M-3 and M-4 Roads and Slope

Watershed Rehabilitation Project

Unit 87-5

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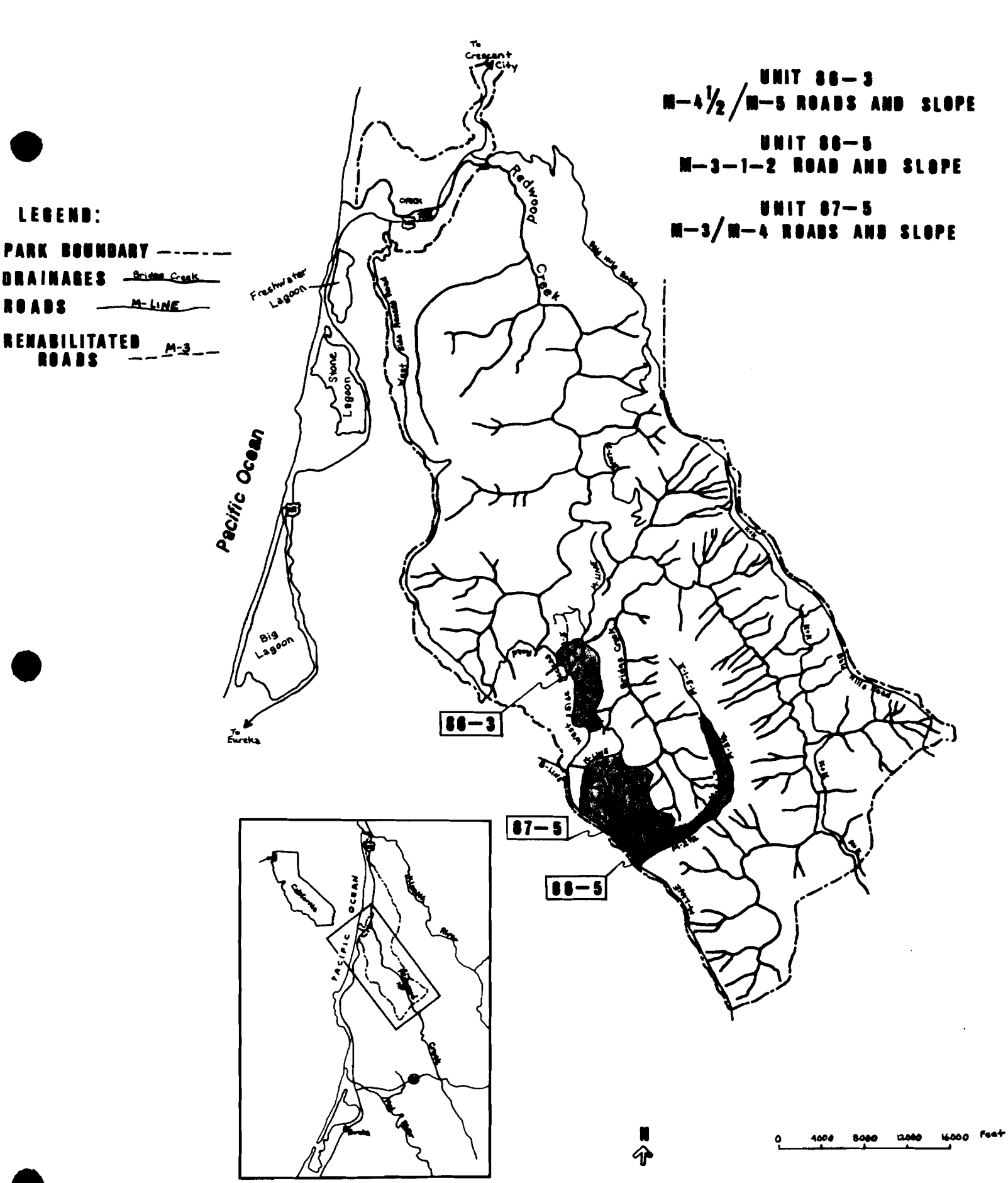
The M-3 and M-4 Roads and Slope
Watershed Rehabilitation Project
Unit 87-5

INTRODUCTION

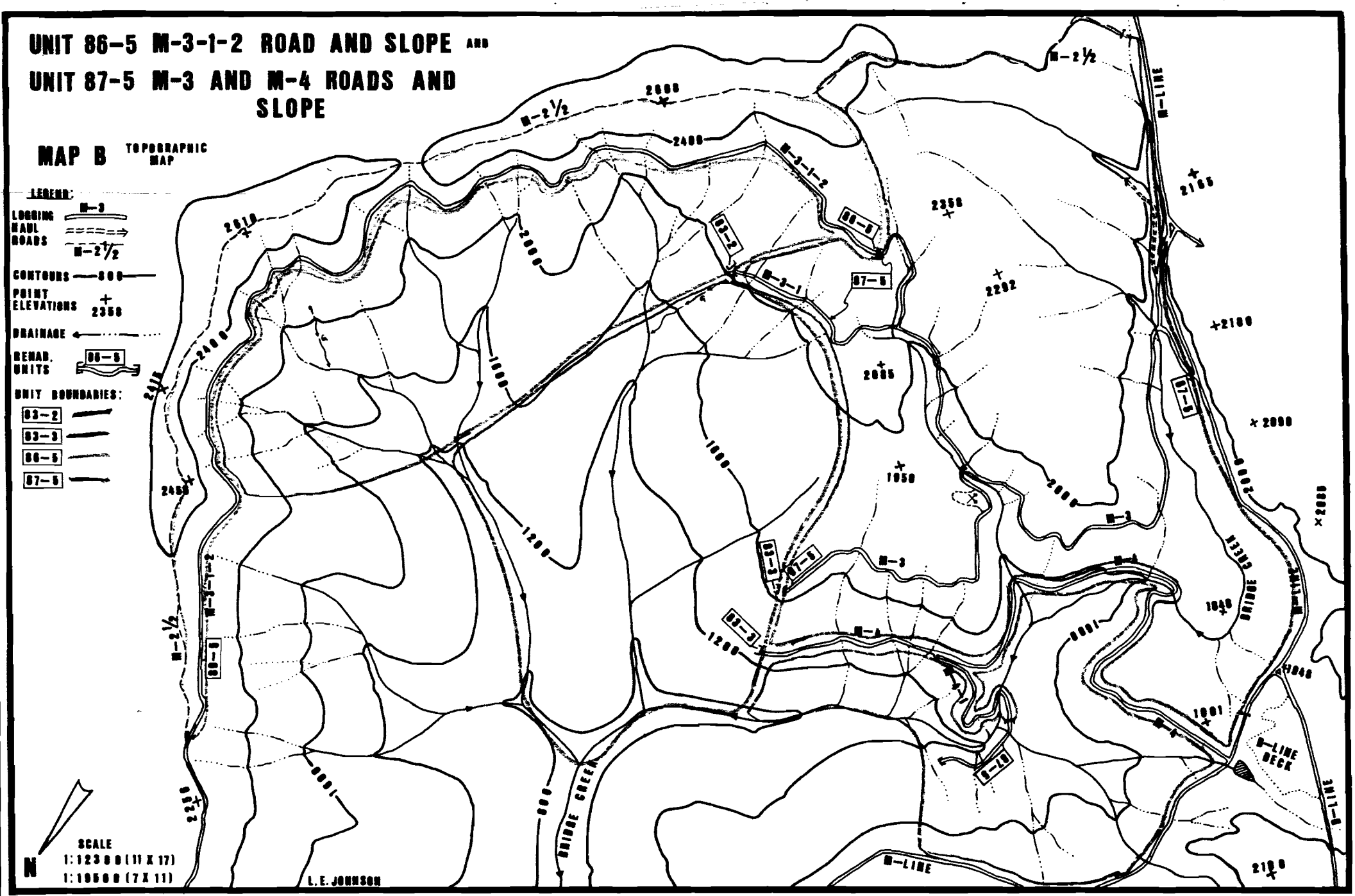
The M-3 and M-4 Roads and Slope Rehabilitation Unit, 87-5, is located on the west side of Redwood Creek, roughly 17 miles upstream from Orick, in the Bridge Creek drainage. The unit encompasses 960 acres (470 acres upslope and including the M-3 Road, 260 acres between the M-3 and M-4 roads, and 230 acres downslope of the M-4 Road) which include two of the main tributaries along the southwestern headwaters region of the Bridge Creek drainage (Map A). The unit consists of 3.7 miles along the remaining portions of the M-3, M-3-1 and M-3-1-2 haul roads; approximately 0.2 mile of the M-4-1 haul road; and all slopework above and below the main haul roads within the unit's boundaries. The remaining road corridor along the M-4 and M-4-1 haul roads is scheduled for rehabilitation in 1988. The southern and western unit boundaries are along the major drainage divides of Devils Creek and Maple Creek (Big Lagoon), respectively. The eastern boundary runs along a major ridge dividing two main tributaries of Bridge Creek, and the northern boundary is the M-Line haul road (within the park boundary below the B-Line intersection).

Total relief on the unit averages 1,750 feet, with elevations ranging from 750 feet along the mainstem tributary of Bridge Creek, to 2,500 feet along the M-2 1/2 road which follows the unit's southern boundary ridge (Map B). Overall hillslope gradients are moderate to steep, averaging 45-90 percent, with the steeper slopes being predominant within the two main tributary stream channel hillslopes. The major ridges within the unit are broad features with gentle to moderate slopes, averaging 15 to 45 percent. The M-3/M-4 unit contains first, second and third order, ephemeral, intermittent and perennial streams that make up the southwestern headwaters region of the Bridge Creek drainage. The first order streams are ephemeral and intermittent which are characteristically slightly incised with steep profiles that are controlled by organics within the channel. The two main tributaries are second order, perennial streams which have gentle to moderate gradients (10-35 percent) with fairly broad stream valleys (25-50 feet wide). Profiles along these streams are controlled mainly by man-introduced organics (logs and rootwads), though some bedrock control is present near the M-3 rock pit and just above and downstream of the M-4 haul road, virtually the entire length along this mainstem channel has been impacted by recent landslides (streambank, hillslope and haul road origin). The thalweg is impacted by numerous log jams and terraces where deposition has occurred.

