. The C-40 was finished at the beginning of the ninth and during this week the work that was left on the C-50, C-70 and lower C-line was completed.

Heavy Equipment Treatment Objectives, Costs and Evaluation

The totals of all the costs procured on this rehabilitation unit is summarized on table 2. The average costs of heavy equipment for specific prescriptions can be found on table 3. Primary treatments involved the excavation of haul and skid road - stream crossings, removal of unstable road reaches by outsloping the fill prism, ripping the road surface within stable road reaches to facilitate infiltration of water and aeration of the soil, and cross - road draining of springs, seeps, and concentrated water onto stable slopes and into defined drainages. Secondary treatment involved channel armoring of haul road stream crossing excavations and some minor transportation of straw.

Channel armor may be organic (logs, branches, etc.) or inorganic (rock) depending on availability. Organic armoring usually consists of debris which is left intact (usually keyed) as part of the channel bottom or bank during excavation, or is locally accessed. Rock armor is often acquired from the spoil of an excavation or locally from the road surface or other source. However, almost all the rock armor used on this site was delivered in 1982. This was done prior to the closing of a local rock pit in anticipation of future work along the C-40 and C-50 roads.

The most costly treatment incurred on this rehabilitation unit was the outsloping of road reaches. This accounted for 66.7% of the total cost of heavy equipment (see table 3). Table 4 gives a breakdown of all the outslope reaches excavated on this unit. Outsloping was prescribed in areas where excessive fill had been placed adjacent to a stream channel or where the roadway had cracks or scarps and a failure could endanger the old growth forest below. The old growth forest is considered to be a very valuable resource worth the funds for protection. Most of the outsloping was related to large landings constructed on steep slopes which required large volumes of fill in their construction. A total of 46853 yd was excavated and transported to more stable slopes.

Outsloping on this rehabilitation unit was a very cost effective treatment averaging \$0.93/yd of excavated fill. This parameter includes the cost of excavation and placement of the fill at the fillsite. This relatively low unit of cost can be attributed to using very efficient earth movers (the bulldozers) which excavated approximately 90 to 95% of most of the outslope reaches. The D-7, even though less powerful than the D-8, could push almost as much fill as the D-8. The reason being that the D-7 had a U-blade attached to it which is specifically designed for pushing fill. Combine the lower rental rate of \$74.00/hr for the D-7, compared to \$95.00/hr for the D-8, and its ability to approximate the push volume of a D-8 lead to a very cost effective team of equipment on outsloping. The excavation conditions, for the most part, were excellent for the bulldozers to work in. Manuverability, composition of the fill, very favorable ground conditions, and easy straight pushes also contributed to the cost effective figures as seen in Table 4. These costs are atypical of outsloping on other rehabilitation units. A higher cost/yd³ should be anticipated unless working with ideal situations.

TABLE 2 SUMMARY OF REHABILITATION COSTS Unit 85-54

	Technician	RNP Laborers	Heavy Equipment	Redwoods United Inc.	YCC	Total Task Cost	Total Phase Cost	Phase % of Total
Mapping	4844.00					4844.00	9801.25	11
Prescriptions	4957.25					4957.25		
Primary Treatment			58,032.50			58,032.50	68,769.08	74
Miscellaneous			5,326.00			5,326.00		
Supervision	5410.58					5410.58		
Secondary Treatment	257.34	4248.00	2387.75	2350.00	1021.25	10,264.34	10,264.34	11
Cost Analysis	3980.00					3980.00	3980.00	4
Documentation								
TOTALS	19449-17	4248.00	65,746.50	2350.00	1021.25	92814.67		100%

1. Includes help of
H.E. with straw

2. Miscellaneous costs
include:
1. clean-up
2. lunches
3. Rx53 (large drain)

Table 3 Summary of Heavy Equipment Costs Unit 85-44

Treatment	# of Worksites	Total Quantity	Total Costs	Average Cost Per Worksite	Range in Cost Per Worksite	Average Cost Per Quantity	Range in Cost Per Quantity	% of Total Cost
Haul road stream crossings	8	6,521 yds ³	9,358.00	1,169.75	474.75 4,127.75	1.43	0.84/yd ³ 2.74/yd	14.2
Skid trail stream crossings	2	200 yds ³	266.50	133.25	93.00 174.00	1.33/yd ³	193/yd ³ 1.74/yd ³	0.4
Outslipping	15	46853	43,879.50	2925.23	190.00 11,284.00	0.93/yd ³	1.93/yd ³	66.7
Cross road drains			4,528.75					7.0
Rock Armor Placement			1,872.50					2.8
Straw Hauling			515.25					0.8
Miscellaneous			5,326.00					8.1
Non-itemized								
Totals		53,574 yds ³	65,746.50					100

