

SUMMARY REPORT

1820, 1821, and Lower 1800 Road
REHABILITATION UNIT 84-3

Resource Management Division
Redwood National Park

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Introduction

Unit Description

Rehabilitation Unit 84-3, 1820, 1821 and lower 1800 Roads and Slopes, encompasses 685 acres of tractor logged forest land located near Redwood National Park's southern upstream boundary along Redwood Creek (Figure 1). The major portion of the unit (94%) lies along the western side of Redwood Creek from Devil's Creek to Little Elf Creek. The remainder of the unit borders Redwood Creek on its eastern side and extends upslope to the K&K road. Portions of three stream systems pass through the unit (Dwarf Creek, Little Elf Creek, and Elf Creek) ranging in size from 121-490 acres of watershed.

Total relief within the rehabilitation unit is about 1,400 feet from Redwood Creek (240 ft elevation) to the upslope boundary of the unit within the Dwarf Creek drainage (1,700 ft. elevation). Hillslopes within the unit are composed of two distinct classes: 1) relatively stable with a mean slope of about 32 percent located above the inner gorge; 2) relatively unstable with a mean slope of about 57 percent located within the inner gorge. Soils within the unit are strongly associated with the two slope classes. Soils within the relatively stable slope class are generally deep, more developed, and well drained. Soils within the unstable inner gorge slope class are usually deep, less developed, and generally do not drain well.

On the upper slopes, prior to timber harvest, vegetation was Forest type III with redwood, Douglas-fir, western hemlock, and tan oak. Since timber harvest these slopes have largely revegetated with brush, Douglas-fir, redwood, and red alder. Mass wasting is uncommon on the upper slopes, however, where water is concentrated fluvial erosion in the form of rills and gullies is common.

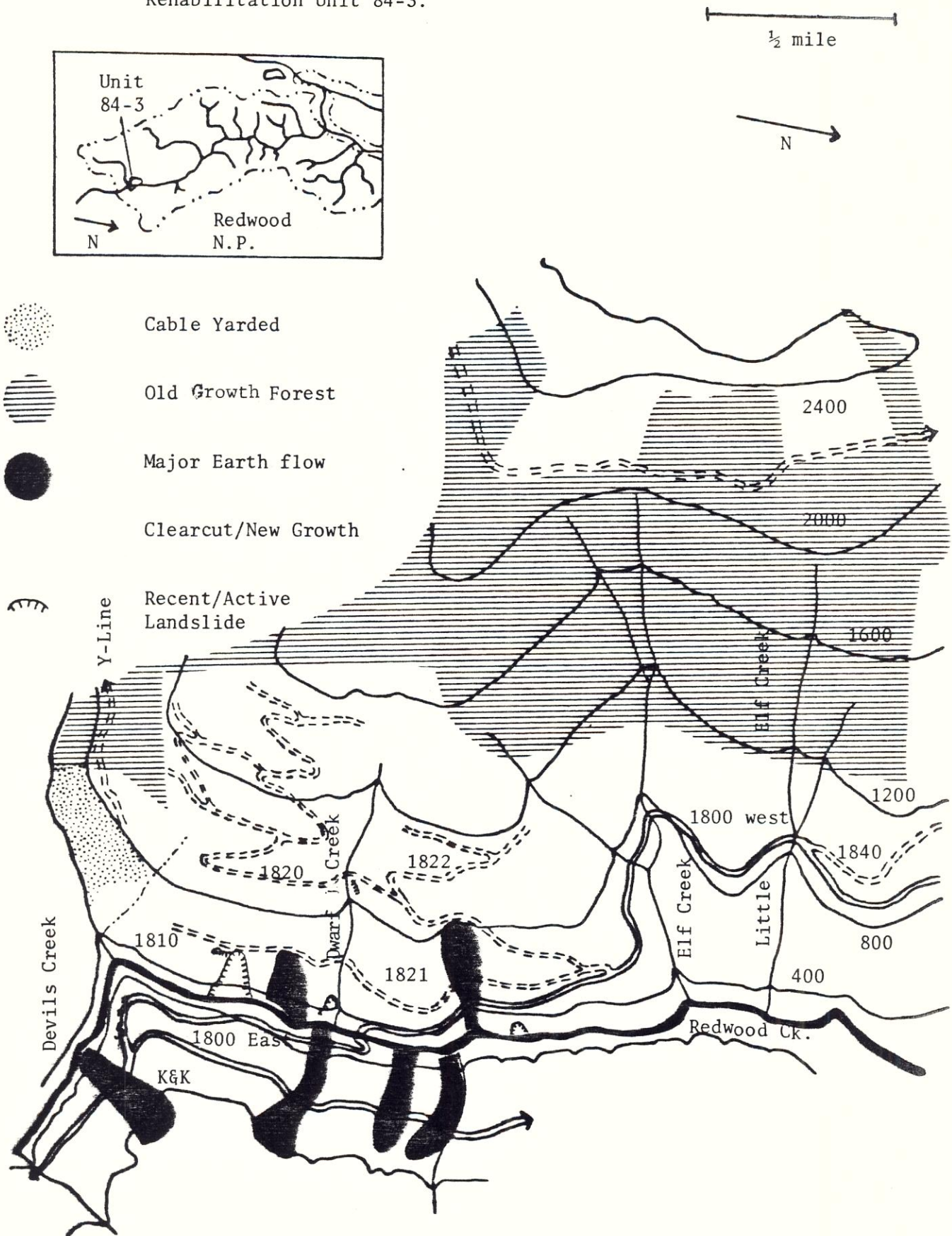
Prior to timber harvest the slopes of the inner gorge were vegetated by Forest Type IV with redwood, hemlock, tanoak, and Douglas-fir. Since timber harvest red alder has predominated, although regrowth of redwood and Douglas-fir is common on relatively stable areas. Inner gorge slopes are prone to mass movements in the form of translational slides and earthflows. These processes appear to have been accelerated by alteration of the hillslope morphology and surface/subsurface drainage due to road construction and forest removal.

Erosion History

Erosion Features 1958

The 1958 aerial photographs indicate that the rehabilitation unit supported a pristine predominately old growth redwood/Douglas-fir forest. The old growth canopy inhibits analysis of surficial erosion but does suggest, through geomorphic expressions, (arcuate breaks in slope, etc.) that most of the landslides proximal to Redwood Creek existed prior to land use activities (Figure 2).

Figure 1. Location and Description Map
Rehabilitation Unit 84-3.



The summer of 1958 marked the initial construction of the 1800 road. The road extended from the K&K haul road to Redwood Creek. A section of the 1800 road had been pioneered traversing the creek on the west side for a few hundred feet. Timber harvest was restricted to a narrow strip adjoining the 1800 road that was cut while gaining access.