This rehabilitation unit is underlain by the schist unit of Redwood Creek. Soil types in this unit have a well defined distribution pattern. The deep, well developed, clay-rich red soils of the Trailhead series occur almost entirely on the gentle to moderate slopes along the major ridges within the unit. These soils are quite resistant to erosion by surface runoff. Most of the rehabilitation unit is characterized by soils of the Tectah, Coppercreek, Ahpah, Lackscreek and Devilscreek series, which occur on middle to lower slopes within the unit (along the major haul roads). All of these soils are very susceptible to erosion by surface runoff where mineral soil is exposed on steep



MAP A WATERSHED REHABILITATION UNIT LOCATION MAP


UNIT 86-5 M-3-1-2 ROAD AND SLOPE AND
UNIT 87-5 M-3 AND M-4 ROADS AND SLOPE
MAP B TOPOGRAPHIC MAP
LEGEND:
LOGGING HAUL ROADS
M-3
M-2½
CONTOURS 800
POINT ELEVATIONS 2358
DRAINAGE
REHAB. UNITS 86-5
UNIT BOUNDARIES:
83-2
83-3
86-5
87-5
M-2½
M-3-1-2
M-3-1
M-3
M-4
M-LINE
B-LINE
B-LINE DECK
BRIDGE CREEK
2688
2488
2358
2292
2185
2165
2085
1950
1848
1801
2258
2418
2458
2188
2088
1800
1600
1400
1200
1000
800
N
SCALE
1:12000 (11 X 17)
1:19500 (7 X 11)
L.E. JOHNSON

slopes. With the exception of the Devilscreek series, these soils are well drained and have a low to moderate landslide potential, depending on slope gradient and hydrologic conditions. Because they occupy wetter areas on steep slopes, Devilscreek soils are very prone to landslides. This is evident along the M-3 haul road and especially along the M-4 and M-4-1 haul roads and adjacent hillslopes where numerous landslides have occurred. A detailed description of these soils may be found in the 1985 inhouse report, "Soils of the M-2-1-1, M-3-1-2, M-4-1, and beginning of M-3 and M-4 roads" by J. Popenoe.

The rehabilitation cost (including the evaluation and documentation phases) for the M-3/M-4 unit was $134,672.58 (Table 1). Of this total, hourly heavy equipment and labor intensive costs accounted for 78 percent and 14 percent, respectively. Evaluation and documentation phases comprise the remaining 8 percent. These costs are discussed in detail in the Erosion Control Work section.

Nearly four miles of logging haul roads were rehabilitated within the unit: 2.4 miles of the M-3; 1.0 mile of the M-3-1; 0.3 mile of the M-3-1-2; and 0.2 mile of the M-4-1. A total of 31,284 cubic yards of channel fill was excavated from 18 haul road stream crossings, and 7,035 cubic yards from 26 skid trail worksites. One and one half miles of outsloping and exported outsloping occurred along the haul roads, totalling 31,831 cubic yards of fill material moved. Twenty-four cross road drains were installed along 0.5 mile of the M-3 haul road system.

Table 1
SUMMARY COSTS OF EROSION CONTROL REHABILITATION WORK
Unit 87-5

	Task	RNP Employees: Geologist & Technician	RNP Employees: Laborers	YCC	Redwoods United	Heavy Equipment	Materials	Total Task Cost	Phase Totals	Phase %
EVALUATION PHASE	Mapping[1]	$2,149.57	--	--	--	--	--	$2,149.57	$7,700.65	6%
	Prescription	5,551.08	--	--	--	--	--	5,551.08		
HEAVY EQUIPMENT PHASE	Primary Treatment	7,464.28	--	--	--	$95,650.20	--	103,114.48	105,162.33	78%
	Secondary Treatment	--	--	--	--	--	--	--		
	Miscellaneous[2]	--	--	--	--	2,047.85	--	2,047.85		
LABOR INTENSIVE PHASE	Secondary Treatment[3] (straw)	--	5,312.62	$241.20	$5,059.57	--	$3,090.00	13,703.39	19,043.27	14%
	Miscellaneous[3] (brushing)	--	5,339.88	--	--	--	--	5,339.88		
DOCUMENTATION PHASE	Cost Analysis and Reports	2,766.33	--	--	--	--	--	2,766.33	2,766.33	2%
	TOTALS:	$17,931.26	$10,652.50	$241.20	$5,059.57	$97,698.05	$3,090.00	$134,672.58	$134,672.58	
	% OF TOTAL:	13%	8%	<1%	4%	73%	2%			

[1]Mapping employee hours and cost are only for th 1986-87 mapping season. Approx. 65% of the unit was previously mapped for rehabilitation units 83-2, 83-3, and 86-5. See text for further details.

[2]Miscellaneous heavy equipment cost include move in and out.

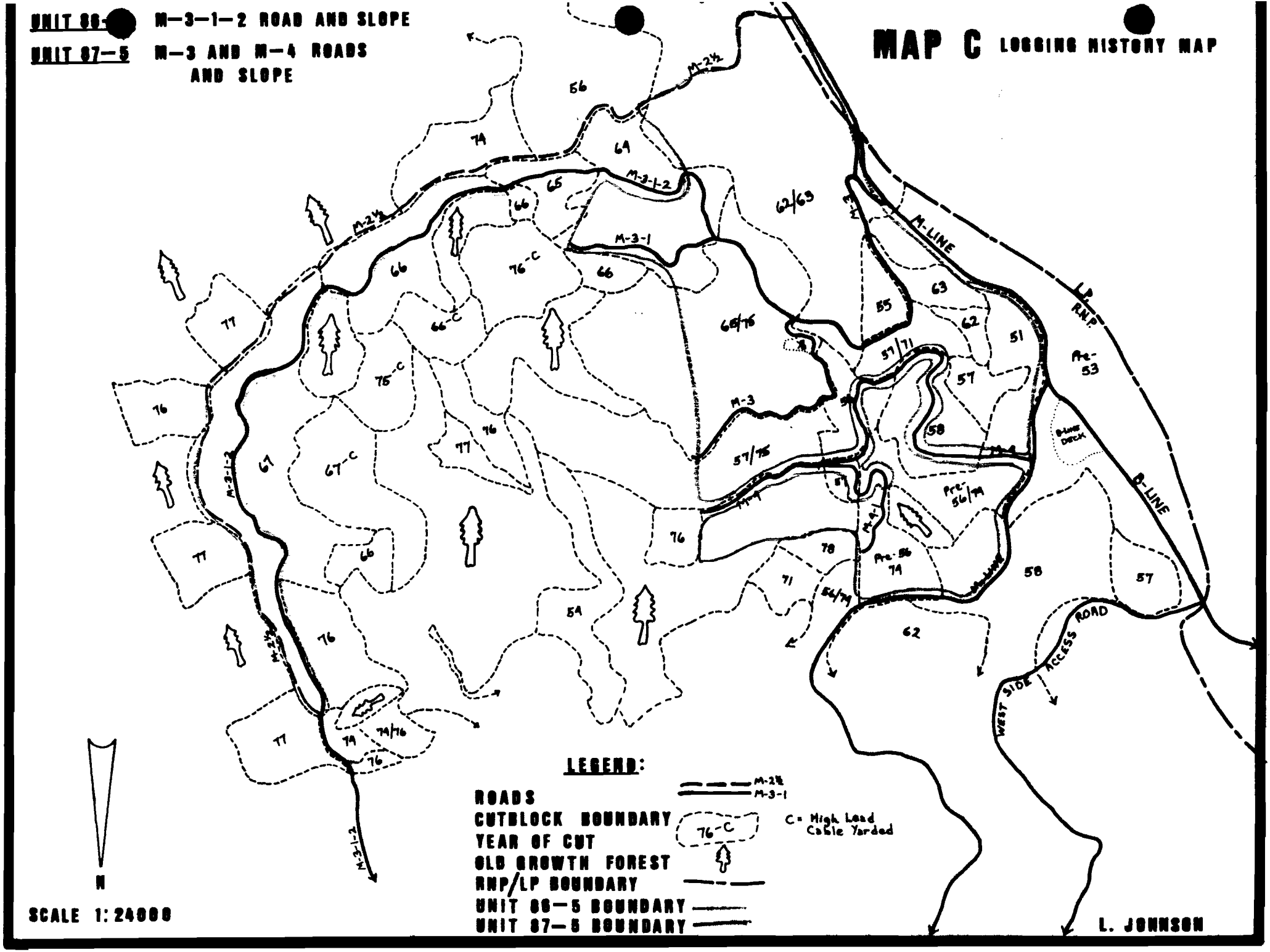
[3]All labor intensive costs include travel expenses.

LOGGING HISTORY

Based on early aerial photographs, this headwater region of Bridge Creek remained undisturbed until 1954. Timber harvest and haul road construction activities began in 1954-1955, when Louisiana Pacific Corporation began pioneer road work on both the M-3 and M-4 roads from the M-Line haul road. From that year until 1966, haul road construction (M-4, M-3, M-3-1 and M-3-1-2) and timber harvest activities coincided and progressed eastward across the upper tributary drainages of Bridge creek (Map C). Two areas of old growth Redwood forest remain below the M-4 road, totalling 70 acres, or less than one percent of the unit's total area. The 160-acre cut unit north of the M-4 road was cable yarded from the M-Line haul road in the mid-1950's, and then later clear cut and tractor yarded in the 1970's.

By 1960, the M-4 road had been constructed across the lower portion of the hillslope. Between 1956 and 1963, the hillslopes between the M-4 and M-3 were harvested by seed-tree-leave methods and tractor yarded, totalling 260 acres. The M-3 road system had been constructed by 1966, providing access to the hillslopes above the road. Between 1955 and 1966, the entire 470 acres above the M-3 was harvested by seed-tree-leave methods and tractor yarded. Typical to this age of timber harvest, stream protection was not considered and streams along the hillslopes were crossed numerous times, and earth and organic debris were sidecast into channels.

A lull in timber harvest activities occurred between 1966 and 1971, followed by a 4-year period of relogging by clear cut tractor yarded methods, totalling 320 acres (33 percent of the unit). The M-4-1 spur road was built during this period of timber harvest activities.


