

Summary Report
WATERSHED REHABILITATION UNIT 89-2
LOWER K&K AND 1800 ROAD

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WATERSHED REHABILITATION UNIT 89-2 Lower K&K Road and Slope

INTRODUCTION

The Lower K&K Rehabilitation Project addressed accelerated erosion problems associated with road construction and timber harvest on naturally erosion-prone hillslopes and stream channels. The rehabilitation unit is located on the east side of Redwood Creek, between Copper Creek and Coyote Creek, about 14 miles southeast of Orick, California (Map A). Erosion control work treated 0.9 miles of the K&K Road and the remaining section of the 1800 Road. Unit 89-2 was the second phase of a several year project to rehabilitate the K&K Road.

The 1989 project was executed by IFB Contract (CX#8480-9-0001) and was awarded to and the work performed by Carl M. Kjer and Sons of Arcata, California. Contract costs for erosion control work utilizing heavy equipment was \$190,247. Labor cost for brushing and site preparation was \$3,987. Labor and materials cost for straw mulch application was \$6,980. Personnel cost associated with site evaluation, planning, contract administration, and documentation was \$23,922 (not including costs borne by other divisions within Redwood National Park). The total project cost was \$229,616 (Table 1).

Geology/Geomorphology

The entire rehabilitation unit area of 150 acres is underlain by the Incoherent Coyote Creek Unit of the Franciscan Formation. The Coyote Creek Unit is comprised of unmetamorphosed mudstones and sandstones, with a low sandstone/mudstone ratio (Harden and others, 1982). The rocks are typically more brecciated and sheared than other units, especially in the vicinity of the Grogan Fault Zone. Tectonic blocks of chert, greenstone, and sandstone are common and are usually in a sheared mudstone matrix. The Incoherent Coyote Creek Unit has not been named melange based on a lesser degree of shearing and absence of exotic blocks described in Franciscan melange elsewhere in the California Coast Range.

Much of the 1989 work along the K&K is likely within the Grogan Fault Zone. The Grogan Fault is defined along a zone of slightly metamorphosed and pervasively sheared rocks (Harden and others, 1982). The shear zone is of varying width and separates the Redwood Creek Schist from the unmetamorphosed rocks of the Incoherent Coyote Creek Unit and Coherent Lacks Creek Unit (all are Franciscan rocks). The expression of the fault zone is relatively straight compared with other NNW trending faults in the region suggesting a near vertical dip. Tectonically isolated blocks of Redwood Creek Schist and unmetamorphosed sandstones were commonly found juxtaposed along the rehabilitation unit, especially near Coyote Creek.

The rehabilitation unit occupies a varied landscape. Subdued, rolling topography is most often associated with the several large landslide complexes that dominate the character of the Lower K&K. These translational/rotational slides support grass-bracken fern prairie on the upper slopes with shrub or forest-type vegetation on the lower slopes. Large, resistant rocks form

prominent points on the landscape and steep inner gorge topography is typical where these are near Redwood Creek.

The site has a southwesterly slope aspect and has moderate relief from 400 feet to about 800 feet in elevation (Map B). Streams generally occupy poorly to moderately incised valleys and amount to nothing more than large gullies when they flow through landslide terrain. Stream gradients are mostly steep although quite variable in the tread/riser topography of the active landslides.

Soils

Rehabilitation Unit 89-2 is dominated by Atwell Series Soils (Popenoe and Sturhan, 1988). They are mostly found in wet hollows, amphitheater shaped concavities, and along earthflow tracks underlain by mudstone. Atwell soils are imperfectly drained soils that typically have 30 to 35 percent clay content in the Bt horizon and have low permeability. Subsurface horizons are commonly mottled (Cg horizons) indicating that the zone is saturated for part of the year. Even in natural conditions, these materials are prone to fluvial erosion due to principally to restricted internal drainage, fine grained character, and a high runoff coefficient. Debris slides, flows, and slumps are common in disturbed materials where Atwell Soils occur.

In areas where slopes are convex or uniform in shape, Coppercreek and Slidecreek Soils are dominant. Coppercreek Soils are brown, deep (> 60 in.), well-drained soils. They contain 15 to 35 percent gravel and cobble-size rock fragments and are quite susceptible to fluvial erosion. Mass failure generally only occurs in areas where fill material has been oversteepened. Slidecreek Soils are quite similar except that they have a 35 to 60 percent rock fragment content and are therefore less prone to fluvial erosion.