At the location of the present day 1821 landslide (Figure 2) there is a break in the forest canopy with down trees on the slope suggesting that a mass movement landslide is active. However no visible scarps can be detected from the photographs. Breaks in the canopy also exist upstream from the 1821 L.S. where there is a present day earthflow. Below these breaks in the canopy Redwood Creek is being deflected into the opposite bank and there is a considerable amount of boulder lag in the channel. Other breaks in the canopy also occur between the 1800 and the 1821 roads in locations where the mapping in the winter of 1983-84 indicate mass movements (Figure 2). The hillslopes on the east side of Redwood Creek also exhibit mass movement features in locations where there are now very active earthflows. (Figure 2). In view of these geomorphic expressions, the hillslopes on the 84-3 rehabilitation unit had a history of mass-movement prior to any logging activities.

Erosion Features 1965

By 1965, the 1800 road (westside) had been constructed past Little Elf Creek. The 1820 road had been crudely constructed up to the dog leg and a short segment of the 1822 had been pioneered. The 1805 road had been constructed off of the 1800 road (eastside) immediately above Redwood Creek extending downstream and the 1810 road had also been completed by this time. Selective timber harvest had begun between the K&K haul road and Redwood Creek. Timber was selectively cut between Redwood Creek and the 1820 road from the southern end of the unit north to the 1820/1800 intersection. The 1821 road had not yet been constructed and timber in this area was skidded to the 1800, 1810 or 1820 roads.

Selective cuts also occurred above and below the 1800 road, from the 1800/1820 intersection to Little Elf Creek. These cuts were adjacent to the 1800 road extending up or downslope a few hundred yards. In some of the selective cut units and adjacent areas, mass movement features were developing and older landslides were reactivating. The Big Tree earthflow and the 1800 Road Earthflow had developed downstream from the 1800 bridge (See Figure 2). Along portions of the 1810 road a few mud/debris flows had occurred. Due to the scale of the 1965 photographs (1:15,000) analysis of surficial erosion (gullies, etc.) was infeasible.

Erosion Features 1966

Road construction within the 84-3 rehabilitation unit had not progress since 1965. Timber harvest was concentrated around the Elf Creek Basin in two clear-cut blocks above the 1800 road. The Big Tree Earthflow downstream of the 1800 bridge had reactivated and a large block had slide across the 1805 road (making it impassable) into Redwood Creek. The 1800 Road Earthflow had enlarged and was delivering detritus into Redwood Creek.

SITE BOUNDARY

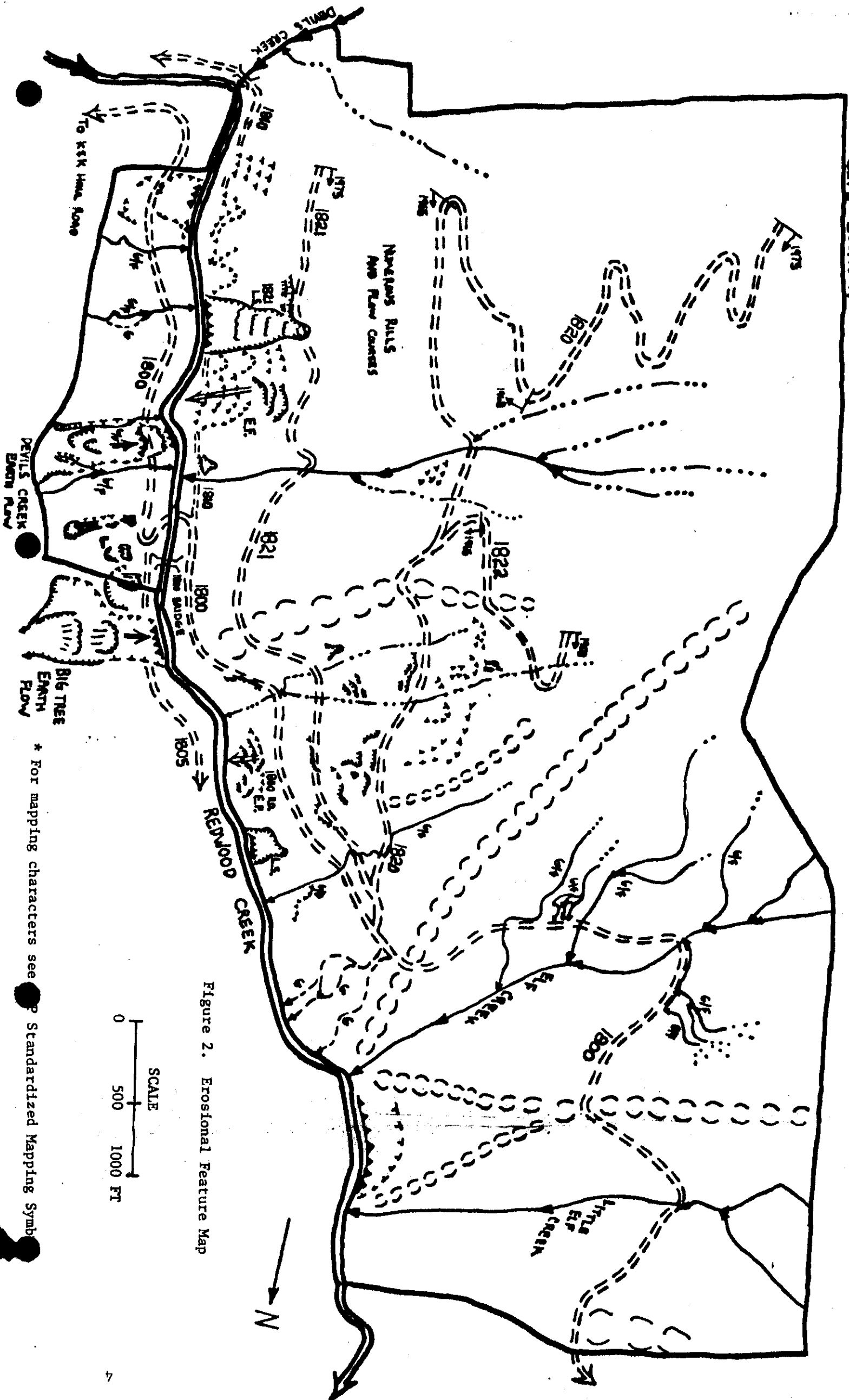


Figure 2. Erosional Feature Map

* For mapping characters see  Standardized Mapping Symbol

A gully system below the 1800/1820 intersection was laterally developing, incising, and prominent in the aerial photographs. This gully system was a result of water being captured by the 1800 and 1820 roads. Flow crossed the 1800 road and diverted down numerous skid trails. All other major gully systems were developing and were primarily a result of subsurface flow emerging from skid trail cutbanks and becoming overland flow.

Erosion Features 1968

The 1820 road had been extended to the first switch-back above the dog-leg. The 1822 road had been completed up to its present day location.

Timber was being clear-cut above the 1820 and 1822 for a few hundred yards, logging had extended to Elf Creek above the earlier selective cut units of the 1800 road.

The Big Tree earthflow had become more active and had obliterated the 1805 road. There was a large volume of earth resting in the creek channel that was deflecting flow into the left bank. The 1800 Road Earthflow had become less active than in previous years.

Erosion Features 1971

The west side of Redwood Creek had no additional road construction or timber harvest since 1968. Timber on the east side was clear-cut between the K&K haul road and the 1800 road. Earthflows had existed in this area prior to logging. A dormant earthflow, (Devils Creek Flow) located above the 1800 Bridge, had reactivated and was enlarging following tree removal.