UNIT 86-5 M-3-1-2 ROAD AND SLOPE
UNIT 87-5 M-3 AND M-4 ROADS AND SLOPE
MAP C LOGGING HISTORY MAP
M-2½
M-3-1-2
M-3-1
M-3
M-LINE
LP RNP
B-LINE
WEST SIDE ACCESS ROAD
Pre-53
Pre-56/74
Pre-56 74
Blow Deck
56
74
69
65
66
66-C
76-C
62/63
66/76
63
55
62
51
57/71
57
58
57/75
67
67-C
76
77
78
71
64/74
54
62
74/76
N
SCALE 1:24000
LEGEND:
ROADS
CUTBLOCK BOUNDARY
YEAR OF CUT
OLD GROWTH FOREST
RNP/LP BOUNDARY
UNIT 86-5 BOUNDARY
UNIT 87-5 BOUNDARY
C = High Land Cable Yarded
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1

EROSION FEATURES

The most significant erosion features exhibited on unit 87-5 are mass movement features (Map D, back pocket). The headwaters of Bridge Creek are an inherently unstable area, where mass movements have sculptured the landscape and are a part of the natural processes in the area. However, road building and timber harvest activities have reactivated some dormant features and have contributed to a number of recent failures. To a lesser extent and significance are potential and/or active fluvial erosion features which include haul road and skid trail stream crossing fill failures and diverted stream flow hillslope gullying.

Mass movement features are numerous along the lower hillslopes below the M-3 and M-4 haul roads, and include debris torrents, landslides, streambank slides and road cutbank failures. These lower elevation hillslopes have fairly moderate to steep gradients, often 45-90 percent. In many areas, especially along drainages, the bedrock is sheared black schist, with a veneer of Devilscreek soil, which is very prone to landsliding. This landslide activity has probably been accelerated by past timber harvest activities since the mid 1970's, and especially since most of this area was tractor yarded further affecting the inherently unstable hillslopes.

A small number of these mass movement features exist along the hillslope below the M-3 haul road between stations E 45+00 and E 75+00, and include past debris torrent tracks, hillslope landslides, and active slides just above the M-4 haul road. The majority of the mass movement features within the unit exist along the M-4 and M-4-1 haul roads and adjacent hillslopes. Virtually the entire length along the main stem Bridge Creek channel, below these two haul roads, has been impacted by recent mass movement features, which include hillslope landslides and earthflows, road related debris torrents, and streambank slides. The thalweg is impacted by numerous log jams and terraces where deposition has occurred. A complete detailed erosion history for the M-4 and M-4-1 haul roads and adjacent hillslopes will be presented in the 1988 Rehabilitation Report for Unit 88-3, by G. Bundros.

The 0.2 mile of the M-4-1 haul road that was rehabilitated this year had numerous erosion features which were haul road and skid trail stream crossing fill failures, landing fill failures, unstable road fill failures and hillslope landslides and debris torrents. This section of the M-4-1 road is 25 to 75 feet in elevation above the third order tributary stream of Bridge Creek, therefore, all fill failures along this road are deposited directly into the stream.

Fluvial erosion processes play a major role along the M-3 road system and adjacent hillslopes. This area has gentle to moderate hillslope gradients of 15 to 45 percent. Along the major ridges the soils are deep, well developed, clay-rich red soils of the Trailhead series, which are quite resistant to erosion by surface runoff. Most of the soils along the middle slopes of the unit (along the M-3 road system) are soils of the Tectah, Coppercreek, Ahpah, and Lackscreek series, which are very susceptible to erosion by surface runoff where mineral soil is exposed.

Haul road stream crossings along the M-3, M-3-1 and M-3-1-2 were all humboldt-type (logs and fill) crossings, with a corrugated metal pipe (culvert) set

higher in the crossing fill or down the road. All of these crossings were still intact, and all had the potential for future fill failures. The crossings along the steep grade sections of the M-3-1 and M-3-1-2 all had stream diversion potentials. The M-3 road system had been constructed by 1966, after the 1964 flood. Though there's some evidence visible on the 1972 and 1975 aerial photographs of crossing fill failures and stream diversions along the steep grade of the M-3-1 road. This resulted in inboard ditch gullying and destabilization of the road cutbanks. Fortunately drainage areas are relatively small (10-40 acres) for these streams that were diverted, and the flow usually ended up in the next drainage down road and eventually into the main tributary stream below the M-3-1.

Second order streams within this middle slope area are low gradient (5-20 percent) with wide channel valleys (15-30 feet) and are extremely impacted with large amounts of accumulated sediment and organics left by past logging activities. In many sections the stream flow is subsurface and only emerges in the few channel sections that were left relatively untouched by man's manipulation of the landscape. Haul road stream crossings across these second order streams were usually very large (2,000 to 8,000 cubic yards in volume size), and many were used as decks and skid trail converging points. Therefore, large accumulations of organic debris and skid trail fill were left at these crossings. Stream crossing culverts were all undersized, though at least fifty percent of the stream flow was subsurface during most of the year. Fill failures were common along the outboard edge of these crossings, and stream gullying through the deck and skid trail fill upstream of the crossing culverts also existed.

Another erosion feature along the M-3 road system was potential road fill failures where road sections were built across steep headwater hillslope regions and areas of wet Devilscreek soils. Cutbank failures and slides occurred everywhere along the roads in areas of Devilscreek soil. All of these road sections were export outsloped to re-establish dispersed surface runoff and eliminate road fill landsliding.

Since the unit was tractor yarded during past logging activities, the hillslopes are riddled with skid trails, and streams were crossed numerous times and/or had skid trails built in the channel or perched directly upslope. Potential erosion on the hillslopes existed as intact crossing fills and possible stream diversions. A total of 55 skid trail stream crossings were mapped within the unit, though only 22 were determined to be treatable due to their active and/or potential diversions and fill failures. The remaining 23 crossings had no diversion potential, were in various stages of decay, and are now densely revegetated and were judged to be fairly stable.

Other fluvial erosion was occurring on skid trails, where ground water had been intercepted and surface flow collected and concentrated forming rills and small gullies. Most of these actively eroding skid trails were waterbarred by this year's rehabilitation efforts. Because there's 10-20 years of regrowth present on almost all the skid trails, future surface erosion will probably be minimal.

EROSION CONTROL WORK

Redwood National Park's watershed rehabilitation and erosion control program is divided into four work phases: Evaluation, heavy equipment, labor intensive and documentation. The evaluation phase includes: Geomorphic and hydrologic field mapping; prescribing erosion control treatments which are accomplished using heavy equipment and labor intensive work crews; volumetric surveying at all proposed worksites; field peer reviews of erosion control prescriptions; establishing photo points that will document the effects of the erosion control work; and planning the erosion control work schedule for both the heavy equipment and labor intensive phases. The heavy equipment phase includes completion of all primary erosion control treatments (direct sediment saving prescriptions) which are haul road and skid trail stream crossing fill excavations, export outsloping of fill material along unstable road sections, and road outsloping (recontouring) and cross road drain construction. The labor intensive erosion control work includes all secondary treatments for surface erosion which comprises distributing and applying straw mulch to critical areas on finished rehabilitation worksites such as stream crossing sidebanks and steep outslopes. The final erosion control phase is the documentation process which includes post heavy equipment excavation volumetric surveys, photo points, cost data compilation and the watershed rehabilitation project report.

Evaluation Phase

The evaluation phase for unit 87-5 includes mapping, prescribing erosion control treatments, surveying, establishing photo points, and planning the work schedule and cost estimates for the hourly heavy equipment and labor intensive erosion control work. This phase involved approximately 68 person days, between September 1986 and June 1987. The following is a more detailed cost breakdown of the evaluation phase:

Mapping (1986-87)	$2,149.57
Prescriptions (includes survey staking and photo points)	2,702.83
Surveying	1,977.53
Planning Work Schedule and Costs	870.72
TOTAL	$7,700.65

The mapping for this unit was started in 1982-1983 as part of rehabilitation units 83-2 and 83-3. During this time, the eastern 285 acres along the M-3 and M-4 was mapped by G. Bundros and D. Burns (83-3) and the M-3-1 and M-3-1-2, 65-acre section was mapped by L. Johnson and T. Spreiter (83-2). Later in 1984 and 1985, the remaining M-4 and M-4-1, 245 acres was completed by G. Bundros and D. Burns. The remaining 365 acres above the M-3, west of the M-3-1 and near the M-Line was mapped in 1986-1987 by J. Hoffard, M. Horns, L. Johnson and J. Wood. The mapping costs include 22 person days for 1986-1987.

Prescriptions, surveying and planning the erosion control work were completed between December 1986 and June 1987, and involved approximately 46 person days to complete. Initially this rehabilitation unit was scheduled to be completed under a heavy equipment fixed price contract format. Therefore, prescriptions and field work included placing stakes and flagging for haul road stations and

all survey worksites. Detailed volumetric surveying was completed at all haul road stream crossings (RX), exported outslope (TOS or BOS) road reaches, outslope (OS) road reaches, and significant slope worksites (skid trail stream crossings and outsloping). As estimated heavy equipment costs increased for the other two contract units for FY 1987 (87-2 and 87-3), the M-3/M-4 contract format was abandoned and the unit's estimated heavy equipment budget decreased considerably. At this time, the only erosion control work that would be completed on unit 87-5 would be all the slope worksites and the remaining sections of the M-3-1 and M-3-1-2 haul roads. The remaining haul roads (M-3, M-4 and M-4-1) would be done under a contract format in 1988.

By the end of May, the bids came in for the two contracts under park estimates, and during early summer, several hourly rehabilitation projects finished under budget. This resulted in a shift of excess money to unit 87-5, thus allowing for total removal of the entire M-3 road system (including the M-3-1 and M-3-1-2), all slope worksites within the unit, and a portion of the M-4-1 road and slope. Fortunately, all prescribed worksites on the M-3, M-3-1, M-3-1-2 and M-4-1 roads and slope had been surveyed, photographed, and cost estimates for heavy equipment erosion control work had been completed.

Erosion control prescriptions for worksites on the M-4-1 road and slope, and M-4 slope were completed by G. Bundros in 1984-1985. All other erosion control prescriptions for worksites on the M-3 road system and slope were completed by L. Johnson in 1987 (time included field prescription work, staking and flagging worksites for surveying). All volumetric survey work was completed by May 1987, by J. Hoffard, L. Johnson and J. Wood. Final work schedule plans and cost estimates were done in June 1987 by L. Johnson.