Land Use History

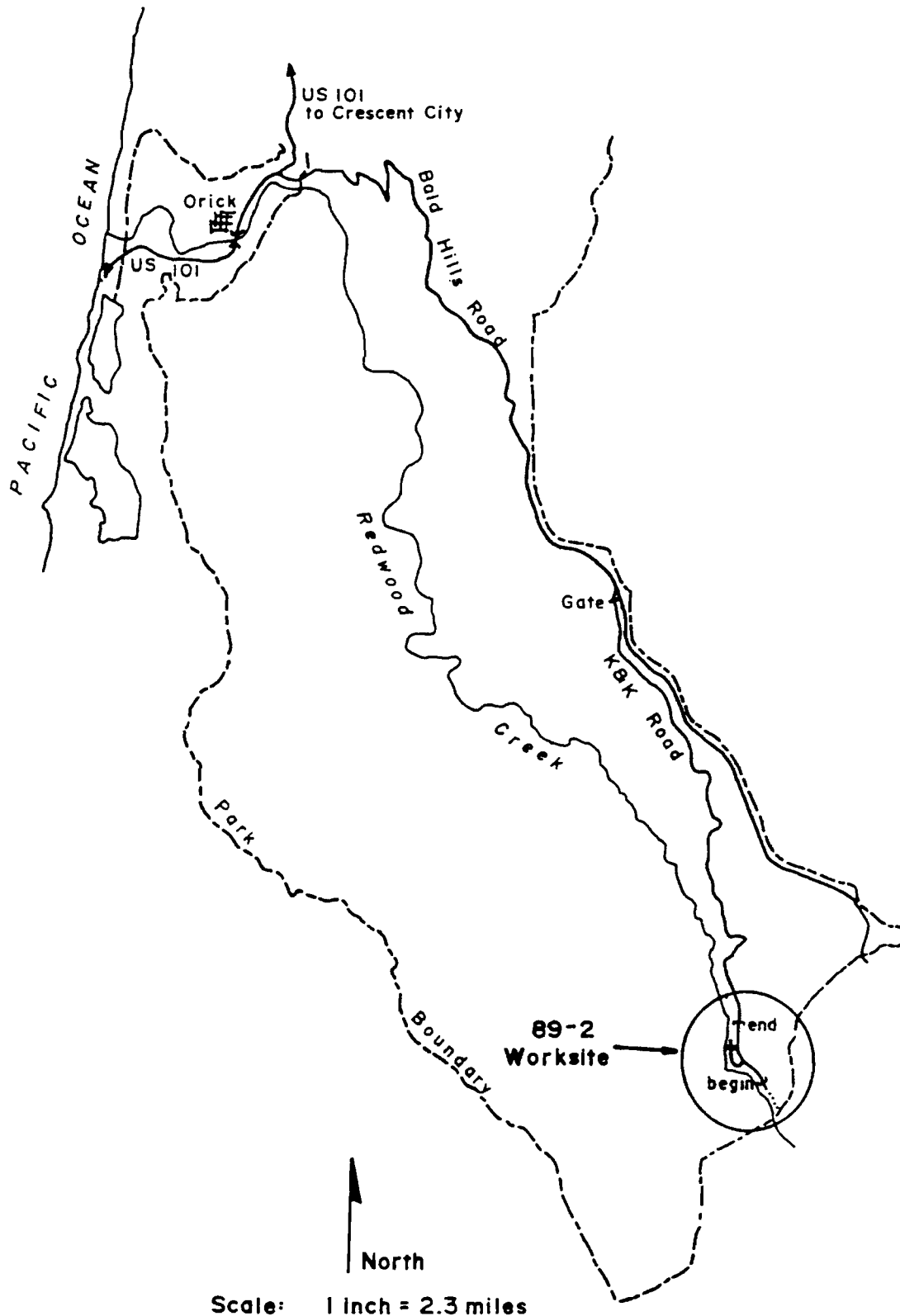
Prior to construction of the K&K Road and subsequent logging, intensive land use consisted of running cattle and sheep on the grass prairie and grass-oak woodland areas of the upper hillslopes. The K&K Road was constructed between 1955 and 1958.

Timber harvest commenced soon after the road was completed and it appears that logging started above the K&K as selective cuts. As time progressed, these cuts became more complete (seed-tree leave and clearcut) and an increasing number of trees were removed from the downslope region between the K&K and Redwood Creek (Map C). From aerial photo analysis, it appears that much of the logging below the road was a salvage effort when the slopes began to fail. There are a couple of small (<5 ac.) stands of old growth remaining, possibly because they are growing on stable ground. The upslope areas were logged with either tractor or cable yarding methods, depending on the steepness of the terrain. The downslope areas were yarded by cable methods except one small swath near the present Park Boundary.

After Redwood National Park was expanded in 1978, Simpson Timber Company retained the privilege of using the K&K until 1987. Simpson was also required

Map A

89-2 SITE LOCATION MAP



to maintain the road. In 1987, RNP became solely responsible for maintenance and management.

Erosional Features

The Lower K&K Unit includes some of the most erodible terrain in the Redwood Creek Basin (Coleman, 1973; Janda and others, 1975; Kelsey, 1981). Erosion rates are naturally high and have been exacerbated by land-use practices. Virtually all of the sediment generated from the K&K entered directly into Redwood Creek.

The most notable features are the large complex landslides that are abundant along the adjacent reaches of Redwood Creek. All of the earthflow toes were well-vegetated prior to timber harvest, although differences in vegetation size and/or type are visible in 1954 aerial photographs on some of the landslides. Earthflow movement rates and sediment yields from earthflow terrain has been summarized by Harden and others (1978), Nolan and others (1979), and Sonnevil (personal communication).

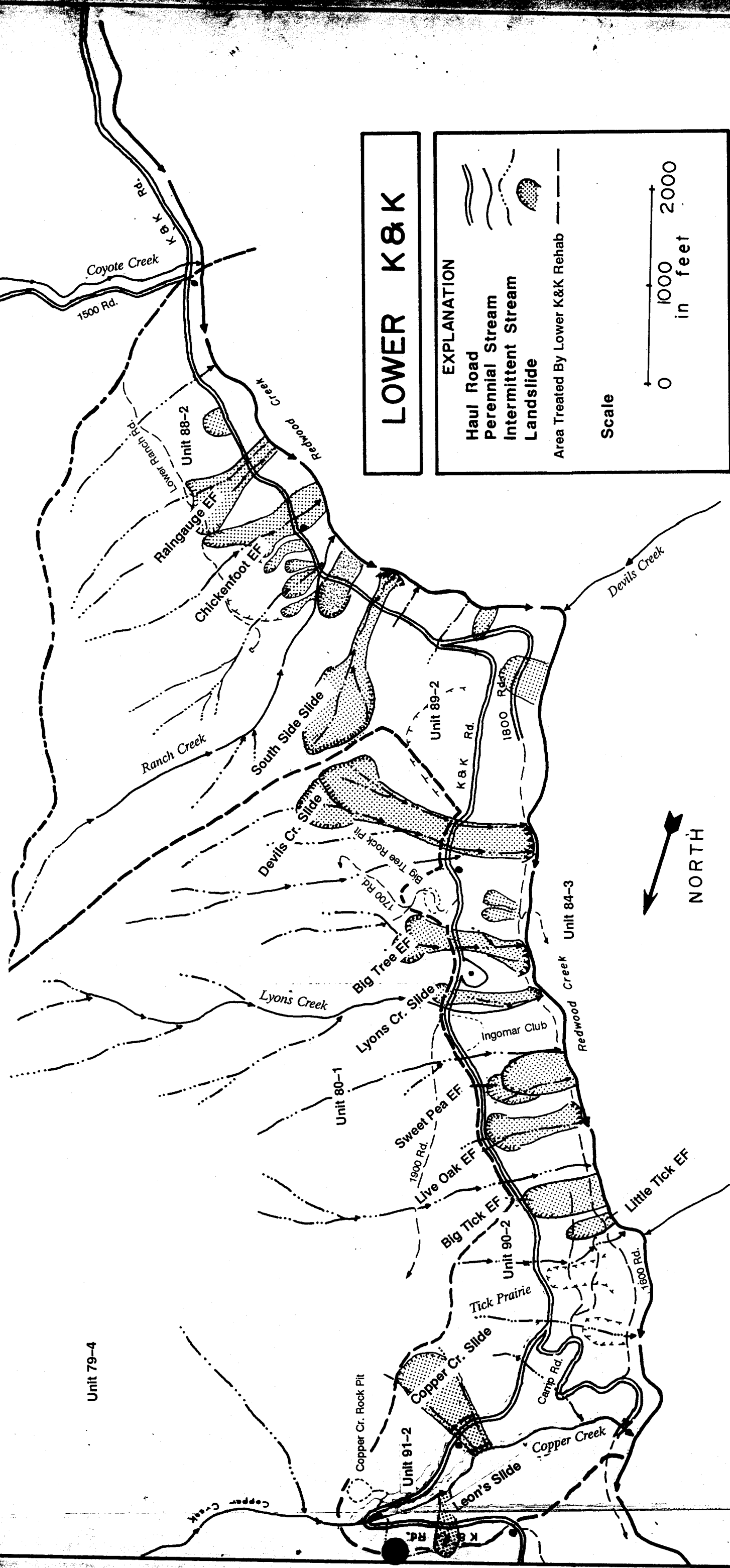
Stream-side debris slides and slide scars are also visible in aerial photographs taken pre-logging. The number of these has greatly increased probably due to channel aggradation and resultant undercutting of unstable banks. Effects of large magnitude storm events in 1955, 1964, and 1972 are difficult to differentiate from those exclusively associated with timber harvest, since they occurred contemporaneously. The increased incidence of debris sliding within the rehabilitation unit is partially a result of large quantities of fill material sidecast from the K&K adjacent to the banks of Redwood Creek.