Table 4 Outslope Road Reaches: Unit 85-54

Road Reaches	Equipment	Hours	Cost	Volume (yds)	Unit Cgst (\$/yds)	Average Push Distance (feet)	yd ³ /ft
C-40							
R-1	D-8	15.75	1,496.25	2724	.55	50	9.4
R-7	D-8	2	190.00	250	.76	75	2.5
R-10	D-8	29.75	4,081.25	3634	1.12	100	14.5
	D-7	7.5					
	980B	7					
R-12	D-8	7.25	1,297.75	2246	.58	100	17.3
	D-7	3.5					
	980B	3.5					
R-13	D-8	30.5	6,712.50	11,335	.59	100	21.7
	D-7	22.5					
	980B	21.5					
R-16	D-8	24.5	4,613.00	5418	.85	120	8.1
	D-7	20.75					
	980B	7.5					
R-18	D-8	10.5	2,418.50	4170	.58	100	12.9
	D-7	16.5					
	980B	2					

Table 4 Outslope Road Reaches: Unit 85-54

Road Reach	Equipment	Hours	Cost	Volume (yds)	Unit Cgst (\$/yds)	Average Push Distance (feet)	yd ³ /ft
<u>C-40 Continued</u>							
R-19	D-8	3	495.00	1195	.41	40	2
	D-7	2.5					
	980B	.25					
R-20	D-8	9.5	3,058.50	2600	1.18	50	3.5
	D-7	19					
	980B	7.5					
<u>C-50</u>							
R-3	D-8	6.25	960.25	1332	0.72	90	11.1
	D-7	2.25					
	980B	2					
R-7	D-8	.25	1,198.75	835	1.44	30	2
	980B	11.75					
R-8	D-8	10.5	2321.5	3,153	0.74	60	6.6
	D-7	13.5					
	980B	3.5					
<u>C-70</u>							
R-2	D-7	36.75	2,719.00	1402	1.93	70	4.7

Table 4 Outslope Road Reaches: Unit 85-14

Road Reach	Equipment	Hours	Cost	Volume (yds)	Unit Cost (\$/yds)	Average Push Distance (feet)	yd ³ /ft
<u>Continued</u>							
<u>Lower C-Line</u>							
R-1	D-7	4.5	1,033.00	650	1.58	40	3
	980B	7					
R-2	D-7	19	11,284.00	5909	1.90	Endhaul 1000 ft	9.0
	980B	44					
	3 Dumptrucks	132					

Outslope reach R-7 on the C-50 was the only reach not outsloped by bulldozers. The 980-B did all the excavation at a cost of \$1.44/yd. This was a higher cost than the average but was still a good unit cost for outsloping by an excavator. The roadway was narrow which allowed the 980-B to excavate the fill and place it on the cutbank in one motion.

The endhauling of fill on the lower C-line (R-2) had atypically low cost of \$1.90/yd. This low unit cost can also be attributed to ideal conditions. The low cost/yd³ for truck endhaul was accomplished because the fill was easily excavated, it contained little logging debris, the dumptrucks had a good road surface to drive on, dumping at the fillsite was quick, and the 980-B could dig the fill with little repositioning and could load the dumptrucks directly. Again, higher costs should be anticipated in more typical situations.

Haul road stream crossings were the second most costly treatment on the unit. This treatment accounted for 14.2% of the total cost of heavy equipment. For a summary of the haul road and skid trail crossings categorized by size (volume) see table 5. Table 6 gives a breakdown of all the haul road stream crossings excavated on this unit. Removal of haul road stream crossings was deemed necessary due to the extremely high potential for fill to fail directly into a stream channel and to prevent water being diverted out of the channel at the crossing. Excavation prescriptions were designed to achieve a stable channel morphology and, when feasible, complete removal of the fill to expose the original channel banks and bottom. The stream crossing RX-44 had the lowest cost of all the crossings at \$0.84/yd. This can be attributed to ideal excavation conditions. The D-8 excavated approximately 75% of the crossing. Manuverability and ground conditions were ideal and the mean push to the fillsite was about 40 feet. These factors lead to a very cost effective excavation.

The stream crossing RX-46 had a cost of \$2.19 yd³. This stream crossing included not only removing the roads fill prism but the channel below the crossing had to be excavated for approximately 100 feet. This was due to the large amount of logging debris and fill in the channel that was restricting the flow. This required the 980-B to work on uneven wet ground and it had to reposition itself many times. The work was tedious and time consuming.