HEAVY EQUIPMENT PHASE

Introduction

Primary erosion control treatments concentrated on features capable of delivering sediment directly to the main tributary streams of Bridge Creek. These features were haul road and skid trail stream crossings, skid trail sidecast fill material in streams, unstable road reaches adjacent to streams, and road reaches across steep unstable headwater regions. Nearly four miles of logging haul roads were rehabilitated within the unit, for a total heavy equipment cost of $97,698.05. A total of 70,150 cubic yards of material was excavated from 18 haul road stream crossings (31,284 yd^3), 26 skid trail worksites (7,035 yd^3), 0.3 mile of export outsloping (11,541 yd^3), and 1.2 mile of outsloping (20,290 yd^3). Table 2 summarizes the number of worksites, quantities, total costs, and average unit costs and rates for each heavy equipment erosion control treatment completed on unit 87-5. All worksites are located on Map D.

The heavy equipment erosion control work was done under hourly heavy equipment rental agreements. Four pieces of heavy equipment were utilized on the unit, three bulldozers and one fairly large hydraulic excavator. The excavator was a CASE 125B with a 1 2/3 yard bucket ($109.50 per hour), leased and operated by David Burnson. One of the bulldozers was a Caterpillar D7E with a "U"-blade and winch ($78.50 per hour), owned and operated by Wendell Larkin. The other two bulldozers were both Caterpillar D8H 46A series, one with a "U"-blade, winch and 28-inch wide high floatation tracks ($86.94 per hour), and the other D8 had two rear-mounted ripper teeth and a straight blade ($94.89 per hour). Both were owned by Jay Franke and operated by Jay Franke ("winch cat") and Jack Wiggins ("ripper cat").

The excavator and D7 bulldozer worked from start to finish on the unit as the primary equipment team, working on all erosion control treatments. Whereas, the D8 bulldozers were employed on specific rehabilitation treatments for a limited time during the sequence of heavy equipment work on unit 87-5. The D8 ripper bulldozer was used to decompact all haul road surfaces and to recontour the M-3 rock pit. The D8 winch bulldozer with it's "U"-blade and high floatation tracks was utilized on haul road stream crossings and export outslope road reaches as the primary earth mover. This bulldozer has the highest production rate with the "U" (or universal) blade which is perfect for moving big loads over long distances. And the high floatation tracks insure that the dozer will be able to "dish" down a stream crossing beyond the point where comparable equipment would be stuck-in-the-muck, which causes a major reduction in the production rate. The D7 bulldozer and excavator worked together as a team most of the time. Though on outslope road reaches the excavator worked independently, with the highest production rate, while the D7 completed preliminary excavations independently on haul road and skid trail stream crossings and export outslope road reaches.

Heavy equipment erosion control work began on July 27, 1987, and took 7 1/2 weeks to complete ending on September 15, 1987 (totalling 1,034 hours of combined heavy equipment time). Equipment work started on the M-4-1 road and M-4 slope worksites, which took 5 days to complete. Then the equipment moved to the end of the M-3 haul road (E0+00) and completed all road and slope worksites upstation to the M-3 and M-3-1 road intersection. At this point, the

Table 2

SUMMARY OF AVERAGE COSTS OF HEAVY EQUIPMENT EROSION CONTROL TREATMENTS

Unit 87-5

	Totals:					Averages:				
Treatment	Number of Worksites	Total Quantity	Total Heavy Equipment Hours	Total Cost	Percent of Total	Cost Per Worksite	Unit Cost Per Quantity	Range: Cost per Quantity	Rate: Quantity Per Hour	Rate Range: Quantity Per Hour
Haul Road Stream Crossings	18	31,284 yd^3	413.75	$37,136.49	38%	$2,063.00	$1.19/$yd^3$	$.70-1.92 per yd^3	76 yd^3/hr.	46-143 yd^3/hr.
Skid Trail Worksites[1]	26	7,035 yd^3	110.0	10,712.00	11%	412.00	1.49/yd^3	.63-2.54 per yd^3	66 yd^3/hr.	37-133 yd^3/hr.
Exported Outslope	13 1,839 linear feet of road	11,541 yd^3	125.75	11,437.98	12%	6.22/LF	.99/yd^3	.58-1.46 per yd^3	92 yd^3/hr.	64-142 yd^3/hr.
Outslope	14 6,356 linear feet of road	20,290 yd^3	131.75	13,217.35	13%	2.08/LF	.65/yd^3	.48-.96 per yd^3	154 yd^3/hr.	110-213 yd^3/hr.
Drains(D) and Ripping(R)	7 drains(D) 19,495 linear feet of ripping(R)	24 drains 1,629 feet of drain	61.75	1310.36 ~~5,654.47~~ 2846.70 1497.41	6%	2,692 per road mile(D) 771 per road mile(R)	.80/foot of drain .15/LF-R	.56-1.39 per LF drain --	116 ft/hr. 650 linear feet of road per hour	73-186 feet of drain per hour --
BLADING/OPENING ROAD										
Other Rehab Treatments[2]	SEE TABLE 10	--	191.25	17,491.91	18%	--	--	--	--	--
Move In/Out	--	--	--	2,047.85	2%	--	--	--	--	--
TOTALS =	--	70,150 yd^3 of Material Moved	1,034.25 Heavy Equip. Hours	$97,698.05 Total Heavy Equipment Cost		--	--	--	--	--

Footnotes on next page.

Table [redacted] continued
Footnotes

[1]Skid Trail Worksites include: 16 skid trail stream crossings ($6,934.39); 2 skid trail export outslope reaches ($1,781.87); 4 skid trail outslope reaches ($1,744.75); and 4 skid trail drain reaches ($250.99). See summary on Table 5.

[2]Other rehabilitation treatments include: The M-3 Rock Pit Contouring; the M-2 1/2 road blade n' drain; moving equipment and straw bales; discussions, breaks, and paid down time. Refer to Table 10 for more detailed information and costs.

equipment moved again to the end of the M-3-1 and M-3-1-2 roads, and work progressed along the roads and slope back down to the M-3 road, then on out the M-3 to the end of the unit at the M-Line haul road. This unit was the final stage in completing all rehabilitation efforts on the M-3 roads system and associated slopework which began back in 1981.

The next section will cover heavy equipment techniques and cost effectiveness for each type of erosion control treatment completed on unit 87-5 (e.g., stream crossings, different types of road treatments - outsloping, export outsloping, cross road drains and ripping).

Haul Road Stream Crossings

Eighteen haul road stream crossing excavations were completed on unit 87-5. Table 3 shows average stream excavation costs, unit costs and excavation rates for haul road and skid trail crossings combined in the four size categories listed. Table 4 details this information for each haul road stream crossing. The total cost for 18 crossings was $37,136.49, with a unit cost of $1.19 per cubic yard and an overall excavation rate of 76 cubic yards per hour per piece of equipment. Overall average blade push distance to a fillsite was 183 feet. A total of 31,284 cubic yards of fill material was excavated from the 18 stream crossings. Nine of these crossings were greater than 1,000 cubic yards in size, ranging from 1,000 to 8,627 cubic yards in size, with production rates ranging from 46 to 102 cubic yards per hour per piece of equipment.

These haul road stream crossings were excavated to prevent erosion due to road fill failures and/or stream diversions resulting from potential culvert failures. Excavations were designed to tie into stable base levels at, or near, the original channel bed level, and with sideslopes of 30-45 percent. Stream crossing excavations on first order streams usually had much steeper channel gradients (35-50 percent), than stream crossing excavations on second order streams which usually had gentle channel gradients of 5-20 percent and were situated in broad stream valleys, 20-40 feet wide.

The heavy equipment excavation method was virtually the same for all eighteen haul road stream crossings. First, either the D7 or D8 winch bulldozer with a U-blade would excavate out (by digging down and pushing the fill spoils to the fillsite) as much crossing fill material as possible, usually 50-75 percent of the crossing's total volume. Then, the excavator was used to define the final channel grade and lower sideslopes, with a bulldozer pushing the excavator fill spoils to a fillsite. The overall percent ratio of total hours of bulldozer to excavator time was 72:28. By using one or two bulldozers (depending on crossing size) to complete as much of the excavation as possible, the fill material is only being handled by one piece of equipment from crossing to fillsite, versus when the excavator is digging and the bulldozer is pushing the same fill to the fillsite. This is an extremely efficient method for completing stream crossing excavations, resulting in a high production rate and a low unit cost. During hourly heavy equipment rental work on stream crossing excavations, the project supervisor needs to pay close attention to the efficiency during the preliminary bulldozer excavation, and bring in the excavator as soon as the dozer begins to bog down in the near bottom channel muck, in order to achieve a high excavation production rate and low unit cost.

Table 3
HAUL ROAD AND SKID TRAIL STREAM CROSSING EXCAVATION COSTS
Unit 87-5

Size Category (cu.yds)	# of Work Sites	Range of Volumes (cu.yds)	Equipment[1] Percent	Range of Hours (total hrs)	Total Cost	Range of Actual Costs	Total Volume cu.yds.	Average: cost/ cu.yd.	Range: cost/ cu.yd.	Ave: Exc. Rate (cu.yd/hr.)	Range: Exc. Rate (cu.yd/hr)
Small 1-400	14	100-350	Bulldozers 34% Excavator 66%	.5-2.75 (11) .5-4.0 (21.25)	$3,190.37	$79.00-536.00	2,875	$1.11	$.63-1.53	89	67-143
Medium 400-800	9	450-800	Bulldozers 52% Excavator 48%	2-8.75 (44.75) 1.25-8.5 (40.5)	8,013.04	458.00-1,524.00	5,598	1.43	.95-2.54	66	37-96
Large 800-2000	7	810-1,326	Bulldozers 64% Excavator 36%	6.25-16.75 (78) 4.25-7.75 (44.5)	11,157.00	1,283.00-2,161.00	7,702	1.45	.97-1.92	63	53-102
Extra Large >2000	4	2,550-8,627	Bulldozers 80% Excavator 20%	30-74.5 (196) 11.5-13 (49.5)	21,710.47	3,861.00-7,457.00	19,794	1.10	.86-1.51	81	60-100
TOTALS:	34	100-8,627	Bulldozers 68% Excavator 32%	.5-74.5 (329.75) .5-13.0 (155.75)	$44,070.88	$79.00-7,457.00	35,969	$1.23	$.63-2.54	74	37-143
			Total Hours =	485.5							

[1]Bulldozer hours include the D8 ripper, D8 winch and D7 winch combined.