Direct man-influenced sediment sources included stream crossing fills and large quantities of sidecasted materials. Four intermittent streams were crossed by the K&K in the section that was treated in Unit 89-2. Each of these crossings had misplaced culverts, with resultant gully systems developed away from the natural channels which constitute an indirect consequence of roading. The culverts themselves had a propensity for failure (i.e., plugging) which on several occasions diverted streams several hundred feet down the K&K. Stream channel grades above the K&K were invariably undercut by road construction and channel instability has migrated several hundred feet upstream. Unstable headcuts and stream bank slides are persistent sediment sources above and below the K&K.

The earthflow feature informally named the South Side Slide (Figure X), locally failed in the area immediately above the K&K during a spring, 1987 storm. This blocked the K&K and delivered approximately 5,000 cubic yards of material to Redwood Creek (volume estimated by pace and clinometer survey). The debris fan deposited in the channel of Redwood Creek was almost completely removed by fluvial processes when the rehabilitation project began in 1989.

Road-related mass movements include debris torrents and debris slides, although more commonly road failures were part of larger, slope failures. In several locations, cutbank failures have migrated 200-300 feet upslope.

Map B - Generalized Geomorphology



Map C - Land Use History

LEGEND

59 - Year logged.

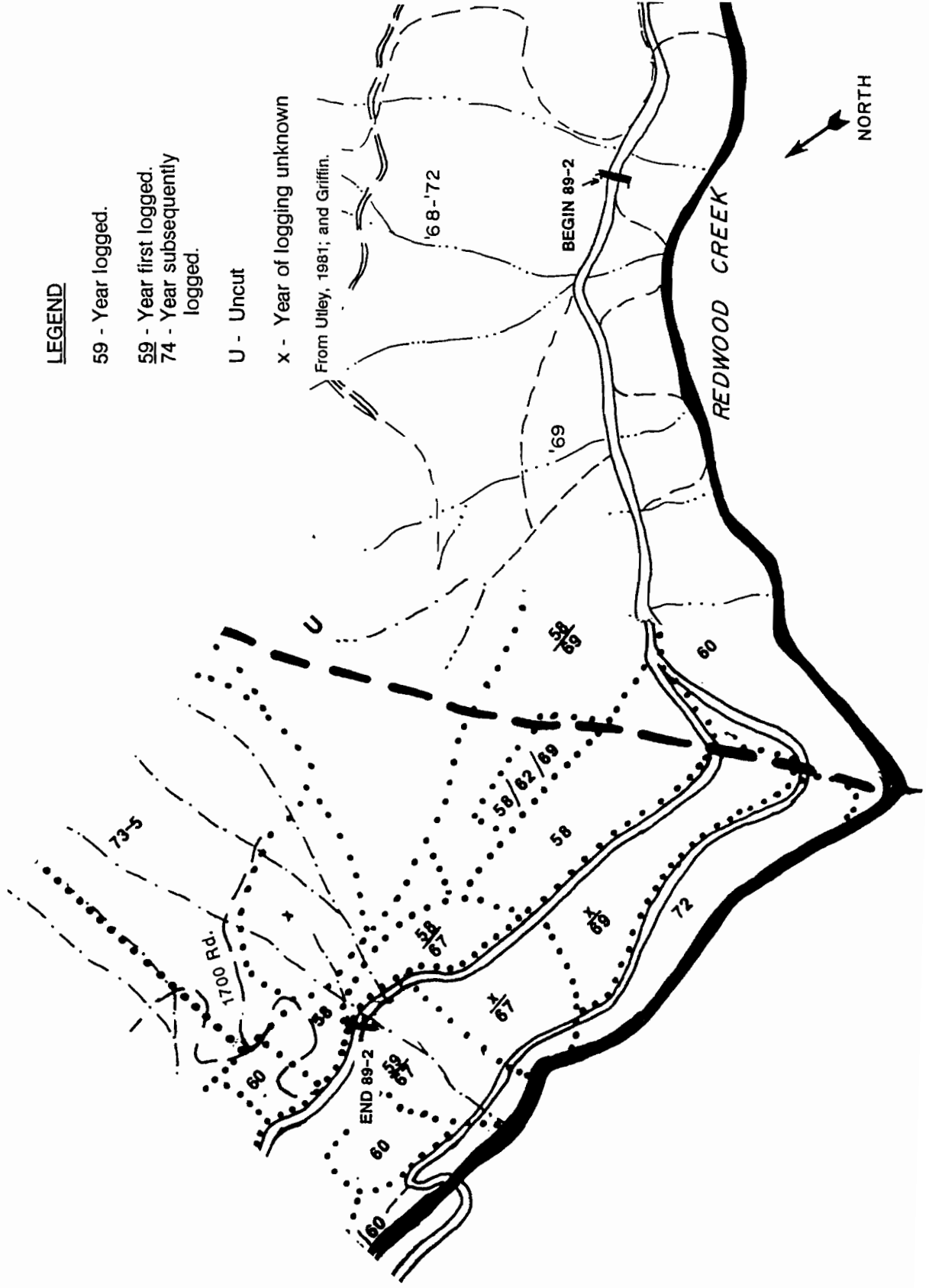
59 - Year first logged.