The largest, continuous fault in Redwood National Park, the Grogan fault, passes very close to the RX-52 haul road stream crossing and it roughly follows the trend of the stream channel in this location. The volume removed from the crossing was 2,130 cubic yards at a cost of \$3,928.75. This resulted in an average cost of \$1.85/yd³. The crossing was excavated with both bulldozers and the excavator. The two bulldozers were capable of excavating approximately 80% of the crossing. After the initial stage of excavation the D-7 took over excavating the fill and pushing it to the D-8 which continued the push to the fillsite. The mean push to the fillsite was 250 feet. The last 20% of the crossing was excavated by the 980-B that feed the D-7 the fill and as before the D-7 feed the D-8. The drainage

Table 5. Summary of Haul Road and Skid Trail Stream Crossing Excavation Costs Unit 85-5

Size of Excavation	# of Worksites	Equipment	Total Cost	Total yds3	Avg. Cost/ Worksite	Average Cost/yd3	Range: Cost/yd3
Extra-small 0-100 yd3	2	D7-G 980-B	\$266.50	200	\$133.25	\$1.33	\$.93-1.74
Small 101-400 yd3	3	D8-46A, D7-G 980-B	1,544.00	880	293.22	1.75	1.49-2.74
Medium 401-800 yd3	2	D8-46A, D7-G 980-B	1,857.00	1,340	928.50	1.38	1.15-1.56
Large 801-2,000 yd3	2	D8-46A, D7-G 980-B	2,028.25	2,171	1,014.12	0.93	.84-1.00
Extra Large 2,000 yd3	1	D8-46A, D7-G 980-B	3,928.75	2,130	--	1.85	--
Totals	10		\$9,624.50	6,721	\$962.45	\$1.43	

Table 6. Haul Road Crossings Unit 85-5

Crossing	Equipment	Excavation Hours	Excavation Cost	Volume (yds3)	Unit Cost (\$/yds3)	Avg. Push Distance	Drainage Area (acres)	Volume of Rock Armor (yds3)	Cost of Armoring*	Total Cost
RX41	D-8	2.75	\$522.25	350	1.49	50 ft.	12	--	--	\$522.25
	D-7	1.5								
	980B	1.5								
RX42	D-8	6.5	1,201.50	770	1.56	100 ft.	19	90	783.00	1,984.50
	D-7	3.5								
	980B	3.75								
RX44	D-8	3.25	787.25	933	0.84	40 ft.	31	45	436.00	1,091.75
	D-7	2.75								
	980B	2.75								
RX45	D-8	2	655.50	570	1.15	40 ft.	31	45	436.00	1,091.50
	D-7	3.25								
	980B	2.25								
RX46	D-7	3	547.00	250	2.19	50 ft.	29	--	--	547.00
	980B	3.25								
RX47	D-8	2.25	474.75	330	1.44	35 ft.	5	--	--	474.75
	D-7	1.5								
	980B	1.5								
RX51	D-8	7.5	1,241.00	1238	1.00	50 ft.	22	--	--	1,241.00
	D-7	2.75								
	980B	3.25								
RX52	D-8	20.25	3,928.75	2130	1.85	250 ft.	31	90	199.00	4,127.75
	D-7	20								
	980B	5.25								

*Cost of armoring only includes cost of placement by heavy equipment not cost of rock or transportation to worksite.

area above the crossing was relatively small, at 31 acres even so the stream channel was excavated as much as possible due to the high erodibility of the fill comprising the crossing. Ninety cubic yards of large clast rock armor was placed at the bottom of the crossing to discourage downcutting and establish a base-level for the channel bottom. A higher cost/yd³ would have been expected if the two bulldozers were unable to excavate such a large amount of the crossing.

The cost of placing cross-road drains and the ripping of road reaches totaled \$4,528.75 (see table 7 for break down). This is a very cost effective rehabilitation treatment in areas where the stability of the road and adjacent hillslopes are not questionable. Miscellaneous costs are costs not applicable to being placed in any of the conventional rehabilitation treatment categories. These costs include ditch work, walking heavy equipment to new worksites, moving fuel tanks and trucks, discussing work strategy, and lunches. Cross-road drain reaches and miscellaneous costs accounted for 15.1% of the total cost of heavy equipment. The final 3.6% of the total cost was absorbed by rock armor placement and the hauling of straw by heavy equipment.