Table 4
HAUL ROAD CROSSING EXCAVATION COSTS
Unit 87-5

Worksite	Equipment Hours: D7W	125B	D8W	D8R	Total Cost	Volume Cubic Yards	Unit Cost Per Cubic Yards	Rate Cubic Yards Per Hour	Ave. Push Dist. to Fillsite (ft.)
M 1+00	12.25	5.0	-	-	$1,509.13	1,200	$1.26	70	125
M 9+00	17.0	12.75	13.0	-	3,860.85	2,550	1.51	60	175
M 26+00	27.75	13.0	17.0	-	5,079.86	4,500	1.13	78	250_D
V 166+04	11.0	12.25	35.75	-	5,312.98	4,117	1.29	70	275_D
V 170+17	-	6.75	6.25	-	1,282.50	1,326	.97	102	245_D
V 186+00	2.5	2.0	1.5	-	545.66	575	.95	96	250_D
V 191+00	13.75	7.5	3.0	-	2,161.45	1,125	1.92	46	225_D
V 195+81	4.5	4.25	-	-	818.63	669	1.22	76	125_D
V 200+00	9.75	7.75	-	-	1,614.00	1,250	1.29	71	125
E 11+00	6.0	7.75	-	-	1,319.62	750	1.76	55	350
E 36+00	2.75	-	-	-	215.87	300	.72	109	100
E 44+00	12.25	6.5	-	-	1,673.37	1,000	1.67	53	150
E 79+05	5.0	4.25	5.0	2.5	1,529.80	991	1.54	59	250
E 95+00	3.5	1.25	5.25	-	868.06	754	1.15	75	150
E 100+00	4.25	1.5	1.0	-	584.81	500	1.17	74	100
E 102+00	35.0	11.5	37.5	2.0	7,456.78	8,627	.86	100	200
#32 (M-4-1)	.5	1.25	-	-	176.12	250	.70	143	75
#34 (M-4-1)	2.5	8.5	-	-	1,127.00	800	1.41	73	125
18 Worksites	170.25 (41%)	113.75 (28%)	125.25 (30%)	4.5 (1%)	$37,136.49	31,284	$1.19	76	183

Total Hours = 413.75

D = Downhill push

Haul Road Treatments

There were three types of erosion control road treatments completed on this unit: Outsloping, export (blade endhauled) outsloping, and ripping and cross road draining (Map D). One and two-tenths of a mile (6,356 feet) along the M-3-1-2 and M-3 haul roads was outsloped, with a total of 20,290 cubic yards of fill material moved. Total cost for outsloping was $13,217.35, with an average unit cost of $.65 per cubic yard of fill material moved, and an average excavation rate of 154 cubic yards per hour per piece of equipment. These costs are detailed for each outslope reach in Table 5, which also includes average cubic yards per linear foot of road, average road width, and average cut depth for each outslope section.

Road sections that were outsloped were directly adjacent to drainages, and in many areas tension cracks were forming along the outboard fill edge of the road. First the D8 bulldozer ripped the road between the balance point (near mid-road) inward and including the inboard ditch. The excavator was the primary outsloping piece of equipment, completing numerous outslope road reaches independently, with only minimal bulldozer support. This medium-sized excavator is capable of reaching outslope cut depths (along average size haul roads, 20-35 feet wide) and placing the fill against the cutbank while contouring the finished slope all at the same time, thus handling the same material only once. Utilizing the excavator as the sole outsloping equipment is the most productive and cost effective method. Though on wider (35-50 feet) road sections with deeper cuts (20-30 feet) or along landings, bulldozers are more cost effective for outsloping (since the fill needs to be pushed to the cutbank), requiring only minimal excavator assistance to remove the fill from the lower extent of the outslope cut depth, and around trees or stumps.

Thirteen export (blade endhauled) outslope excavations were completed along 0.3 mile of the M-4-1, M-3-1 and M-3 haul roads, totalling 11,541 cubic yards of haul road fill material moved. Total cost for export outsloping on this unit was $11,437.98, with an average unit cost of $.99 per cubic yard of material moved, and an overall excavation rate of 92 cubic yards per hour per piece of equipment. The overall average blade endhauled push distance to a fillsite was 242 feet. These costs are detailed for each export outslope reach in Table 6, which also includes average cubic yards per linear foot of road, average road width, and average cut depth for each export outslope road section.

These export outslope road reach areas were where the haul road was constructed (with a complete fill road prism) across headwater regions, usually with drainages directly downslope. Most of these road sections were located within Devilscreek soil, with a high potential for debris torrent failure of the entire road prism into a stream channel. The heavy equipment erosion control treatment prescribed for complete removal of the road prism with either the top of cut being along the inboard ditch (Total Outslope = TOS), or leaving an inboard bench along road sections where cutbanks were unstable and wet with seeps and springs (Bench Outslope = BOS).

The heavy equipment excavation method was the same for all export outslope road reach worksites, with some variation between bench outslope (BOS) and total outslope (TOS) treatments. First, either the D7 or D8 winch bulldozer would cut down the road level to the depth of the inboard ditch. On TOS prescribed road sections, the bulldozer would excavate out as much road fill material as

Table 5
OUTSLOPE ROAD EXCAVATION COSTS
Unit 87-5

Worksite	Equipment Hours: D7W	125B	D8W	D8R	Total Cost	Quantity Cubic Yards	Unit Cost Per Cubic Yard	Rate: Cubic Yards Per Hour	Ave. yd^3 per Linear Foot of Rd.	Ave. Rd.width/ Cut Depth (ft.)
V 163+57	-.-	3.0	-.-	-.-	$328.50	406	$.81	135	2.31	27/12
V 172+31	-.-	7.75	-.-	-.-	848.63	1,145	.74	148	2.07	28/12
V 193+00	2.5	2.5	-.-	-.-	470.00	550	.85	110	5.50	35/18
E 29+05	2.75	12.5	-.-	-.-	1,584.63	1,644	.96	108	2.59	26/15
E 40+00	-.-	8.5	-.-	-.-	930.75	1,297	.72	153	3.65	32/13
E 44+50	3.75	3.75	-.-	-.-	705.00	1,457	.48	194	5.83	45/18
E 64+00	-.-	1.5	.5	-.-	207.72	425	.49	213	2.30	30/11
E 65+85	-.-	3.75	-.-	-.-	410.63	643	.64	171	2.99	23/21
E 77+00	1.25	2.25	-.-	-.-	344.50	505	.68	144	2.53	25/15
E 84+00	2.5	8.75	1.5	-.-	1,284.79	2.455	.52	193	2.46	28/14
E 96+50	1.25	3.5	.5	-.-	524.84	710	.74	135	2.03	29/11
E 105+50	2.0	-.-	2.25	-.-	352.61	550	.64	129	1.38	25/8
M-3 Y-Spur	-.-	23.75	-.-	-.-	2,600.62	4,900	.53	206	2.80	25/19
#29(M-4-1)[1]	14.25	4.0	-.-	11.25	2,624.13	3,603	.73	122	19.27[1]	50/32
14 Worksites	30.25 (23%)	85.5 (65%)	4.75 (4%)	11.25 (8%)	$13,217.35	20,290	Ave. $.65	Ave. 154	Ave. 3.19	Ave. 30/16

Total Hours = 131.75

[1]Number 29 on the M-4-1 Road was an inplace landing outslope along 187 feet of road.
*Outslope road reaches total 6,356 linear feet of road.
Average cut depth is measured vertical from road level down to the cut-to-here depth along the fillslope.

Table 6
EXPORTED (BLADE ENDHAULED) OUTSLOPE ROAD EXCAVATION COSTS
Unit 87-5

Worksite	Equipment Hours: D7W	125B	D8W	Total Cost	Quantity Cubic Yards	Unit Cost Per Cubic Yard	Rate: Cubic Yards Per Hour	Ave. Push Distance to fillsite (feet)	Ave. yd^3 per Linear Foot of Rd.	Ave. Rd. width/ Cut Depth (ft.)
M 22+40[T]	4.0	-.-	-.-	$314.00	525	$.60	131	290	5.25	29/14
E 15+60[T]	7.5	6.75	-.-	1,327.88	1,030	1.29	72	300	7.63	32/16
E 20+74[T]	6.25	4.5	-.-	983.38	1,014	.97	94	200	8.38	39/17
E 25+29[T]	12.0	12.5	-.-	2,310.75	1,580	1.46	64	300	7.98	20/17
E 47+00[B]	3.75	3.25	-.-	650.25	547	1.19	78	175	3.65[B]	27/17
E 49+15[B]	4.25	4.75	-.-	853.75	956	.89	106	150	5.17[B]	35/16
E 52+25[T]	3.0	2.0	10.25	1,345.63	1,410	.95	92	375	8.06	36/17
E 61+50[T]	3.25	-.-	2.25	450.74	782	.58	142	200	6.02	37/11
E 68+00[B]	3.5	5.5	3.5	1,181.29	1,097	1.08	88	275	5.93[B]	33/16
E 72+85[T]	-.-	-.-	5.25	456.43	739	.62	141	200	5.47	25/16
#31(M-4-1)[T]	3.75	3.75	-.-	705.00	545	1.29	73	250	4.95	24/14
#33(M-4-1)[T]	1.0	1.75	-.-	270.13	296	.91	108	200	2.96	28/8
#33.5(M-4-1)[T]	7.5	-.-	-.-	588.75	1,020	.58	136	225	8.87	35/15
13 Worksites	59.75 (48%)	44.75 (35%)	21.25 (17%)	$11,437.98	11,541	Ave. $.99	Ave. 92	Ave. 242	Ave. 6.28	Ave. 31/15

Total Hours = 125.75

T - Total Outslope, B - Bench Outslope
*Exported Outslope road reaches total 1,839 linear feet of road.
Average Cut Depth is measured vertical from road level down to the cut-to-here depth along the fillslope.

possible, leaving only the lower edge material for the excavator to pull up. On BOS prescribed road sections, the bulldozer first outslopes the inboard bench to a 5-10 percent slope approximately blade-length wide, and then begins to cut down the outboard half of the road. Since finished slopes are usually steeper on BOS than they are on TOS, the excavator is required to complete the majority of the outslope excavation, while the bulldozer pushes the fill spoils to the fillsite. By leaving a slightly outsloped road bench on bench outslopes, this eliminates the need for bench drains and creates a more natural overland flow pattern. Whereas, cross bench drains concentrate flow onto the newly finished outslope possibly causing rill and/or gully erosion to occur.