The Big Tree Earthflow was still adding earth to Redwood Creek and directing flow into the left stream bank. The 1800 Road Earthflow had revegetated and was becoming more stable. There was a fill failure scarp in the 1800 road directly above the earthflow that could suggest that the head scarp of the earthflow was migrating upslope into the fill prism. The 1800 road was showing signs of instability all along its length with fill failures developing in the road prism.

Erosion Features 1973

The 1800 road had continued to deteriorate and several slumps had developed. The 1800 bridge had been "washed out", presumably by the winter storms of 1972. The earthflows on the east side were continuing to enlarge and were very active. No further timber harvest or road construction had occurred since 1971.

Erosion Features 1975

By 1975, the remainder of 1820 and the 1821 roads had been constructed. A seasonal bridge over Redwood Creek had been installed upstream from the old bridge. Fill failures continued to develop along the 1800 road on both sides of Redwood Creek.

Timber harvest had resumed and the large clear-cut block on the south end of the rehabilitation unit, along the 1820 road, had been logged. Numerous skid trails were constructed causing extensive ground disturbance and disrupted stream channels. Some landings were constructed immediately above stream channels and one was constructed across a channel. There was extensive rilling of the cut block with most of the water flowing from one skid trail to another. Very little gullying occurred except where stream channels were crossed and water was diverted.

The selective cut units between Elf Creek and Little Elf Creek had been reentered and the remainder of the timber removed. After tractor logging, gullies reformed in the same locations as previous gully systems.

Erosion Features 1978

The 1800 road on the east side of Redwood Creek displayed numerous scarps with some large segments of the road failing. Some scarps extended past the centerline of the road. The Big Tree Earthflow remained very active.

The 1821 road was showing signs of instability. One road segment, near the 1820/1821 intersection (on the 1821 road) was failing with large blocks of the road coming apart. Directly upslope on the 1820 a segment of the road had failed with a visible scarp approximately 250 feet long. On the cut-bank north of Elf Creek and above the 1800 Road, gullies had redeveloped in about the same locations as in previous years. Additional timber harvest had occurred in the Little Elf Creek drainage and on a cut-block north of Little Elf Creek. The hillslopes on the rehabilitation unit were experiencing good vegetative regrowth. Most of the landslides and the gullies appear to be less active.

Erosion Features 1982

The winter of 1982 stimulated the appearance of numerous road failures and some additional landslides not previously active. The 1821 landslide was activated this year due to the failure of a landing located directly above its head scarp. The landing was poorly drained and was located on a 50-60% slope. The fill became saturated and the landing failed as a debris flow. This debris flow scoured the hillslope and acted as a catalyst to reactivate the 1821 landslide.

Some streambank failures along Redwood Creek occurred due to undercutting the toe of the hillslope during high flows. The largest stream bank failure was a translational landslide (6' Head Scarp) that occurred immediately downstream of the 1800 Road Earthflow (Figure 2). The 1800 road (east) had become impassable due to large fill failures that occurred along its length, some extending to the inboard ditch.

Channel diversions and gully systems remained unchanged since 1978. Most of the large landslides remained active with most of the smaller landslides becoming more stable.

Erosion Features 1984

In the winter of 1983-84 field assessment of the rehabilitation unit began. All previously referred erosional features were mapped (Routon & Vann, 1984), and a full reconnaissance of the unit was implemented.

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 erosional problems and locating sediment sources. This is accomplished through aerial photo interpretation, reconnaissance, and detailed geomorphic field mapping.

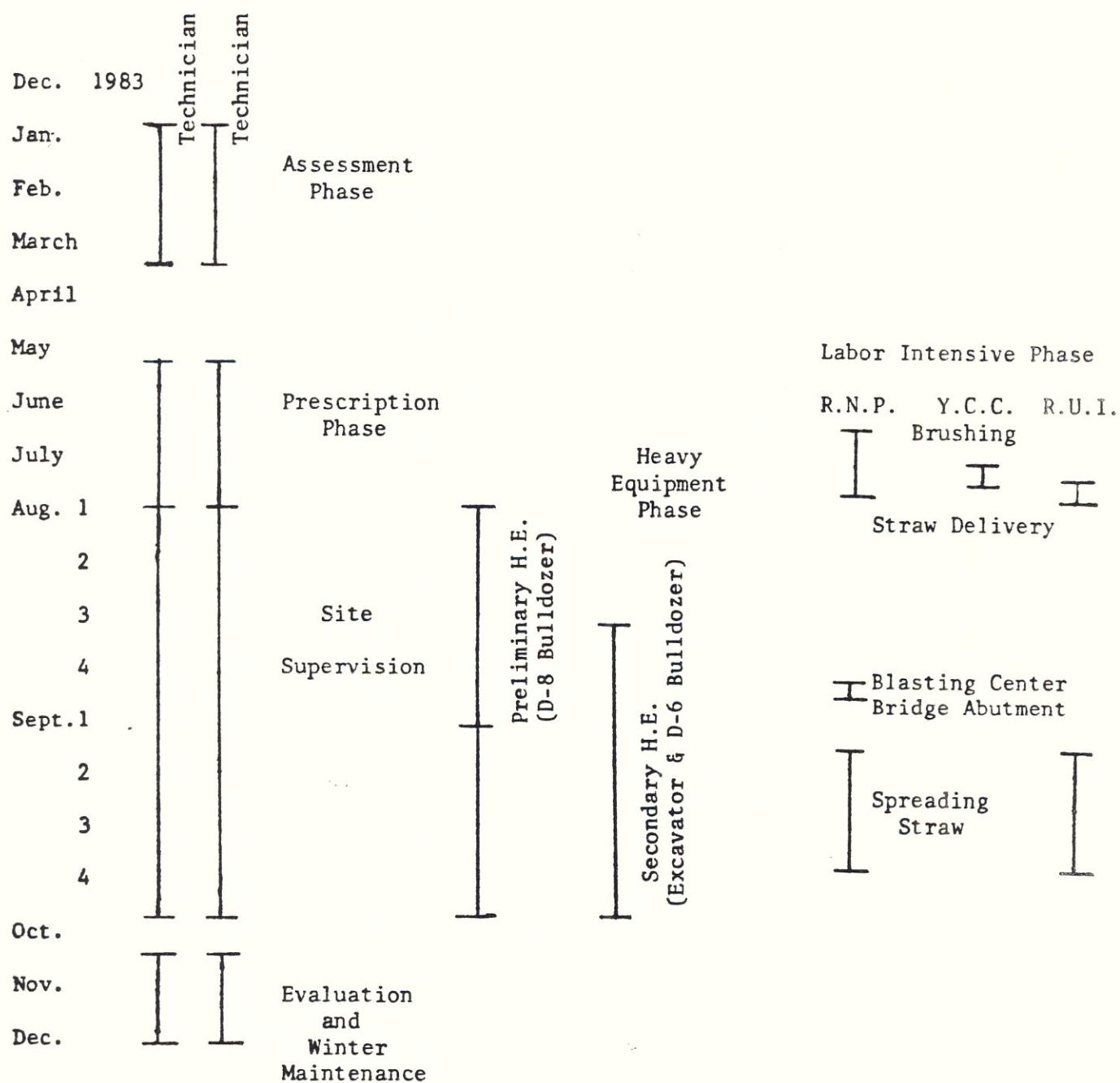
Prescription entails design of appropriate treatments to reduce erosion by correcting disrupted drainage patterns and stabilizing sediment sources adjacent to stream channels. This phase also includes selecting the types of heavy equipment to be used, surveying the worksites, documentation (photo points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

The heavy equipment phase involves earth moving equipment used to excavate fill, correct water diversions, and 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 bare 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 adjustments 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. Figure 3 lists the sequence and time frame of the phases as performed on the 84-3 rehabilitation unit.