74 - Year subsequently logged.

U - Uncut

x - Year of logging unknown

From Utley, 1981; and Griffin.



REHABILITATION WORK

The principle that guided rehabilitation work within the earthflow terrain was conforming excavation design to the existing conditions, since reestablishing "original conditions", one of the guiding principles in much of the work at Redwood N.P., was often impossible since the "original" had usually vanished downslope somewhere. Stabilizing the drainage systems was probably the greatest cost-effective contribution toward future stability.

Project Implementation

Field mapping was accomplished between December, 1988 and mid-February, 1989, by D. Steensen and L. Johnson. Site morphology was mapped in the field on enlarged aerial photography at a scale of 1:600. Evaluation and formulation of rehabilitation prescriptions was accomplished by D. Steensen. Surveying and photo-documentation was completed by D. Steensen, D. Short, K. Griffin, M. Napolitano, and J. Wood. Heavy equipment work was principally supervised by D. Steensen (as contracting officers representative) and M. Napolitano (project inspector). T. Spreiter and D. Short were intermittently on-site as contracting officers representative. Table 1 summarizes the costs for the rehabilitation work on Unit 89-2.

Primary rehabilitation treatments included excavation of 5 haul road stream crossings, 2,650 feet of exported outsliping (truck-enhauled), and 2,150 feet of outsliping on the K&K Road. Secondary treatments included placing rock channel armor in 3 of the 5 haul road crossings, and applying straw mulch to the finished slopes of the entire unit. Refer to Map D for locations of individual worksites. The first RX treatment for Unit 89-2 is RX-5, the first four crossings having been completed in 1988 (Unit 88-2); the numbering of the site treatments and station numbers are consecutive from the beginning of the K&K road near Coyote Creek (southern park boundary).

Heavy equipment utilized to accomplish this work consisted of Bucyrus Erie 300H and 350H hydraulic excavators, Bucyrus Erie 25B dragline crane, International TD-20E and Case 850B bulldozers, and four 10 yd³ dump trucks. See Table 2 for detailed information on equipment specifications. Table 5 details miscellaneous costs for this project.

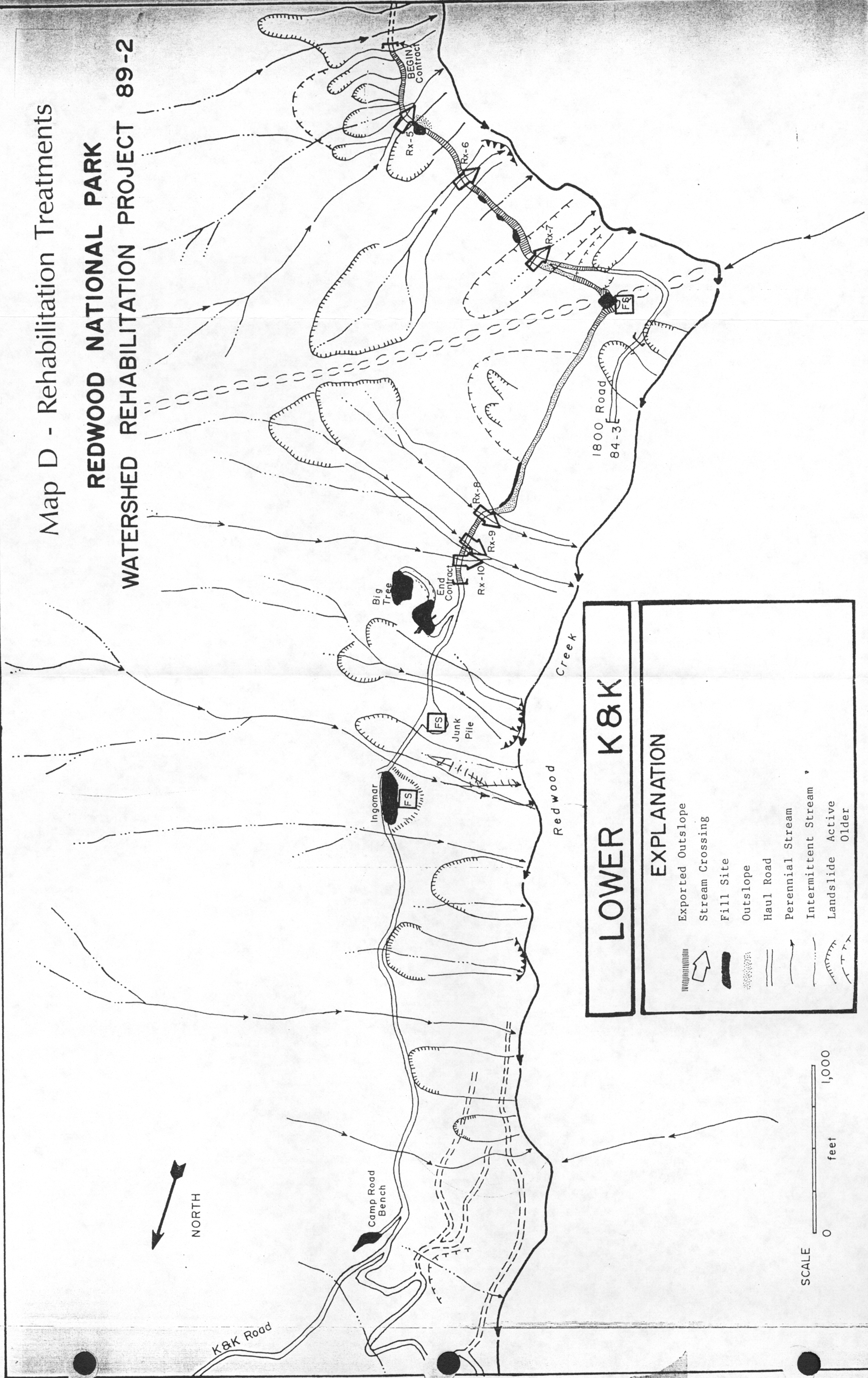
Primary Treatments

Haul Road Stream Crossings

Haul road-stream crossing excavations (RX) entail the removal of road fill material from buried stream valleys and channels. This work eliminates diversion potential at crossings and directly removes sediment sources. Six crossings were excavated in Unit 89-2 (Table 2). The crossings along the Lower K&K vary from most of the typical examples of stream crossing excavations accomplished at Redwood N.P. from the standpoint that the stream valleys are poorly developed in the natural, pre-disturbed state. The excavations do not so much resemble exhumed valleys, but more like the gully systems that exist up- and down-channel.