Twenty-four cross road drains were constructed along 0.5 mile of the M-4-1 and M-3 haul road systems. Cross road drains were constructed at frequent intervals to disperse hillslope runoff and inboard ditch spring flow. These were mostly done by the D8 and D7 bulldozers, with the excavator used to open the outlet of each drain. Total cost for drain construction was $1,310.36, with an average unit cost of $.80 per foot of drain. These costs are detailed for each drain reach in Table 7.

A total of 3.7 miles of the M-3, M-3-1 and M-3-1-2 haul roads were ripped, for a total cost of $2,846.70 (Table 8). The roads were ripped to a depth of 18-24 inches, using the D8 bulldozer with two rear mounted ripper teeth. Decompacting the road increases infiltration through the road surface and makes it easier for vegetation to become established.

Table 7
CROSS ROAD DRAIN COSTS[1]
(Haul Roads Only)
Unit 87-5

Worksite	Equipment Hours: D7W	125B	D8W	Total Cost	Quantity No. of drains/ Ft. of drain	Cost Per Foot of Drain	Rate: Ft. of drain Per Hour
V 172+15	-.-	.5	.25	$76.48	1/55	$1.39	73
V 180+44	.5	1.75	-.-	230.87	3/260	.89	116
M 13+14	1.5	-.-	-.-	117.75	3/135	.87	90
E 0+00	2.75	1.0	-.-	325.38	8/367	.89	98
E 18+83	.25	1.0	-.-	129.13	2/229	.56	183
E 56+00	1.0	-.-	-.-	78.50	2/123	.64	123
M-4 Rd.	-.-	1.75	-.-	191.62	3/325	.59	186
M-4-1 Rd.	1.0	.75	-.-	160.63	2/135	1.19	77
						Ave.	Ave.
8 Worksites	7.0 (50%)	6.75 (48%)	.25 (2%)	$1,310.36	24/1,629	$.80	116

Total Hours = 14

[1]Crossroad drain costs include equipment hours spent on spring drains and inboard ditch improvements, linear feet included.

Table 8
HAUL ROAD OPENING AND RIPPING COSTS
Unit 87-5

Category	Equipment Hours: D7W	D8W	D8R	Total Cost	Linear Feet of Road	Cost Per Linear Foot	Rate: Linear Ft. Per Hour
Opening[1] Haul Roads	7.5	5.25	3.0	$1,329.86	4,150	.32	263
Ripping M-3, M-3-1 & M-3-1-2 Haul Roads	-.-	-.-	30.0	2,846.70	19,495	.15	650
Blading the Ripped Road	.75	1.25	-.-	167.55	--	-.-	--
Totals:	8.25	6.5	33.0	$4,344.11	--	-.-	--

Total Hours = 47.75

[1]Sections of the M-4-1 (rebuild several stream crossings), M-3 and M-3-1 haul roads.

Slopework

Four types of erosion control rehabilitation treatments were completed on the hillslopes adjacent to the M-4, M-4-1, M-3, M-3-1 and M-3-1-2 haul roads. These were 16 skid trail stream crossing excavations, 2 skid trail export outslope reaches, 4 skid trail outslope reaches and 4 skid trail cross road drain reaches. All slope worksites are located on Map D. Table 9 details the costs, unit costs and production rates for each worksite, and includes a cost summary for each of the four categories. The total cost for 26 slope worksites was $10,712.00, totalling 7,035 cubic yards of material excavated, with a unit cost of $1.49 per cubic yard and an overall excavation rate of 66 cubic yards per hour per piece of equipment. Heavy equipment time and costs include opening skid trails and travel time to and from between the haul roads and slope worksites.

The sixteen skid trail stream crossings were excavated to prevent erosion due to continued fill failures and/or active or potential stream diversions resulting from a failed humboldt-style (log and fill) constructed crossing. Excavations were designed to tie into stable base levels at, or near, the original channel bed level, and with sideslopes of 40-50 percent. The total cost for the 16 skid trail crossing excavations was $6,934.39, totalling 4,685 cubic yards of fill material. The overall average unit cost was $1.48 per cubic yard, with a production rate of 65 cubic yards per hour per piece of equipment. The percent ratio of bulldozer to excavator time (total hours) was 41:59.

The heavy equipment skid trail stream crossing excavation method varied depending upon the size of the crossing and the conditions encountered during excavation. On small crossings (less than 300 cubic yards), the excavator completed the excavations independently since the fillsites were within the excavators reach distance. On medium to large crossings (300-810 cubic yards), the D7 bulldozer would do preliminary excavation work, digging out as much fill as possible, prior to the excavator arriving to complete the channel grade. This is an ideal excavation method which is not always accomplished on slope crossings due to the difficulties in excavating wet humboldt-log constructed crossings, working in tight spaces on skid trails, and with fillsites around tight turns and many of them uphill from the crossing. Therefore, unit costs are usually higher and production rates lower for skid trail stream crossing excavations, than they are for haul road crossings.

Two export outslope skid trail reaches were excavated due to their proximity to and potential failure into adjacent stream channels. Excavation costs totalled $1,781.87 and 1,100 cubic yards of fill material was moved. The average unit cost was $1.62 per cubic yard with an excavation rate of 59 cubic yards per hour per piece of equipment. The heavy equipment excavation method was the same for both skid trail total outslope reaches. Both the D7 bulldozer and excavator worked together as a team, with the excavator digging the skid trail fill and contouring the finished slope, while the bulldozer pushed the fill spoils to a stable fillsite approximately 200 feet away.

Four skid trail reaches were outsloped for a total cost of $1,744.75, and each reach averaged 200 feet in length. These four skid trail reaches were all perched directly adjacent to or were built partially within a stream channel. Two skid trail reaches were built within first order intermittent stream

Table 9
SLOPEWORK COSTS[1]
Unit 87-5

Worksite	Equipment Hours: D7W	125B	Total Cost	Volume Cubic Yards	Unit Cost Per Cubic Yard	Rate: Cubic Yards Per Hour
2-SX	-.-	3.25	$355.88	300	$1.19	92
3-SX	-.-	.75	82.13	100	.82	133
4-SX	8.25	6.75	1,386.75	810	1.71	54
6-SX	-.-	2.75	301.13	200	1.51	73
7-SX	8.25	8.0	1,523.63	600	2.54[2]	37[2]
8-TOS	2.0	3.0	485.50	375	1.29	75
9-SX	1.25	4.0	536.13	350	1.53	67
10-SX	2.0	2.75	458.13	450	1.02	95
11-SX	.75	2.75	360.00	250	1.44	71
12-OS	.5	4.0	477.25	300	1.59	67
13-OS	1.25	1.25	235.00	150	1.57	60
14-SX	3.5	4.5	767.50	500	1.54	63
15-XRD	1.5	-.-	117.75	4=230' d	.51/ft.d	153 ft.d/hr
16-XRD	.75	-.-	58.87	4=145' d	.41/ft.d	193 ft.d/hr
17-OS	.25	5.25	594.50	550	1.08	100
18-XRD	-.-	.5	54.75	3=200' d	.27/ft.d	400 ft.d/hr
20-XRD	.25	-.-	19.62	1=60' d	.33/ft.d	240 ft.d/hr
21-SX	1.0	-.-	78.50	125	.63	125
22-SX	-.-	1.0	109.50	100	1.10	100
23-SX	1.75	1.75	329.00	250	1.32	71
24-TOS	6.75	7.0	1,296.37	725	1.79	53
25-SX	1.75	-.-	137.37	150	.92	86
26-SX	-.-	1.0	109.50	100	1.10	100
27-OS	-.-	4.0	438.00	250	1.75	63
28-SX	1.25	.5	152.87	200	.76	114
30-SX	-.-	2.25	246.37	200	1.23	89
SUMMARY:						
16 Skid Trail Stream Crossings	29.75 (41%)	42.0 (59%)	$6,934.39	4,685 yd^3	$1.48/$yd^3$	65
2 Skid Trail Exported Outlsope Reaches	8.75 (47%)	10.0 (53%)	1,781.87	1,100 yd^3	1.62/yd^3	59
4 Skid Trail Outslope Reaches	2.0 (12%)	14.5 (88%)	1,744.75	1,250 yd^3	1.40/yd^3	76
4 Skid Trail Drain Reaches	2.5 (83%)	.5 (17%)	250.99	12 drains 635 ft. of drain	20.92/drain .40/ft. of drain	4 drains/hr 212 ft. of drain/hr.
TOTALS = 26 Worksites	43.0 (39%)	67.0 (61%)	$10,712.00	7,035 yd^3 12 drains 635' drain	$1.49/$yd^3$ $21/drain $.40/ft. of drain	66 yd^3/hr 4 drains/hr 212 ft/hr
Total Hours = 110						

[1]Slopework costs include skid trail stream crossings (SX), skid trail drains (XRD), skid trail outsloping (OS), and skid trail exported outsloping (TOS). Equipment hours and costs include access (opening skid trails and travel).

[2]SX 7 was an extremely wet crossing, underlain by sheared black shist. The bulldozer was stuck several times dishing the crossing down, which resulted in having to use the excavator to bail out the muck 2 or 3 times before the dozer could efficiently push the muck to the fillsites.

channels and were outsloped to prevent further fillslope erosion along the outboard edge of the skid trail. The other two skid trail reaches were perched above streams with the potential for direct fill failure into the streams (tension cracks and scarps were present on both). The D7 bulldozer opened (brushed and bladed) the skid trails, then the excavator completed all of the outsloping independently. Three of these outslope reaches were on steep skid trails, with 40-50 percent grades, though the operator was very capable of maneuvering the excavator and working on these grades. a total of 1,250 cubic yards of fill material was outsloped, with an average unit cost of $1.40 per cubic yard and an excavation rate of 76 cubic yards per hour.