Figure 3 Sequence of Rehabilitation Work Unit 84-3



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, predominantly due to haul road and skid trail construction. Primary considerations are; removing active and potential sediment sources (with major emphasis on approximal stream side environments), returning drainage networks to their original configuration, and dispersing water.

The 84-3 rehabilitation site principally addressed the removal of a portion of one major haul road (1800 road) and three secondary haul roads (1820, 1821, & 1822). The total length of the roadways was 5.4 miles and encompassed thirteen stream channel crossings. There was some minor hillslope work that involved channel excavation of six skid trail crossings due to their high erosion and water diversion potential. One landing approximal to Little Elf Creek was outsloped.

A landing located at the head scarp of the 1821 translational landslide, was excavated in order to alleviate perched fill above active scarps. Bordering the landslide were additional active scarps, in fill and probably involving original ground, that were outsloped to decrease their movement and to protect the old growth Redwood below.

Outsloping was prescribed in areas where road fill contributed to overloading and the stability of the hillslope was low to questionable. Outsloping principally involved areas where road segments or landing were perched above stream channels or in locations where a failure would endanger the old growth forest below.

Cost Summary

The costs of erosion control work for this unit are summarized on Table 1. Heavy equipment accounted for 71% of the total cost. About 22% of the cost is attributed to the supervisors (Technicians). The remaining 7% of the costs are associated with hard labor performed by park personnel, YCC and Redwoods United Inc.

Heavy Equipment Phase

Heavy Equipment Application

Rehabilitation work on Unit 84-3 was performed by three types of equipment Table 2: 1) bulldozers; 2) excavators; and 3) dump trucks. A Caterpillar D8 with winch and straight blade was used initially to open up roads that were blocked due to vegetative regrowth and/or road failures. The D-8 also did preliminary excavation work on stream crossings, outslope reaches, and cross-road drains. The D8 was also used to assist an excavator on sites which required long pushes to fill sites. A Caterpillar D6D with winch and straight blade was used primarily to assist an excavator to complete excavation work and outsloping. The excavators, a Bucyrus Erie 300-H with a one-yard bucket and a John Deere 690-B with a three-quarter yard bucket, were primarily used to complete excavation work. Two ten-yard dump trucks were used to endhaul fill material from an unstable area to a suitable fill site in conjunction with an excavator used to load the trucks.

Table 1 Summary of Rehabilitation Costs

	Technicians	Laborers	Heavy Equipment	Redwoods United Inc.	YCC	Total Task Cost	Total Phase Cost	Phase % of Total Cost
Mapping	\$ 5,092.00					\$ 5,092.00	\$11,004.00	13.1
Prescriptions ¹	5,912.00					5,912.00		
Primary Treatment			\$51,658.90			\$51,658.90	\$63,975.53	76.4
Miscellaneous			7,888.63			7,888.63		
Supervision	4,428.00					4,428.00		
Secondary Treatment		\$4,350.71		\$920.00	\$616.40	5,887.11	5,887.11	7.0
Cost Analysis ² Documentation	2,919.00					2,919.00	2,919.00	3.5
Totals	\$18,351.00	\$4,350.71	\$59,547.53	\$920.00	\$616.40		GRAND TOTAL \$83,785.64	
Percent of Costs	21.9	5.2	71.1	1.1	0.7			

1. Includes preliminary survey work, flagging for site limits and straw distribution, brushing delineation, costs estimates, equipment rental, water diversions, photo points, etc...

2. Includes all post survey work, data analysis, photo points, and report writing.

Table 2 Summary of Equipment Specifications

Equipment Type	Make/Model	Year	Rate/Hour	Total Hours
Bulldozer	Caterpillar D8H w/13' wide 4-way hydraulic tilt straight blade and winch	1966	\$ 90.00	218.5
Bulldozer	Caterpillar D6D w/10.5' wide 4-way hydraulic tilt straight blade, winch, and one 18" "blade attachable" ripper	1977	65.00	234
Excavator	Bucyrus Erie 300H ³ w/standard 1 3/4yd ³ toothed bucket and triple grouser tracks	1981	106.00	178.75
Excavator	John Deere 690B ³ w/standard 3/4yd ³ bucket, w/bucket clamp	1978	78.00	28
2 dump trucks	10yd ³ dump truck	1963	34.00	30
		1975	35.00	30

Heavy Equipment Sequencing

Heavy equipment was scheduled such that the D8 began work 12 days prior to the arrival of the 300-H and D6 and completed as much of the preliminary rehabilitation work as was efficiently possible.

Work was initiated by the D8 at the down road extent of each rehabilitation reach (e.g. 1820 road, 1800 east, etc..) and progress up-road. An access road was left along the inboard portion of crossings and outslope reaches. The 300H and D6, for the most part, completed rehabilitation work initiated by the D8. Besides assisting the excavator by removing spoil the D6 and the D8 were used for touch-up work on sloped areas and for winch removal of logs and culverts.

Heavy Equipment Treatment Objectives and Costs

The costs of treatments performed by heavy equipment on rehabilitation unit 84-3 are summarized on Table 3. Stream crossing excavations, summarized on Table 4, accounted for the largest expenditures among treatment classifications. Data for individual haul road crossings are listed on Table 4. Removal of stream crossings was deemed necessary due to the high potential of fill material to fail directly into a stream channel and/or due to active or potential stream diversions. Excavation prescriptions consider achieving stable channel morphology and, when feasible, complete removal of fill for exposure of original channel banks and bottom.

Although stream crossing cost are attributed solely to excavation, some channel armoring was achieved with large organic debris and rock obtained from spoil. Channel armoring costs were not significant and were absorbed by excavation costs. Channel armoring with imported rock was not prescribed for this unit due to prohibitive cost of acquisition.

Variation in cost per unit volume of stream crossings is largely attributed to the distance of which spoil was displaced from the given crossings. The two extremes in cost/yd³ occurred within the small excavation class. The least expensive excavation (\$0.48/yd³) involved a skid trail crossing of 100yd³ (Sx-1; Table 45; Figure 4 with a minimal push and was performed entirely by the D8. The most expensive (\$6.10/yd³) involved a 120yd³ road crossing excavation attributed largely to the 300-H. The 300-H operator was, at that point, inexperienced with excavator operation and with rehabilitation work. Thus the crossing excavation served as a training site and took an unusually long period of time to complete.