Map D - Rehabilitation Treatments

REDWOOD NATIONAL PARK
WATERSHED REHABILITATION PROJECT 89-2



LOWER K&K

EXPLANATION

	Exported Outslope
	Stream Crossing
	Fill Site
	Outslope
	Haul Road
	Perennial Stream
	Intermittent Stream
	Landslide
	Active
	Older

TABLE 1. REHABILITATION WORK COST SUMMARY, UNIT 89-2

TREATMENT	WORKSITE QUANTITY	TOTAL QUANTITY	ACTUAL TOTAL COST \$	ACTUAL AVERAGE UNIT COST \$	T.H.E.R.E. ¹ TOTAL COST \$	T.H.E.R.E. AVERAGE UNIT COST \$
HEAVY EQUIPMENT						
<u>Primary Treatments</u>						
Stream Crossing Excavations	6	19,427 yd ³	84,313.80	4.34/yd ³	60,274.28	3.10/yd ³
Outsloping	4	7,230 yd ³	11,760.00	1.60/yd ³	9,459.90	1.31/yd ³
Exported Outsloping	9	19,815 yd ³	76,161.50	4.11/yd ³	59,856.52	3.02/yd ³
Ripping	1	2,798 ft.	391.78	0.14/ft.	1,034.01	0.37/ft.
Other (See Table 5)	5	-	9,000.00	-	7,043.74	-
<u>Secondary Treatments</u>						
Rock Quarry and Transport	-	570 yd ³	(19,362.90) ²	(33.97/yd ³) ²	-	-
Rock Distribution	1	570 yd ³	4,345.00	7.62/yd ³	2,360.05	4.14/yd ³
Rock Placement	1	570 yd ³	4,275.00	7.50/yd ³	3,910.86	6.86/yd ³
TOTAL HEAVY EQUIPMENT			190,247.08			
LABOR INTENSIVE						
Straw Bales	-	800 Bales	2,560.00	3.20/bale	-	-
Contract Straw Distribution	1	800 bales	4,000.00	5.00/bale	-	-
RNP Straw Delivery/Spread	-	800 bales	4,420.38	5.53/bale	-	-
RNP Brushing	-	-	3,987.83	-	-	-
Other (See Tables 5 & 6)	-	-	478.87	-	-	-
TOTAL LABOR INTENSIVE			15,447.08			
PROJECT IMPLEMENTATION						
<u>Evaluation</u>						
Mapping	-	-	3,299.93	-	-	-
Prescription	-	-	905.74	-	-	-
Surveying	-	-	2,579.63	-	-	-
Drafting	-	-	998.92	-	-	-
Contract Preparation	-	-	3,337.93	-	-	-
Overall Planning	-	-	630.06	-	-	-
<u>Supervision</u>						
Contract Supervision	-	-	10,294.84	-	-	-
Labor Crew Supervision	-	-	225.15	-	-	-
<u>Documentation</u>						
Photo-Documentation	-	-	1,055.94	-	-	-
Cost Analysis and Report	-	-	1,650.00	-	-	-
TOTAL PROJECT IMPLEMENTATION			23,922.20			
TOTAL REHABILITATION PROJECT COST			229,616.36			

¹Total Heavy Equipment Rental Equivalent: T.H.E.R.E. values are based on actual equipment time accomplishing the treatments multiplied by an average of equipment rental bids for 1989. See Table 2 for a detailed description of these costs. T.H.E.R.E. costs are distinguished from H.E.R.E. costs found in following tables by the multiplication of a miscellaneous cost factor (which includes non bid-item costs such as breaks, fueling, down time, etc. See Table 5).

²Rock Quarry and Transport costs for Unit 89-2 were actually paid for through Unit 89-4, Y-Line Rock Pit Rehabilitation Project, and are not included in the total cost for the K&K Project.

TABLE 2. HAUL ROAD STREAM CROSSING EXCAVATION COSTS. UNIT 89-2, LOWER K&K

WORKSITE/STATION	EXCAVATED VOLUME (yd³)	ACTUAL COST(\$)	H.E.R.E. ¹		EQUIPMENT HOURS ²								MEAN ENDHAUL DIST.(ft.)	EXCAV. ³ RATE (yd³/hr)	
			TOTAL UNIT COST	COST(\$)	X1	X2	C	W1	W2	D1	D2	D3			D4
RX-5 @ 34+42	3,221	13,979	12,200	3,79	25.75	27.75	0.0	28.0	11.5	18.0	18.0	18.0	8.75	2,408	60
RX-6 @ 41+20	1,841	7,990	4,369	2.37	0.0	5.75	7.25	11.25	0.0	11.5	8.75	11.5	7.5	4,780	142
RX-7 @ 48+02	2,220	9,635	8,749	3.94	0.75	18.0	16.0	21.25	0.25	21.5	12.5	21.5	0.5	4,098	64
RX-8 @ 72+53	5,075	22,025	154,649	3.08	7.0	39.25	19.75	39.0	4.0	31.25	31.75	21.5	0.0	1,347	77
RX-9 @ 74+42	4,135	17,946	10,013	2.42	8.25	26.5	3.5	26.25	4.25	8.75	28.5	25.5	0.0	1,058	108
RX-10 @ 76+67	2,935	12,738	9,294	3.17	5.0	21.75	3.75	32.0	0.0	28.0	6.5	27.0	1.25	1,933	96
TOTALS	19,427	84,313	60,274		46.75	139.0	50.25	157.75	20.0	119.0	106.0	125.0	18.0		
AVERAGE				3.10										2,187	82

¹ H.E.R.E.: Heavy Equipment Rental Equivalent. This acronym is similar to T.H.E.R.E. costs, however, without a miscellaneous "factor" (see Table 1).