Twelve cross road (cross trail) drains were constructed along four skid trail reaches to direct concentrated surface runoff into nearby stream channels. Nearly all of the drains were constructed by the D7 bulldozer for a total cost of $250.99.

Other Heavy Equipment Rehabilitation Costs

Other heavy equipment erosion control rehabilitation treatments completed on this unit were the recontouring of the M-3 rock pit, and blading and draining the M-2 1/2 ridge road. Also, general miscellaneous heavy equipment costs include all equipment time which can not be assigned to a specific worksite, which includes moving support equipment (fuel trailers, etc.), travel between haul roads, moving straw bales, general discussions, paid breaks, paid down time, and equipment move in and out lowboy costs. Table 10 shows the costs for each of the other rehabilitation work and miscellaneous categories, totalling $19,539.76.

The M-3 rock pit recontouring cost of $4,572.30 includes: Outsloping the outboard edge of the road for 300 feet; contouring the rock pit to a more uniform slightly convex slope; spreading and mixing approximately 30 cubic yards of compost in a test plot about 50 feet across near the top of the rock pit ($341.77); and punching in the straw mulch to prevent wind loss on this exposed ridge ($189.78). The D7 winch and D8 ripper bulldozers completed almost all of the work, while the excavator completed only the outsloping along the outboard edge of the M-3 road at the base of the rock pit.

The entire 3.7 miles of the M-2 1/2 ridge road was bladed (devegetated) and approximately 75 cross road drains were installed, for a total cost of $608.38. The purpose for completing his project was to open (or improve the driveability of) this ridge road for continued fire suppression and wildlife study access along Bridge Ridge. The work was completed by the D7 bulldozer in less than eight hours.

Table 10
OTHER REHABILITATION WORK COSTS FOR HEAVY EQUIPMENT
Unit 87-5

Category	Equipment Hours: D7W	125B	D8W	D8R	Total Cost
M-3 Rock Pit Contouring[1]	17.75	9.75	-.-	22.25	4,572.30
M-2 1/2 Road Blade n' Drain[2]	7.75	-.-	-.-	-.-	608.38
Moving Support Equipment[3]	6.5	3.25	6.5	-.-	1,431.24
Moving Straw Bales	1.25	2.0	-.-	-.-	317.12
General Discussions	5.25	5.25	2.75	1.25	1,344.70
Paid Breaks	22.5	22.75	8.5	5.75	5,541.98
Travel[4]	6.5	7.75	1.5	2.25	1,702.78
Paid Down Time (first half hour)	4.0	2.25	3.75	-.-	886.40
Miscellaneous	6.75	3.5	2.0	-.-	1,087.01
Totals:	78.25	56.5	25.0	31.5	$17,491.91
		Total Hours = 191.25			
PLUS MOVE IN/OUT	$335.75	$417.95	$341.00	$953.15 =	$2,047.85
					$19,539.76

[1]The M-3 Rock Pit cost includes: Outsloping the outboard edge of the road for 300 feet; contouring the rock pit to a more uniform slope with a central ridge; spreading approximately 30 yd^3 of compost along a 50' x 50' area at the top of the rock pit ($341.77); and "punching" in the straw mulch to prevent wind loss ($189.78).

[2]All four miles of the M-2 1/2 Road was bladed (de-veged) and approximately 75 crossroad drains were installed.

[3]Moving support equipment included fuel trailers, compressor, welder, pickup trucks, etc.

[4]Travel includes between worksites and between the major haul roads (M-4-1, M-4, M-3, M-3-1, and M-3-1-2).

Labor Intensive Phase

The labor intensive phase involved two tasks which were pre-season brushing for volumetric survey work, and the distribution and application of straw mulch with a total labor intensive cost of $19,043.27. Costs are shown in Table 11. Brushing was completed on all haul road stream crossings, and at survey control points along export outslope and outslope road reaches (a total of 45 worksites). The brushing provided better visibility and access for volumetric survey and photo documentation work. Redwood National Park (RNP) labor crews were responsible for brushing, totalling 478 person hours and costing $5,339.88. Brushing 45 worksites took 13 days to complete.

Straw mulch was applied to haul road stream crossing side slopes and moderate to steep finished slopes along outsloped (TOS, BOS and OS) road reaches and fillsites. The total area disturbed by rehabilitation efforts and treated with straw mulch was 19 acres, and a 4000 lbs/acre straw mulch application rate was prescribed. The total number of straw bales used on the unit was 1,000 bales. Straw bales were distributed by Redwood National Park (RNP), Redwood United Inc. (RUI) and Youth Conservation Corp (YCC) labor crews, totalling 305 person hours and costing $3,096.99, with a unit cost of $3.10 per bale. The distribution of 1,000 bales took 7 1/2 days to complete. The straw bales were placed in small stock piles (5-25 bales each) along the inboard ditch at stream crossings and export outslope road reaches. Along fillsite and outslope road reaches, the excavator was used to place the straw bales on top of the cutbanks.

Redwood National Park, Redwood United Inc. and Youth Conservation Corp labor crews were responsible for spreading the straw, totalling 936 person hours and costing $7,516.40, with a unit cost of $7.52 per bale. The spreading cost for straw mulch on Unit 87-5, including acquisition, distribution and application, was $13,703.39, involving 1,241 person hours, with a total unit cost of $13.70 per bale.

Documentation Phase

Following completion of the erosion control phase, the work was surveyed where needed, photo points were retaken, cost data was compiled, and the annual report was prepared. Total cost of this phase was $2,766.33. Work was done by L. Johnson and D. Short, and was completed by January, 1988.

Table 11
LABOR INTENSIVE COSTS
Unit 87-5

Work Types	Type of Laborers	Person[1] Hours	Cost	Total Cost	Quantity	Cost/ Quantity	% of Total
Straw Distribution	RNP	226	$2,550.72	$3,096.99	1,000 Bales	$3.10/Bale	23%
	RUI	73	526.17				
	YCC	6	20.10				
Straw Application	RNP	250	2,761.90	7,516.40	1,000 Bales	7.52/Bale	55%
	RUI	620	4,533.40				
	YCC	66	221.10				
Straw Acquisition	--	--	--	3,090.00	1,000 Bales	3.09/Bale	22%
TOTAL SECONDARY TREATMENTS =		1,241		$13,703.39	1,000 Bales	$13.70/Bale	72%
Brushing[2]	RNP	478	5,339.88	5,339.88	45 Worksites	119.00/worksite	--
TOTAL MISCELLANEOUS TREATMENTS =		478		$5,339.88	--	--	28%
TOTAL LABOR INTENSIVE COSTS =		1,719 Person Hours		$19,043.27			

[1]Wages used to determine costs for RNP employees include benefits. All person hours and costs include round trip travel time.

[2]Brushing was completed at all haul road stream crossings (18), export outslope road reaches (13), and outslope road reaches at each control point (14).

CONCLUSION

Overall, the quality and cost effectiveness of the erosion control work completed on unit 87-5 by the heavy equipment operators and labor intensive crews was excellent. The combination and size of heavy equipment used on this unit worked very well, resulting in some of the highest excavation rates achieved in the watershed rehabilitation program to date. The techniques utilized to achieve these high production rates for specific prescription categories were described in detail under the Heavy Equipment Phase of the Erosion Control Work section of this report.

The Caterpillar D7 bulldozer and CASE 125B excavator worked well together as a team. Each have an estimated production rate (including job condition correction factors) of approximately 150 cubic yards per hour, which eliminated any idle time that usually occurs when equipment with different production rates are paired together (e.g., CAT D8 bulldozer and a John Deere 690B excavator, 175 cubic yards per hour versus 75 cubic yards per hour, respectively). The CASE 125B excavator is an ideal size excavator, capable of working in tight work spaces (slopework), yet, large enough for average size (35 foot wide) haul road worksites.

As has been the case over the past several years, there's no question that caterpillar D7 and D8 sized bulldozers are perfect for erosion control rehabilitation road removal work, due to the obvious fact that this was the same size machine used to build the road in the first place. In addition, bulldozers equipped with U-blades and wide high floatation tracks are perfect for working in wet, muddy excavations (which is usually the norm) and for pushing fill several hundreds of feet to a fillsite. (Refer to Caterpillar Performance Handbook, Edition 8, Section 4, pages 6, 18 and 20.)

The issue of outsloping for aesthetics (along non-erosional road reaches) versus cross road draining (which has been an established treatment in the past) was discussed to some length between Technical Services and Resource Management personnel several times this year on field reviews. The discussions centered around the value and cost effectiveness of doing a more expensive treatment purely for aesthetic values. Outsloping is not just a purely aesthetic treatment. A slight to moderate (5 to 15 foot cut depth) outslope treatment is a more permanent solution for re-establishing a natural hillslope runoff pattern and provides a much better growing medium for vegetation to become established once again, especially in sensitive soils or in areas where the upper soil horizons have been stripped away.

Approximately one half mile along three sections of the M-3 haul road were moderately outsloped to compare costs with a typical cross road drain prescription. In comparing unit cost per linear foot of road for a moderate outslope (30-foot wide haul road with a 10-foot cut is $1.15 per linear foot of road) versus cross road drains (average 50 feet long and constructed every 100 feet is $.50 per linear foot of road), the cost on average will be twice as much to moderately outslope as it would be to construct drains. On a typical rehabilitation project, the total length of road usually cross road drained is a relatively small percentage of the overall total treatments for the project.

Therefore, a slight to moderate outslope along these cross road drain sections will increase the total budget for a typical rehabilitation project on average between 2 and 10 percent, which is a small amount, considering the extremely beneficial long term effects of an outslope treatment.

Over the next few years, outsloping should be used as a viable and cost effective treatment for road reaches that have minimal erosional problems. Especially road reaches adjacent to old growth redwood stands; or those that will be used or are near a proposed visitor access trail; or are in sensitive soil types. This is a National Park that is being restored and established for present and future visitor usage. Therefore, the Resource Management's watershed rehabilitation program's efforts should reflect a responsibility to achieve this goal, "to restore and/or maintain the natural ecosystems of the park as they would have evolved without disturbance by human technology". (Redwood National Park, General Management Plan, August 1979, page 25.)