Given that the distance of spoil displacement was the same at every crossing, the larger crossing would commonly be among the least expensive relative to cost per unit volume. Usually, the geometry of large crossing allows for a maximum of excavation work to be performed by a large bulldozer. This was not the case for the extra large crossings (2,000+ yd³) on unit 84-3. Most of the Elf Creek crossing (2,608yd³) had to be endhauled about .25 miles by dump-trucks loaded by the excavator. Consequently, the resulting cost of \$3.04/yd³ was higher than would be expected if the fill site were more proximal to the excavation. Due to the wetness of fill material, approximately half of the Little Elf Creek crossing (2,313yd³) had to be excavated with the 300-H. In addition, the spoil had to be pushed a relatively long distance (250 ft) resulting in a cost of \$2.53/yd³.

Table 3 Summary of Heavy Equipment Costs Unit 84-3

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	13	11,602/yd ³	\$25,460.60	\$1,958.50	\$ 185.50- 7,934.30	\$2.19/yd ³	\$1.03/yd ³ 3.04/yd ³ ¹	42.8
Skid trail stream crossings	6 ²	915/yd ³	1,640.15	273.35	17.70- 684.00	1.79/yd ³	0.48/yd ³ - 2.28/yd ³	2.7
Outsloping	14 ³	13,002/yd ³	16,389.20	1,119.23	53.00- 5,533.00	1.20/yd ³	0.63/yd ³ - 2.20/yd ³	27.5
Cross road drains	--	23,700 LF (225 CRDS)	5,047.45	22.43/CRD	--	0.21/LF	--	8.5
Log/culvert recovery	--	--	3,121.50	--	--	--	--	5.2
Miscellaneous Itemized	--	--	7,793.23	--	--	--	--	13.1
Non-itemized	--	--	95.40	--	--	--	--	.2
Total heavy equipment cost			\$59,547.53					100

1 Rx-1 was exceptionally expensive (\$6.10/yd³) due to the initial inexperience of the 300-H operator. Rx-1 involved only 120yds total of fill and is excluded as an index within the range of cost per quantity. Elf Creek crossing (\$3.04/yd³) was endhaunched.

2 The channelization downslope of Rx-1820 35+50 is included as a skid trail crossing treatment.

3 One outslope (LD-2) is not listed because it was not surveyed. The cost of this OS was \$720.00 and is included under "Total Costs" but not in other statistics shown.

4 Drain size varies.

Table 4 Summary of Haul Road and Skid trail Stream Crossing Excavation Costs Unit 84-3

Size of Excavation	# of Worksites	Equipment	Total ¹ Cost	Total yds ³	Average Cost/ Worksite	Average ³ Cost/yd	Range: Cost/yd ³
Extra-small 0-100yd ³	1	300-H	\$ 17.70	15	--	\$1.18	--
Small 101-400yd ³	10	300-H, D6-D, D8-H	3,856.65	2,005	\$ 385.66	1.92	\$0.48-6.10
Medium 401-800yd ³	3	300-H, D6-D, D8-H	2,959.05	1,623	986.35	1.82	1.25-2.50
Large 801-2,000yd ³	3	300-H, D6-D, D8-H	6,480.05	3,953	2,160.02	1.64	1.03-1.96
Extra-large 2,000yd ³	2	300-H, D6-D D8-H	13,787.30	4,921	6,893.65	2.80	2.53-3.04
Totals	19		\$27,100.75	12,517	\$2.16		

1 Access costs for worksites are not accounted for. All access costs on Unit 84-3 are lumped together and listed as "Travel" on Table 7.

Table 5 Haul Road Crossings: Unit 84-3

Crossings	Equipment	Hours	Cost	Volume (yds)	Unit Cqst (\$/yds ³)	Average Push Distance	Drainage Area(acres)
Rx 1800 West 15+30	D8 300H D6	1.1 2.5 2.2	\$ 503.30	402	\$1.25	150 ft.	35
Rx 1800 West 53+32 (Elf Ck.)	300H D6 10 yd dump trucks	35.7 32.1 60.0	7,934.30	2,608	\$3.04	.25 miles (end hauled)	339
Rx 1800 West 74+70 (Little Elf Ck.)	D8 300H D6	30.5 16.7 20.5	5,853.00	2,313	\$2.53	300 ft.	81
Rx-1 1800 East	D8 300H D6	1.3 3.5 3.75	732.60	120	\$6.10	60 ft.	10
Rx-2 1800 East	300H	1.7	185.50	150	\$1.24	40 ft.	10
Rx 1820 LD-1	D8 300H D6	3.7 5.5 5.5	1,269.50	492	\$2.58	100 ft.	25
Rx 1820 17+80	D8 300H D6	12.8 15.5 12.4	3,605.10	1,843	\$1.96	250 ft.	73
Rx 1820 21+60	D8 300H D6	2.7 2.2 1.8	\$ 597.70	398	\$1.50	150 ft.	5

Table 5 (cont.)

Crossings	Equipment	Hours	Cost	Volume (yds ³)	Unit Cost (\$/yds ³)	Average Push Distance	Drainage Area (acres)
Rx 1820 33+10	D8 300H D6	2.8 1.6 1.4	\$ 514.90	280	\$1.84	50 ft.	10
Rx 1820 35+50	300H D6	1.0 1.5	203.50	157	\$1.30	40 ft.	15
Rx 1821 21+50	D8 300H D6	5.3 6.5 8.8	1,743.20	1,015	\$1.72	200 ft.	97
Rx 1821 39+63	D8 300H D6	6.5 3.2 4.0	1,186.25	729	\$1.62	200 ft.	15
Rx 1821 41+35	D8 300H D6	4.5 4.2 4.2	\$1,131.75	1,095	\$1.03	160 ft.	20