² The hours listed are those that each piece of equipment actually worked on the individual bid item. The abbreviations are as follows:

X1: Hydraulic Excavator - 1979 Bucyrus Erie 300H; 1 1/2 yd³ bucket; 33 ft. reach; 195 h.p. (Kjer and Sons)

X2: Hydraulic Excavator - 1979 Bucyrus Erie 350H; 2 1/2 yd³ bucket; 42 ft. reach; 295 h.p. (Kjer and Sons)

C: Dragline Crane - 1972 Bucyrus Erie 25B; 1 1/4 yd³ bucket; 60 ft. boom; 140 h.p. (Kjer and Sons)

W1: Bulldozer (w/winch) - 1975 International TD-20E; 12 ft. straight blade; 18 inch tracks; 7/8 inch winch cable. (Saottini Ranches)

W2: Bulldozer (w/winch) - 1980 Case 850B; 6-way 9 ft. straight blade, 22 inch tracks; 75 h.p. (Kjer and Sons)

D1: Dump Truck - 1971 Kenworth; 10 yd³ square box; 38,000 lb. rear-end; 335 h.p. (Saottini Ranches)

D2: Dump Truck - 1969 Kenworth; 10 yd³ rock box; 44,000 SSHD rear-end; 335 h.p. (Saottini Ranches)

D3: Dump Truck - 1979 Kenworth; 10 yd³ rock Box; Eaton 44,000 2-speed rear-end; 400 h.p. (Saottini Ranches)

D4: Dump Truck - 1968 Peterbilt; 10 yd³ square box; 44,000 SSHD rear-end; 318 h.p. (Kjer and Sons)

Other equipment on-site for which specific time was not monitored: 1) wheeled, mechanical ripper tooth with one shank (could be attached and detached from TD-20), 2) 2 1/2 ton flatbed, 3) service truck (pickup), and 4) fuel trailer.

³ Excavation Rate is based on time of excavating equipment only. For example, hydraulic excavator, crane, and bulldozer (if working at the fill source or worksite) time is included, but not dump truck time or bulldozers working at a fillsite. Keep in mind, however, that the excavating equipment may be limited by dump truck cycle time.

RX-5 is one excavation along the K&K to date where a fair amount of original channel elements were found. Numerous large boulders, logs, and abundant fine roots and small organics were uncovered through the central portion of the channel. The upper and lower segments were cut into debris slide deposits. Very few channel elements have been uncovered in any other stream crossing excavations.

RX-6, RX-8, RX-9, and RX-10 flow through or are adjacent to earthflow tracks. RX-9 and RX-10 are not within active earthflows, but the geomorphology of the area suggests that the slopes may have been active in the recent, pre-disturbance past (hummocky, irregular terrain, with poorly developed channels). These RX's are adjacent to exported outslope reaches (complete removal of the former road bench) and adds a gully-like appearance to the crossings.

RX-6 drains through the axial portion of the South Side Slide (Map B) which failed in 1987 blocking the K&K. Approximately 5,000 cubic yards of material was delivered to Redwood Creek. The excavation work was designed to address two problems. First, the drainage pattern required stabilization through the site, which required in a general sense, a morphologically stable stream profile and cross sectional width. Secondly, the left-lateral lobe of the earthflow, which was being supported by K&K road bench, required leaving as much material as possible to help buttress the mass. The finished design (and excavation) produced a configuration that accomplished both of these criteria, however, the tradeoff was in leaving the sideslopes of the channel excavation steep (appx 60-70%).

RX-7 is located at the intersection of the 1800 Road and the K&K and amounted to a large excavation relative to the contributing drainage area (7 acres). RX-8 aligns drainage channels along the left lateral scarp of the Devils Creek Slide. RX-9 flows just outside of the most recently active right lateral pressure ridge of the Devils Creek Slide and is probably along an older right lateral scarp system.

Heavy equipment utilized to excavate road-stream crossings in Unit 89-2 consisted of combinations of two hydraulic excavators and a dragline crane. This equipment loaded trucks directly or "passed" fill material up to one of the other machines to then be loaded into trucks. The majority of fill was hauled to the Big Tree Rock pit or the Ingomar Club (see Table 2 for average hauling distances). Some crossings were worked down (lowered) to some degree before finish work in the channel began, but most finish work began well before the bulk of the fill was removed. The use of the dragline enabled the contractor to begin pulling grade (usually from the bottom first) from a fair distance away.

Outsloping

Outsloping entails the removal of fill material from the outboard edge of a road and storing this material against the cutbank, essentially recontouring the road to the former topography. Outsloping is an appropriate rehabilitation measure in areas where treatments solely for erosion control do not encourage vigorous natural revegetation. The segment of the K&K between station 53+00

TABLE 3. OUTSLOPING COSTS. UNIT 89-2, LOWER K&K

EXCAVATED BEGINNING STATION	VOLUME (yd ³)	H.E.R.E. ACTUAL COST(\$)	H.E.R.E. TOTAL COST(\$)	H.E.R.E. UNIT COST (\$/yd ³)	EQUIPMENT HOURS ²				L.F. OF TREAT.(ft.)	VOL./FT. (yd ³ /ft.)	TYPICAL BENCH WIDTH(ft.)	EXCAV. RATE (yd ³ /hr)
					X1	X2	C	W1	W2			
01+30 (1800)	445	712	545	1.22	3.0	0.0	0.0	0.0	3.0	2.1	21	74
35+16	1,800	3,072	2,067	1.15	11.0	0.0	0.0	10.5	0.5	6.4	landing	82
48+50	465	744	950	2.04	7.75	0.0	0.0	0.0	2.25	2.0	18	47
57+51	4,520	7,232	4,736	1.05	3.5	18.0	5.0	15.5	1.25	3.2	24	118
TOTALS	7,230	11,760	8,297		25.25	18.0	5.0	26.0	7.0			
AVERAGE				1.15						3.4	41	89

¹ H.E.R.E.: Heavy Equipment Rental Equivalent

² See Table 2 for a complete description of abbreviations and equipment specifications.