Table 7. Cross-Road Drain Reaches Unit 85-5

<u>Road Reach</u>	<u>Equipment</u>	<u>Hours</u>	<u>Cost</u>	<u>Length</u>	<u>Road Width (Feet)</u>	<u># of CRD</u>	<u>Cost/Ft</u>
C-40							
R-2 - R-4	D-8	1.75	\$166.25	695	30	6	.24
R-5	D-8	1	95.00	375	110	2	.25
R-6	D-8	1.5	142.50	410	20	5	.35
R-8	D-8	1.5	142.50	1050	20	11	.14
R-9	D-8	1.5	142.50	830	55	7	.17
R-11	D-8	.25	23.50	170	30	0	.14
R-14	D-8 D-7 980B	5.75 2 3	944.25	1330	30	9	.71
R-15	D-8 D-7 980B	1 .5 .5	182.00	300	25	1	.61
C-50							
R-1	980B	3	300.00	320	90	3	.94
R-2	D-8	2	190.00	360	40	2	.52
R-4	D-8	3.5	332.50	580	32	6	.57
R-5	D-8 D-7 980B	3.75 2.5 1.75	716.50	295	75	3	2.43

Table 7. Cross-Road Drain Reaches Unit 85-5 (cont'd)

<u>Road Reach</u>	<u>Equipment</u>	<u>Hours</u>	<u>Cost</u>	<u>Length</u>	<u>Road Width (Feet)</u>	<u># of CRD</u>	<u>Cost/Ft</u>
C-50 (cont'd)							
R-6	D-8 D-7	2.25 .5	\$250.75	500	45	5	.50
C-70							
R-1	D-8 D-7	1.25 1.75	248.25	500	30	6	.50
Lower C-Line							
R-3	D-8 D-7 980B	1.75 1.5 3.75	652.25	740	30	5	.88

Labor Intensive Phase

Labor Intensive application

The labor intensive work was implemented by three crews: Redwood National Park laborers (RNP) Redwood United Inc. employees (RUI), and the Youth Conservation Corps (YCC). The principal task of the labor intensive personnel was the spreading of a straw mulch over disturbed ground. Other tasks included straw delivery, hauling culverts and hand rocking (see table 8).

Straw was distributed by placing a pre-calculated number of bales in stockpiles at flagged locations along the road. Straw mulch concentrations were the greatest on the side banks of stream crossing excavations and on the outslope reaches with an applied rate of 5000 lb/acre and 4500 lb/acre respectively. Some cross-road drain reaches were mulched at 3000 lb/acre if the reach was subject to a harsh exposure to the elements. After completion of a worksite by heavy equipment, the straw was spread as soon as possible to minimize walk-in distances over completed sections of road impassable by vehicles.

TABLE 8

SUMMARY OF LABOR INTENSIVE TREATMENT COSTS

<u>Treatment</u>	<u>Crew</u>	<u>Personnel Hours</u>	<u>Average Wage per/hr</u>	<u>Cost</u>	<u>Total Cost</u>
Straw Delivery	RNP	122	\$9.99	1098.00	1617.25
	YCC	155	\$3.35	519.25	21%
Spreading Straw	RNP	338	\$9.00	3042.00	5834.50
	RUI	458	\$5.00	2290.00	77%
	YCC	150	\$3.35	502.50	
Hauling Culverts	RNP	9	\$9.00	81.00	81.00
Rocking	RNP	3	\$9.00	27.00	87.00
	RUI	12	\$5.00	60.00	
Total Cost					<u>7619.75</u>

Labor Intensive Costs

The labor intensive cost for the unit amounted to \$7,619.75 (Table 8). The spreading of straw accounted for 77% of the total cost. Straws delivery was 21% and the remaining 2% was for hauling culverts and hand rocking a portion of RX-42.

HEAVY EQUIPMENT SUMMARY

An experienced, enthusiastic, highly skilled operator is one of the most important factors in achieving low unit costs for excavations. This years operators fit this criteria very well as the tables of the unit costs of excavation reflect.

The most cost effective choice of heavy equipment to date, is the use of a large bulldozer in conjunction with a large excavator/medium size bulldozer team. The large bulldozer, usually a caterpillar D-8, is a very efficient earth mover. For this reason, work is scheduled such that the large bulldozer excavates as much fill as is possible at a worksite. The excavation/medium size bulldozer team is used for "clean-up" of a worksite removing the last amount of fill remaining. This remaining fill is usually in the form of a berm on the outboard edge of outsloped reaches or is fill that was left behind in stream crossings due to limited maneuverability for the large bulldozer. The excavation is very useful in performing the intricate finishing duties at worksites, such as, "sculpturing" the bottoms of stream crossing channels or in placing rock armor.

In conclusion, the staff was very pleased with the quality and cost effectiveness of the erosion control work completed by the heavy equipment operators and labor intensive crews on this rehabilitation unit.



Unit: 85-4 PP1 7/2/85



Unit: 85-4 PP1 6/16/86



Unit: 85-4 PP4 7/2/85



Unit: 85-4 PP4 11/7/85



Unit: 85-4 PP4B 7/2/85



Unit: 85-4 PP4B 6/16/86



Unit: 85-4 PP5 7/2/85



Unit: 85-4 PP5 11/7/85