SITE BOUNDARY

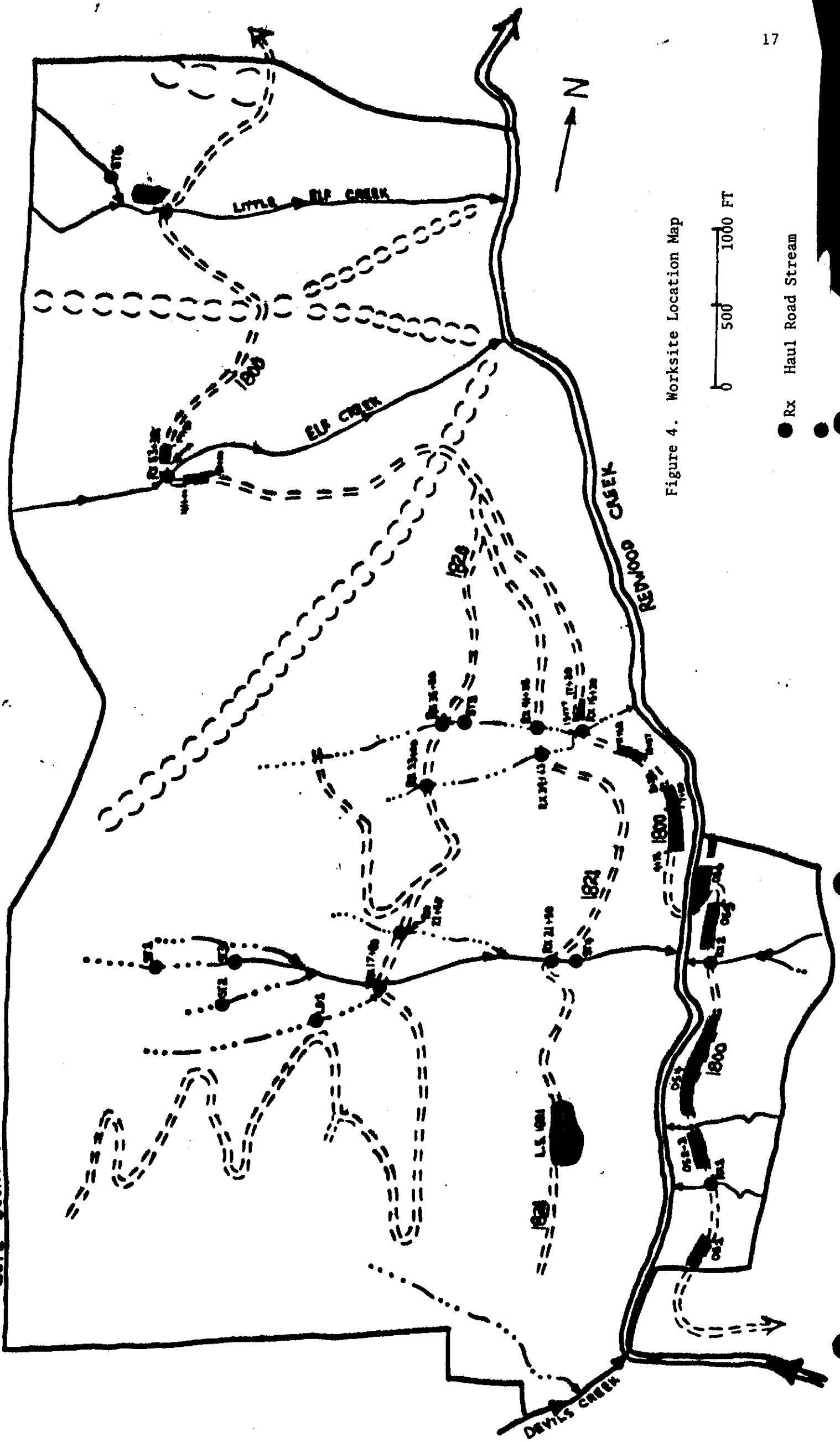


Figure 4. Worksite Location Map

Rx Haul Road Stream

Among road removal costs (Table 6) outsloping is most significant. Outsloping on this unit was prescribed primarily for material which had a high potential of failing directly into Redwood Creek. Outsloping included regular outsloping where material is simply sloped against the local cutbank and benched and total outsloping where material is moved away from the outslope area. Variance in cost per volume of outsloping can largely be attributed to the distance of spoil displacement which is dependent on the type of outsloping.

The most extensive outsloping on this unit involved treatment of the large landslide (22yds³/LF 4,229yds³). Most of the fill removed involved landing material encompassed by the right lateral head scarp (4-8 ft. in height). This landing fill was assessed as representing a potential trigger that would destabilize the lower slope and result in a significant mass movement feature directed into Redwood Creek. In addition, a large portion of the total volume removed from the landslide was located within the scarp boundary of the landslide. This material mostly involved unstable lobes of fill and original ground dislodged from the upslope headscarp.

On stable road reaches that were assessed as having drainage problems, or where outsloping would not significantly affect stability, crossroad drains were placed to disperse water downslope.

Log and culvert recovery costs were associated with excavation and winch removal of culvert and salvageable logs from the rehabilitation unit. Logs which were salvaged had been bucked and left during timber harvest.

Over 80% of the miscellaneous costs for Unit 84-3 had been itemized (Table 7). Significant among miscellaneous costs are those involving travel of equipment from one location to the next within the rehabilitation unit. These costs were relatively high for Unit 84-3 due to the remoteness of many of the work-sites from one another. In addition, it was occasionally necessary to relocate equipment around the site for more efficient tandem operation between different combinations of machines.

Surface ripping of road reaches was not prescribed on this unit. Most of the road surfaces not traveled by vehicle in recent years were experiencing moderate to heavy vegetative regrowth.

Evaluation of Heavy Equipment Application

As was discussed, the D8 started work on the unit ahead of the 300-H and D6. The lag-time between the D8 and 300-H/D6 team was determined from prescription estimates. The logic of the sequence of equipment on this unit was based on the observation that a large bulldozer can perform the majority of the treatments at a relatively high cost of effectiveness. However, the excavator incurred over 70 hours of down-time and disrupted the equipment sequence. The problem was largely alleviated by acquiring the 690B from Unit 84-4 (Spreiter and Johnson, 1985) to work with the D8 on the 1821 landslide treatment. Additionally, the D8 was used on Unit 84-8 (Utley, 1985) after completion of its preliminary work on Unit 84-3 such that it could be acquired when convenient. Besides the inconvenience of shuffling equipment between units several times and the cost incurred in doing so, prescribed work was carried out without significant disruption.

Table 6 Summary of Road Removal Cost of Heavy Equipment

Treatment	Equipment	Total Cost	# of Sites	Length (ft)	Total Yds ³	Range in Yds ³ /LF	# of CRDs	Cost/LF	Range Cost/LF	Cost/Yd ³	Range Cost/Yd ³
<u>Outsloping</u>											
Mild ³ /LF 0-3yds	D8 D6 300-H	\$ 2,956.10	7	906	2,395	0.5-3.0	--	\$ 3.26	\$0.53-5.63	\$1.23	\$0.63-2.20
Medium ³ /LF 3-10yds	D8 D6 300-H	7,180.10	6	1,800	6,378	3.1-4.9	--	3.99	3.59-4.55	1.13	0.74-1.57
Heavy ³ /LF 10yds	D8 690B	5,533.00	1	192	4,229	22	--	28.82	--	1.21	--
Subtotal ¹		\$15,669.20 (\$16,389.20)	14	2,898	13,002			\$ 5.41	\$0.53-28.82	\$1.20	\$0.53-28.82
CRDs											
	D8 D6 300-H	\$ 5,047.45	--	23,700	--	--	225	\$ 0.21	--	--	--
Total road removal											
		\$20,716.65 (\$21,436.65)		26,598							

1 One outslope (LD-2) is not included for statistical analysis (Cost=\$720.00) because it was not surveyed. However, the cost of LD-2 is included for the subtotal and total costs shown within parenthesis.