ABBREVIATIONS

CSP = Color stereo pair
B/W = Single B/W photo
Color ASA 200 Ektachrome
B/W ASA 400 Tri-X
Type = All - CSP B/W
Pre-pp 6-11-87
Post-pp 11-2-87

UNIT 87-5

M-3/M-4-1 ROADS AND SLOPE

PHOTO POINT LOCATION AND DESCRIPTION

PP#	LENSE(mm)	LOCATION	PHOTO-POINT DESCRIPTION
1	35	OS V163+72	VIEW: Looking down road at outslope and excavation FROM: Outboard edge road
2	35	RX V166	VIEW: Down and across excavation FROM: TOCB by V165
2.5	35	RX V166	VIEW: Up channel FROM: Bottom of crossing mid-channel, stake in RB.
3	35	RX V166	VIEW: Across excavation FROM: Top of stump on top of cut bank above left bank.
4	35	FS V167	VIEW: Looking up road at fillsite FROM: Stump at IBD near RX V170
5	35	RX V170	VIEW: Looking down on crossing excavation FROM: TOCB near V171
6	35	OS V172	VIEW: Downroad to O.S. FROM: Mid road near stump. Stump in IB edge road. Stake in stump.
7	28	RX M26	VIEW: Looking perpendicular to crossing. FROM: TOCB on LB of RX
7.5	28 VERT	RX M26	VIEW: Up channel of excavation FROM: Bottom of crossing below K.P.
8	35	RX M26	VIEW: Down centerline channel FROM: Top of RX. Stake in RB.
9	35	RX V186	VIEW: Down road to RX FROM: Stump on IBER

PP#	LENSE(mm)	LOCATION	PHOTO-POINT DESCRIPTION
10	35	RX V190	VIEW: Oblique down channel FROM: CB at RB near big alder. Stake near alder.
11	28	RX V195	VIEW: Down centerline of excavation FROM: TOP stake. Stake on LB
12.2*	28	RX V200	VIEW: Of excavation FROM: Top of log in LB upslope of tall stump.
12.4*	28	RX V200	VIEW: South across channel FROM: IBE downslope of RW clump
13	28	RX E11	VIEW: Down channel FROM: LB above the TOP
13.5*	28 VERT	RX E11	VIEW: Up channel FROM: Centerline bottom excavation at stake in stump.
14A	28	RX E11	VIEW: Across channel into excavation FROM: Stake in stump on OER, top of LB.
15	28	TOS E15	VIEW: Down station FROM: Base of CB on LB
16	28	TOS E15	VIEW: Up at TOS FROM: Below OBE road
17	35	TOS E20	VIEW: Down station FROM: CB slope by "END TOS" LB
18	28	TOS E25	VIEW: Upstation at TOS FROM: Stake in ground near big RW tree
19	35	TOS E25	VIEW: Down section FROM: IBD CB slope stake in ground
20	35	OS E29	VIEW: Up road toward O.S. FROM: Stake at OER
21	35	OS E29	VIEW: Downstation FROM: Mid-road near stake, stake 20' away on CB.
22	28	M-3 Rock Pit	VIEW: Looking up at Rock Pit FROM: OER Stake
23	35	OS E40	VIEW: Looking up road at OS FROM: OER stake

*New Post H.E.

PP#	LENSE(mm)	LOCATION	PHOTO-POINT DESCRIPTION
24A B C	28	M-3 Rock Pit	VIEW: Looking down into rock pit in 3 directions A = left, B = middle, C = right FROM: Top of Road O.C. Top of rock pit.
25	28	RX E44	VIEW: Looking up at OE of RX FROM: Log below "bottom" stake in channel. Stake in stump.
26	28	BOS E49	VIEW: Looking downstation FROM: IBD stake in ground above IBD
27	35	TOS E52	VIEW: Looking down station FROM: IBD at E54. Stake in ground above IBD.
28	35	M-3 Rock	VIEW: Across stream valley to east to the rock pit. FROM: Top of CB near sta. E56+00 stake in CB above foot-hold.
29	35	TOS E61	VIEW: Looking down station FROM: IBD. Stake in ground above IBD.
30	35	OS E65	VIEW: Of road reach FROM: OER stake near E65+00
31	35	BOS E28	VIEW: Downstation to BOS FROM: IBD. Stake above IBD in CB.
33	28	RX E79	VIEW: Down centerline FROM: Above TOP by stake in log.
34A B	35	OS	VIEW: A) Down road (NW); B) Up road (SE) FROM: Centerline road near E90+00 stake on CB 12'away
35	28	RX E95	VIEW: Up channel FROM: Bottom stake. Stake next to 8" alder.
36	28	RX E102	VIEW: Of two channels merging into pond FROM: Ridge above top at base of CB. Stake in CB.
36.2	28	RX E102	VIEW: Of pond FROM: 40' upstream of PP36 at 3 pink flags
37	28	RX E102	VIEW: Looking upchannel FROM: Log in channel 25' below "bottom" stake. PP stake in log.
38	35	RX E102	VIEW: Of main channel above pond FROM: Main channel where canopy cover begins
39A B	28	RX E102	VIEW: A) Upstream; B) View of LB FROM: Top of RB

PP#	LENSE(mm)	LOCATION	PHOTO-POINT DESCRIPTION
40	28	M-3-1 M1+00	VIEW: Of RX FROM: Burned stump below road NOTE: Previously known as PP26 on 83-2
41	28	M-3-1 M9+00	VIEW: Of RX FROM: 3 logs near flagging NOTE: Previously known as PP25A on 83-2

UNIT 86-5 M-3-1-2 ROAD AND SLOPE

UNIT 87-5 M-3 AND M-4 ROADS AND SLOPE

MAP D: EROSION FEATURES AND REHABILITATION TREATMENT MAP

L. JOHNSON

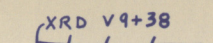
LEGEND:

Scale: 1:6000

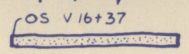
- Drainage
- Major Ridge
- Scarp, inactive
- Scarp, active
- Toe feature
- Rill (R), Gully (G)
- Spring, Seep
- EF, LS, DT — Earthflow, Landslide, Debris torrent
- FF, CBF — Fill failure, Cutbank failure
- Haul road
- Secondary haul road or skid trail
- M-4 83-3



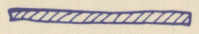
REHAB TREATMENTS:



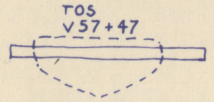
Rip and Drain (XRD)



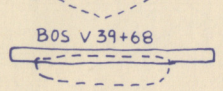
Outslope (OS)



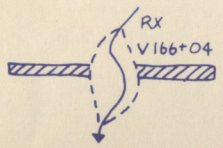
Fillsite (FS)



Total Outslope (TOS)



Bench Outslope (BOS)



Haul Road
Stream Crossing
Excavation (RX)



Skid Trail Stream
Crossing Excavation (SX)
and access. trail

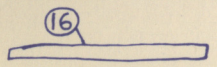


Photo Point Location
and Number



TOS V 123+34
OS V 124+00
OS V 125+48
TOS V 126+45
Slopework XRD A V127+51
TOS V 130+75
Slopework XRD A V130+60
TOS V 132+65
OS V 133+45
XRD V 135+09
Rx M 1+00
Rx M 9+00
TOS M 22+40
M 13+14 XRD
OS V 163+57
Rx M 26+90
Rx V 166+04
OS V 172+31
XRD V 172+15
Rx V 170+17
Rx V 180+44
Rx V 186+00
Rx V 190+00
Rx E 95+00
OS E 96+00
Rx E 100+00
Rx E 102+00
outslope ST
removed culvert
Complete Outslope
OS E 105+50
87-5
83-2
86-5
M-3-1
M-3-1-2
M-3
M-LINE
M-2 1/2


BRIDGE CREEK
M-4
M-3
M-LINE
M-4-1
87-5
83-3
87-5
XRD E0+00
gully w/ fill material
TOS E 15+60
TOS E 20+74
TOS E 25+29
OS E 29+05
M-3 Rock pt
OS E 40+00
BOS E 47+00
BOS E 49+15
TOS E 52+25
TOS E 60+50
OS E 65+85
BOS E 68+00
TOS E 72+85
OS E 84
Rx E 44+00
Rx V 200+00
Rx V 195+81
Rx E 79+05
E 11+00
E 36+00



Unit: 87-5 Date:6-11-1987, PP3, M-3-1-2 Road pre HE, Rx V166+04, 35mm, (LEJ)



Unit:87-5 Date:8-17-1987, PP3, Action 3/4 done, (LEJ)



Unit:87-5 Date:10-17-1987, PP3, M-3-1-2 Road post HE, 35mm, (LEJ)



Unit:87-5 Date:6-11-1987, PP15, TOS 15+16, M-3 Road pre HE



Unit:87-5 Date:7-1987, pp15, D7 cutting down OE, TOS E15, (LEJ)



Unit:87-5 Date:7-1987, PP15, D7 + Exc. at TOS E15, (LEJ)



Unit:87-5 Date:11-2-1987, PP15, M-3, TOS E15+60, 28mm, (LEJ)



Unit:87-5 Date:6-16-1987, PP22, M-3 Rock Pit near E38+50 pre HE, 28mm, (LEJ)



Unit:87-5 Date:11-2-1987, PP22, M-3 Rock Pit, 28mm, (LEJ)



Unit:87-5 Date:6-16-1987, PP34B, OS E84+00 M-3 Road near E90+00 pre HE, 35mm, (LEJ)



Unit:87-5 Date:11-2-1987, PP34B, M-3 OS E84+00 post HE, 35mm, (LEJ)



Unit:87-5 Date:6-16-1987, PP36, Rx E102+00 M-3 Road pre HE, 28mm, (LEJ)



Unit:87-5 Date:9-10-1987, PP36, 2/3 Vol. Removed 10:30am, (LEJ)



Unit:87-5 Date:9-11-1987, PP36 (30' above), Action 1:35pm, (LEJ)



Unit:87-5 Date:11-2-1987, PP36, M-3 Rx 102+00 post HE, 28mm, (LEJ)