TABLE 4. EXPORTED OUTSLOPING¹ COSTS. UNIT 89-2, LOWER K&K

EXCAVATED BEGINNING STATION	VOLUME (yd ³)	H.E.R.E. TOTAL COST(\$)	H.E.R.E. UNIT COST (\$/yd ³)	EQUIPMENT HOURS ²						L.F. OF TREAT.(ft.)				TYPICAL ³ BENCH WIDTH(ft.)		MEAN ENDHAUL DIST.(ft.)	EXCAV. ⁴ RATE (yd ³ /hr)
				X1	X2	C	W1	W2	D1	D2	D3	D4					
00+06 (1800)	670	2,907	2,597	3.88	7.5	0.0	0.0	7.5	2.5	7.5	7.5	7.5	0.0	124	15	1,350	97
29+45	2,670	12,456	9,674	3.37	19.0	21.5	0.0	23.25	0.0	25.25	19.25	19.25	0.0	447	15	3,732	71
36+53	3,790	16,449	10,819	2.85	9.5	25.75	0.0	24.0	5.75	31.25	29.25	31.25	1.0	422	16	3,036	108
41+47 ⁵	5,030	12,575	10,269	2.04	0.0	27.5	13.0	25.25	9.75	15.25	15.25	15.25	2.0	613	26	810 ⁵	124
50+85	2,910	7,275	6,139	2.11	9.75	12.25	0.75	14.75	7.0	5.25	18.35	14.25	0.0	377	24	177	128
54+33	1,550	6,727	4,699	3.03	6.25	11.75	0.0	12.75	0.0	10.0	11.6	12.25	0.0	318	27	3,308	86
72+89	1,200	7,812	2,749	2.29	1.0	6.8	0.0	10.25	3.0	3.5	6.75	4.25	0.0	116	23	1,353	154
75+02	1,225	7,487	3,465	2.82	0.0	12.0	0.0	11.0	0.0	0.0	11.25	11.25	0.0	132	21	1,007	102
77+22	570	2,474	2,087	3.66	0.0	7.0	0.0	6.0	0.0	7.0	0.0	6.25	2.25	100	26	1,828	81
TOTALS	19,815	76,162	52,498		53.0	124.55	13.75	134.75	28.0	105.0	131.95	121.5	5.25	2,649			
AVERAGES				2.65										8.4	22	1,859	104

¹ Fill generated from Exported Outsloping (EOS) workites on the Lower K&K has usually been truck endhaunched to stable fillsites. Worksite EOS 41+47 was an exception (see footnote 5).

² See Table 2 for a complete description of abbreviations and equipment specifications.

³ Typical Bench Width refers to the pre-work width of the roadway.

⁴ Excavation Rate is determined from the hours of the "excavating" pieces of equipment, such as hydraulic excavators or bulldozers. Equipment used to transport fill or smooth fillsites is not included.

⁵ 74% of the fill generated from this worksite was stored "locally" on nearby benches with an average 100 foot push or haul distance. The remaining 26% of fill was hauled by trucks an average of 4,050 feet to a fillsite.

and station 69+00 was the only substantial section of the K&K that was outsloped (Table 3). This section of the road was very mildly outsloped in order to disperse water emerging from wet cutslopes yet conserve vigorous second growth along the outboard edge of the road prism. Several other sections have only the extreme outboard portion of the road bench "pulled back" and were principally used as fillsites (fill outsloped). The result is the appearance of complete outsloping.

Exported Outsloping

Exported outslope treatments can either remove the entire road bench or just the outboard portion of the road, but in both cases the fill must be exported (endhauled) some distance to a stable fillsite. A considerable portion of the effort to treat Unit 89-2 was spent excavating the entire road prism of the K&K and truck-endhauling the fill material to stable fillsites (Table 4). The inherent instability of the materials on this site warranted removing as much material as was practical to relieve some of the driving forces causing the road-related fill failures and discourage propagation of failure through the larger slope failures (e.g. earthflows). For the most part, a 3-5 foot free-draining bench was left, at centerline inboard ditch elevation, to buttress persistent small-scale cutbank failures. Two major fillsites were designated; the Big Tree Rock Pit, an average hauling distance of 3,425 feet, and the Ingomar Club, an average hauling distance of 4,825 feet from the worksites. Smaller, local fillsites were near Station 54+00 and Station 69+00 through 71+00.

Secondary Treatments

Rock Armor

The inherent instability of materials found along the Lower K&K, combined with the prediction that original channel morphology would most likely not be found, led to the decision to provide protection for the channels. Virtually no original channel elements were encountered during excavation (except RX-5, see discussion above). Rock armor is warranted where excessive erosion could result within unprotected channel excavations, or other disturbances that propagate upstream (such as headcuts). Upstream migration of headcuts may cause stream-side slumping and mobilization of larger slope features, resulting in significantly larger amounts of sediment produced regardless of the amount of material eroded from the crossing excavation itself.

Rock armor was placed in RX-8, RX-9, and RX-10 (Table 1). RX-6 did not receive any rock armor due to conditions judged so unstable that it would not be a cost-effective measure. The channel above RX-6 (through the South Side Slide) was actively adjusting to the 1987 event and substantial instability was predicted for the short term. Conversely, the channels above RX-8, 9, and 10 were assessed to be quasi-stable (in the short term) and head cutting as a result of channel excavation could de-stabilize conditions negatively.

Rock was placed in the channels in a "blanket" form, covering the channel bottom, about 5 feet up each bank, and along the entire length of the excavated channel reach. RX-8 has about 100 yd³ of rock armoring and RX-9 and RX-10 each

TABLE 5. MISCELLANEOUS COSTS. UNIT 89-2, LOWER K&K.

ITEM	ACTUAL COST(\$)	H.E.R.E. COST(\$)	EQUIPMENT HOURS ¹								PERCENT OF	
			X1	X2	C	W1	W2	D1	D2	D3	D4	TOTAL COST (%)
<u>Misc. Bid Items²</u>												
Move In	2,500	-	-	-	-	-	-	-	-	-	-	1.3
Move Out	2,500	-	-	-	-	-	-	-	-	-	-	1.3
Open K&K	3,000	1,549	5.25	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	1.5
RX-4Channel Work	250	172	1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Access Road Winterization	750	322	0.0	1.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.4
<u>Misc. Non-Bid Items³</u>												
Breaks	-	8837	12.5	19.5	5.0	23.0	4.5	15.5	15.5	16.5	0.5	4.5
Discussion	-	362	2.5	0.75	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.2
Road Improvements	-	885	0.0	0.0	0.0	4.75	5.5	0.0	0.0	0.0	0.0	0.4
Fueling	-	316	0.5	1.0	0.0	0.75	0.5	0.75	0.0	0.0	0.0	0.2
Travel	-	198	0.25	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1
Paid Down ⁴	-	409	1.0	1.0	0.25	0.5	0.5	0.5	0.5	1.0	0.0	0.2
Standby ⁵	-	10,675	0.0	0.0	0.0	39.5	0.0	106.5	98.25	99.25	0.0	5.5
Waiting (for other equip.)	-	247	0.0	0.0	0.0	2.75	0.0	0.0	0.0	0.0	0.0	0.1
Down Time ⁶	-	-	19.25	69.5	0.5	0.0	4.5	4.5	11.25	4.0	0.0	-
Idle Time ⁷	-	-	227.75	47.25	173.0	0.0	258.0	0.0	0.0	0.0	297.0	-
Misc. RNP Heavy Equip ⁸	129	-	-	-	-	-	-	-	-	-	-	-
TOTAL	\$9,000	\$23,972										15.8 ⁸

1) Abbreviations and specifications are found in Table 2.