Table 7 Miscellaneous Costs-Site 84-3

Task	Equipment	Hours	Cost	Subtotal
Travel ¹	D8	8.1	\$ 727.50	
	300-H	11.8	1,256.50	
	D6	10.2	660.80	
	690-B	4.0	312.00	\$2,956.80
Opening Roadway	D8	4.6	\$ 412.50	\$ 412.50
Strategy ² Talk	D8	.9	\$ 82.50	
	D6	.75	48.75	\$ 131.25
Sitting ³	D8	1.1	\$ 97.50	
	300-H	.75	79.50	
	D6	5.2	336.70	\$ 513.70
Removal of ⁴ Bridge Abutment	D8	3.25	\$ 292.50	
	300-H	2.25	238.50	
	D6	2.25	146.25	\$ 677.25
Maintenance ⁵	D8	1.7	\$ 150.00	
	300-H	1.5	159.00	
	D6	1.3	86.70	\$ 395.70
Move-in/out	D8	--	\$ 723.75	
	300-H	--	523.78	
	D6	--	736.00	\$2,259.53
Standby ⁶	Dump Trucks	--	\$ 276.00	
	D6	19	446.50	\$ 446.50
Miscellaneous non-itemized	D6	1.5	\$ 95.40	\$ 95.40
Total Cost				\$7,888.63

- 1 E.g. walking equipment to/from rehabilitation site following dropoff/pick-up by lowboy to/from one general work area to another to assist another piece of equipment; etc.
- 2 Discussing and/or demonstrating techniques used to achieve specific rehabilitation results.
- 3 Waiting on another piece of equipment for or during tandem operation.
- 4 Equipment and operators were removed from their prospective worksites for safety reasons while a bridge abutment within the Redwood Creek channel was removed by demolition.
- 5 Maintenance time was absorbed by RNP when it was economically advantageous to the project.
- 6 The D6 was put on standby without operator because the 300-H, which the D6 was assisting, broke down.

The D8 proved to be efficient for the preliminary work and the operator was skilled. The 300-H is a relatively powerful machine when compared to Case or John Deere excavators used on previous units and consequently works at a faster rate. Although the 300-H operator was not initially experienced, he quickly evolved into an efficient and skilled operator. The D6 was in good shape and the operator was skilled both with operation of the machine and with rehabilitation techniques. Because of its small size, the D6 was especially effective at dressing fill sites and outslope reaches and working in restricted work spaces. The 300-H/D6 team worked efficiently together except where fill had to be pushed farther than about 100 feet. When long pushes were encountered the D8 was acquired to assist the 300-H.

Labor Intensive Phase

Labor Intensive Application

The labor intensive work, on this unit was implemented by three crews: Redwood National Park laborers (R.N.P.), Redwood United, Inc. employees (R.U.I.), and the Youth Conservation Corps (Y.C.C.). The labor intensive personnel were utilized mainly for worksite preparation and secondary treatments. The principal tasks were brushing stream channel crossings for surveying, and spreading straw mulch over ground disturbed by heavy equipment activities. Other tasks included straw delivery, hauling culverts, hand labor excavation, bucking logs, and the demolition of the center abutment of the 1800 bridge.

Brush removal and straw delivery preceded heavy equipment operations. Straw was distributed by placing a pre-calculated number of bales in stockpiles at flagged locations. Straw mulch was predominantly placed on the side banks of stream crossing excavations. A few outslope reaches were strawed due to a harsh southern exposure or because they bordered a stream channel. The remainder of the unit was not strawed due to its high natural revegetative potential. 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.

The demolition of the center abutment of the 1800 bridge was deemed necessary due to large organics becoming "hung up" on the abutment and deflecting water away from the thalweg leading to accelerated stream bank erosion by Redwood Creek. The demolition by high explosives was accomplished by R.N.P. personnel. After the charges were set off, the D8 was used to scatter some of the large cement blocks to create scour pools, and placed the remainder of the rubble on the streambanks for protection.

One minor hand labor excavation was done at the bottom of the channelization of Rx-35+50. This was intended to enlarge the cross-sectional area of the channel to accommodate the estimated flows. Due to difficult ground conditions the cross-sectional area was not enlarged enough and heavy equipment could not be utilized due to highly restricted access. See Figure 3 for the sequencing of the labor intensive work.

Labor Intensive Costs

The labor intensive costs for the 84-3 rehabilitation unit amounted to \$5,806.24 (Table 8). Brushing the stream crossings and two fillsites accounted for 38.4% of the total cost. Delivery and spreading of straw was 31.7% and the demolition of the 1800 road bridge abutment was 19.2%. The remaining 10.7% was for hauling culverts to the G-Line deck, and the hand labor channel excavation.

The personnel hours shown include travel time from Orick and obtaining equipment. R.N.P. and R.U.I. employees hours were based on ten hour days and the Y.C.C. laborers on eight hours days even though they were paid for ten. The discrepancy is two hours a day travel time to Orick from Arcata for the Y.C.C., that they were paid for, where as R.N.P. and R.U.I. employees were paid when they arrived at Orick. Thus to standardize the hours paid, work hours began when all crews arrived at Orick. Straw costs involve the delivery and spreading by labor crews and not the cost of straw and its transportation to R.N.P.

Demolition of the 1800 bridge abutment costs do not include one hour D8 time for clean up and sitting time of the D6 and excavator while the abutment was being blasted. This would add an additional \$432.00 to the total cost.

Summary and Conclusion

Rehabilitation work on Unit 84-3 began with an analysis of the relationship between drainage features and erosion features based on detailed geomorphic mapping. Minor drainages are observed as complexes composed of interacting elements (slopes, drainage channels, knickpoints, mass movement features, etc.), and as subunits of larger drainages and of the rehabilitation unit as a whole. Based on interpretation of geomorphic mapping and on input from experienced rehabilitation geologists, hydrologists, botanists, and soil scientists, treatment priorities were established. The criteria for prioritizing treatments involves the probability of erosion features to affect stream channels, the magnitude and activity of each erosion feature, revegetation of disturbed areas, the cost/benefit, and the potential for successful stabilization. Treatment priorities on unit 84-3 included: 1) Stream crossing excavations and outsloping 2) cross-road draining of stable roadways and 3) returning flow diversions to the natural drainage channel at the point of diversion.

Stream crossing excavations on this unit did not receive a high degree of channel armoring due to the lack of armoring material. Potential channel adjustment in some of the crossings underlain by highly erodible soils could be fairly extensive relative to heavily armored excavations.

Hillslopes within the inner gorge of unit 84-3 are prone to experiencing extensive earthflow and landslide activity. Where treated, these features may be affected relative to the rate and amount of erosion. However, it should be anticipated that these features will continue to be active.

Table 8 Summary of Labor Intensive Treatment Costs

Treatment	Crew	Personnel Hours	Average Cost Per Hour	Cost	Total Cost
Brushing	RNP	121	\$8.89	\$1,156.00	\$2,231.13
	RUI	124	5.00	620.00	
	YCC	160	3.35	536.00	
Straw Delivery	RNP	80	\$8.81	\$ 704.80	\$ 704.80
Spreading Straw	RNP	98	\$8.56	\$ 838.86	\$1,138.86
	RUI	60	5.00	300.00	
Demolition of center bridge abutment	RNP Blasting Equip. & Explosives	32	\$9.27	\$ 296.64	\$1,114.49 [*]
Hauling Culverts	RNP	42	\$9.44	\$ 396.48	\$ 396.48
Channel Excavation	RNP	8	\$8.76	\$ 140.08	\$ 220.48
	YCC	24	3.35	80.40	
Total Cost					\$5,806.24

* Price does not include 1 hr D8 time and sitting time of the D6 and excavator while bridge was being blasted. 2 hrs.

APPENDIX

Photo Points
Unit 84-3

Photo Point #	Color (400)	B & W (400)	Comment
<u>1820 Rd</u>			
1	35mm	35mm	PP at 9+33 on roadway. View down 1820 rd. across CRD's. Tag is on 2" alder.
2	50mm	50mm	PP midroad at 144+00. View of fill pile (14+00-17+00) along 1820 rd. for xing 17+80.
3	35mm	35mm	PP 15' right of right channel 15' up sloped cutbank of RX 1820-17+80. View down right channel. Taken from sitting position.
4	35mm	35mm	PP 20' right of left channel 8' up cutbank of RX 1820-17+80 Taken from sitting position.
5	35mm	35mm	PP at uppermost point in center of RX 1820-35+50 excavation. View down channel.
6	35mm	35mm	PP on. View up RX 1820-35+50.
7	50mm	50mm	PP on stump located at lower L. bank of RX 1820-35+50. View down channelization.
8	35mm	35mm	PP at uppmost point in center of RX 1820-35+50 excavation. View down channel.
9	50mm	50mm	PP on outside of rd. at 43+35 1820 rd. View down OS reach of 1820.
<u>1821 Rd.</u>			
10A	Eliminated		PP on ST up CB at STA 2+25.
10B	35mm	35mm	View of landing facing up-rd.
11	50mm	50mm	PP in mid-rd. at station 57+25. View up-rd. over CRD reach.
12	28mm	--	PP on top of RW stump on outside of rd. at 7+30. View up road across scarped area composing upper right margin of landslide

Photo Points
Unit 84-3

Photo Point #	Color (400)	B & W (400)	Comment
13	28mm	--	PP 5' up-rd. of 5' alder flagged as 8+00. View upslope of fill area.
14	50mm	50mm	PP at base of large RW along left boundary of slide 70' downslope of station 11+00. View down-rd. across landslide of up-rd. extent of OS work.
15	35mm	35mm	PP on small oak tree along right bank of RX 1821-21+50. View upstream.
16	35mm	35mm	PP next to small oak tree on rt. bank upslope of crossing. View downstream of RX 1821-21+50.
17	35mm	35mm	PP next to 7" alder 15' left of channel at upslope limit of RX 1821-39+63. View downstream.
18	35mm	35mm	PP on schist rk. 30' upslope of RX 1821-41+35 15' left of channel. View downstream. Taken from squatting position.
19	35mm	35mm	PP on 8' dia. RW stump. View upstream of RX 1821-41+35. Taken from sitting position.
<u>1800 rd. East</u>			
20	35mm	35mm	PP at mid-rd. View down-rd. (towards Ck) across rd. failure.
21	35mm	35mm	PP upslope of RX-1. View downstream
22A	35mm	35mm	PP mid-rd. View up-road (towards K&K rd) of FOS.
22B	35mm	35mm	View down-rd. of BOS.
23A	35mm	35mm	PP mid-rd. View up-road of large CRD & BOS.

Photo Points
Unit 84-3

Photo Point #	Color (400)	B & W (400)	Comment
23B	35mm	35mm	View down-rd. of OS.
24A	35mm	35mm	PP mid-rd. View up-rd. of OS.
24B	35mm	35mm	View down-rd. of OS.
25	35mm	35mm	PP upstream of RX-2. View downstream.
26	35mm	35mm	PP on stump. View down- rd. of OS.
27	35mm	35mm	PP View up-rd and down RWC of TOS.
<u>1800 rd. West</u>			
28A	Eliminated		
28B	Eliminated		
29A	35mm	35mm	PP at mid-rd. Sta 7+00. View down-rd. of BOS.
29B	35mm	35mm	View up-rd. of BOS.
30A	35mm	35mm	PP on RW stump on outside of rd. at 11+44. View down-rd. of FOS.
30B	35mm	35mm	View up-rd. of CRD reach over scarp above earthflow.
31	35mm	35mm	PP on right bank 20' below RX 1800-15+20 excavation. View up channel.
32	35mm	35mm	PP 10' upstream of RX 1800- 15+30 excavation and on rt. bank. View downstream.
33	50mm	50mm	PP at 17+63 on inside of rd. next to CRD view down-rd. of OS.
34	50mm	50mm	PP mid-rd. at 24-45. View down CRD reach over head of earthflow.

Photo Points
Unit 84-3

Photo Point #	Color (400)	B & W (400)	Comment
35	50mm	50mm	PP mid-rd. at 28+55. View down CRD reach.
36	35mm	35mm	PP on log in Elf Ck. 20' below crossing excavation. View upstream.
37	35mm	35mm	PP on left bank 15' up- stream of Elf Ck. exca- vation. View down channel.
38	35mm	35mm	PP Little Elf Ck. taken from sitting position.
39	35mm	35mm	PP on left bank upstream of Little Elf Ck. crossing next to 7" alder. View downstream.

Archive File List

- File # 1 Summary Report Maps and Mylars
- File # 2 Field Notes for Heavy Equipment
- File # 3 Prescription sheets; Pre-Rehab Volume and Equipment Estimates;
Graphs
- File # 4 Post Rehab Equipment Hours/Costs.
- File # 5 Drainage Areas; Road Lengths; Timber Harvest History
- File # 6 Labor and Backhoe
- File # 7 Geomorphic/Prescription Map
- File # 8 DI-1's for Heavy Equipment and Time Sheets
- File # 9 Soils

LITERATURE CITED

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- Utley, K.W. 1985 Summary Report. Rehabilitation Unit 84-8: M-7-5-1 Road (unpub.): U.S. Dept. of the Int., Redwood National Park, Orick, Ca. 5 pp.
- Vann, D. and P. Routon. 1984 Geomorphic Map. Rehabilitation Unit 84-3: 1820, 1821, and Lower 1800 Road (unpub.): U.S. Dept. of the Int., Redwood National Park, Orick, Ca. 26 pp.



Unit: 84-3 1800 Rd. Redwood Cr. Bridge Site. Fall 84



Unit: 84-3 Redwood Cr. Old1800 Rd. Bridge pilings Fall 84



Unit: 84-3 Redwood 1800 Rd. Bridge Site. Fall 84



Unit: 84-3 PP#27L 6/18/84 DV



Unit: 84-3 PP#27L 12/3/84 DV



Unit: 84-3 PP#27L 7/9/85



Unit: 84-3 PP#29B 6/18/84 DV



Unit: 84-3 PP#29B-L 12/04/84 DV



Unit: 84-3 PP#36-L 6/18/84 DV



Unit: 84-3 PP#36-L 12/04/84 DV



Unit: 84-3 PP#36 7/09/85 NLY