2) These items were line items in the Bid Schedule. Percent of total cost is based on the actual cost.

3) These items are the true miscellaneous costs. Percent of total cost is based on the H.E.R.E. value (since there is no "actual" bid price).

4) In an hourly rental situation, RNP typically paid the contractor up to one half hour to fix whatever the problem was. Beyond the half-hour would not be paid.

5) It is not known if the contractor incurred any standby costs. However, within the context of an hourly rental situation, contractors would be paid a standby rate by RNP.

6) Down time is the time a piece of equipment is broken down beyond one-half hour.

7) The contractor for this project had several pieces of equipment and rarely was all of the equipment working simultaneously. This time has no associated cost since, within the context of an hourly rental situation, RNP would not have the luxury of having all these pieces on site and paying standby rates for the idle time. The extra equipment allowed the contractor greater flexibility in approaching different tasks. The ability of the contractor to choose the best combination of equipment for each site should probably be kept in mind when comparing H.E.R.E costs directly with excavation and production rates of hourly rental projects, where equipment combinations are chosen for overall project effectiveness.

8) This value is applied to H.E.R.E costs in a cost-weighted manner to obtain T.H.E.R.E. costs.

TABLE 6. LABOR INTENSIVE COSTS. UNIT 89-2, LOWER K&K.

TASK	RNP ¹		RUI ²		TOTAL COST(\$)	UNIT COST(\$)
	Person Hrs	Cost(\$)	Person Hrs	Cost(\$)		
Brush Survey Lines	281	3,634	38	354	3,988	-
Straw Mulch						
Materials Price (800 Bales)	-	-	-	-	2,560	3.20/bale
Delivery (unloading, etc.)	122	1,348	-	-	1,348	1.69/bale
Spreading	231	2,483	50	590	3,073	3.84/bale
Contract Distribution	-	-	-	-	4,000	5.00/bale
Rehab Maintenance (RX-5, Unit 89-2)	12	138	-	-	138	-
RX-6 Half-Round Install/Remove	19	212	-	-	212	-
TOTALS	665 hr	\$ 7,815	68 hr	\$ 944	<u>\$15,319</u>	-

1) Redwood National Park, Research and Resources Management Support Branch (Labor Crew).

2) Redwoods United Incorporated.

have about 200 and 170 yd³ respectively. The top of the armoring on all three channels was well "keyed" by trenching below channel grade and into the banks and backfilling with rock creating a type of buried (or on-grade) checkdam which forces flow into the designed channel.

Rock was hauled to the K&K from the Y-Line Rock Pit, where stockpiles were created as a by-product of the Unit 89-4 project (Johnson, 1990). Costs for rock armor transport and placement are found in Table 1.

Straw Mulch

The K&K Road was treated with straw mulch on all excavated surfaces to inhibit sheetwash and provide cover for the seedbed. This site has a southerly to southwesterly exposure and summer conditions are usually hot and dry. The application rate was 6,000 pounds per acre (approximately 75 bales/ac). See Table 6 for a detail of straw mulch costs.

DISCUSSION

The size of the K&K Road, its proximity to Redwood Creek, and the inherent instability of the terrane, required that this rehabilitation unit be the one of the most effort-intensive sites yet accomplished in Redwood National Park. Examples of other sites in Redwood where extensive truck-endhauling was necessary are the G-Line, Unit 85-3 (Kenning and Wosika, 1986), the M-7, Unit 86-1 (Kenning, 1987), and the Lower K&K, Unit 88-2 (Steensen, 1989). Unit 88-2 was the first phase of a several year project to rehabilitate the K&K Road and it is likely that the remainder of the Lower K&K will consistently be a effort-intensive site until the work is completed through the Copper Creek valley (to the intersection with the 2002 and 2004 Roads).

Unit 89-2 differed from 88-2 from the standpoint that there were more frequent "stable" areas encountered along the road. Several small fillsites were utilized as well as the Big Tree Rock Pit and the Ingomar Club (the name is derived from the mechanics shack that existed there prior to park expansion that was satirically named "Ingomar Club" after the genuine Ingomar Club which is based at the Carson Mansion in Eureka, Calif.). As a consequence, a longer segment of the road and more disturbed watershed area was treated in 1989 relative to 1988.

The Lower K&K Rehabilitation Project addressed erosion problems associated with road construction and timber harvest on naturally erosion-prone hillslopes and stream channels. Direct sediment sources to Redwood Creek that were minimized included removal of stream crossing fills and large quantities of sidecasted materials. Haul road-stream crossing excavations removed road fill material from stream valleys and channels and eliminated diversion possibility. Relief to some of the driving forces causing road-related fill failures was accomplished by removing as much material as was practical (i.e., within limits of equipment capability, cost, etc.) and landscapes now conform with existing conditions outlying the treated area. Stabilization of the drainage systems was likely the greatest cost-effective contribution toward future stability.

As with numerous past accounts of work experiences with heavy equipment operators, the execution of work on Unit 89-2 went smoothly due in part to the experience and capabilities of the contractor. Kjer and Sons has considerable experience working on rehabilitation projects in Redwood National Park and the familiarity with the procedures and goals of the program enabled them to progress without complication. Working with this contractor has affirmed the valid principle that experienced operators are indispensable in implementing rehabilitation work.

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89-2 Movie PP, 24mm RX10 RX9 RX8 TAS 9/89



89-2 Lower k+k Movie PP, 50mm RX9 RX8 TAS 9/89



89-2 Lower k+k Movie PP, 24mm TAS 9/89



89-2 Post H.E. PP26 Lower k+k, Left Bank RX8 Sta 72t10 35mm TAS 9/27/89



89-2 Post H.E. PP36A Lower k+k, OBE Ridge Sta 78+50 35mm DLS 10/4/89



89-2 Post H.E. PP36 k+k, Sta 78->71 28mm DLS 11/89



89-2 From movie P.P. Lower k+k, RX9 RX3 50mm TAS 10/4/89



89-2 Pre H.E. PP30A Lower k+k, Downsta RX8 + O.S STA 74+00 35mm DLS
7/19/89



89-2 Post H.E. PP30A Lower k+k, Downsta RX8 + O.S. JFW 9/27/89