

REPORT ON THE REHABILITATION
OF SITE 80-6

REDWOOD NATIONAL PARK

by
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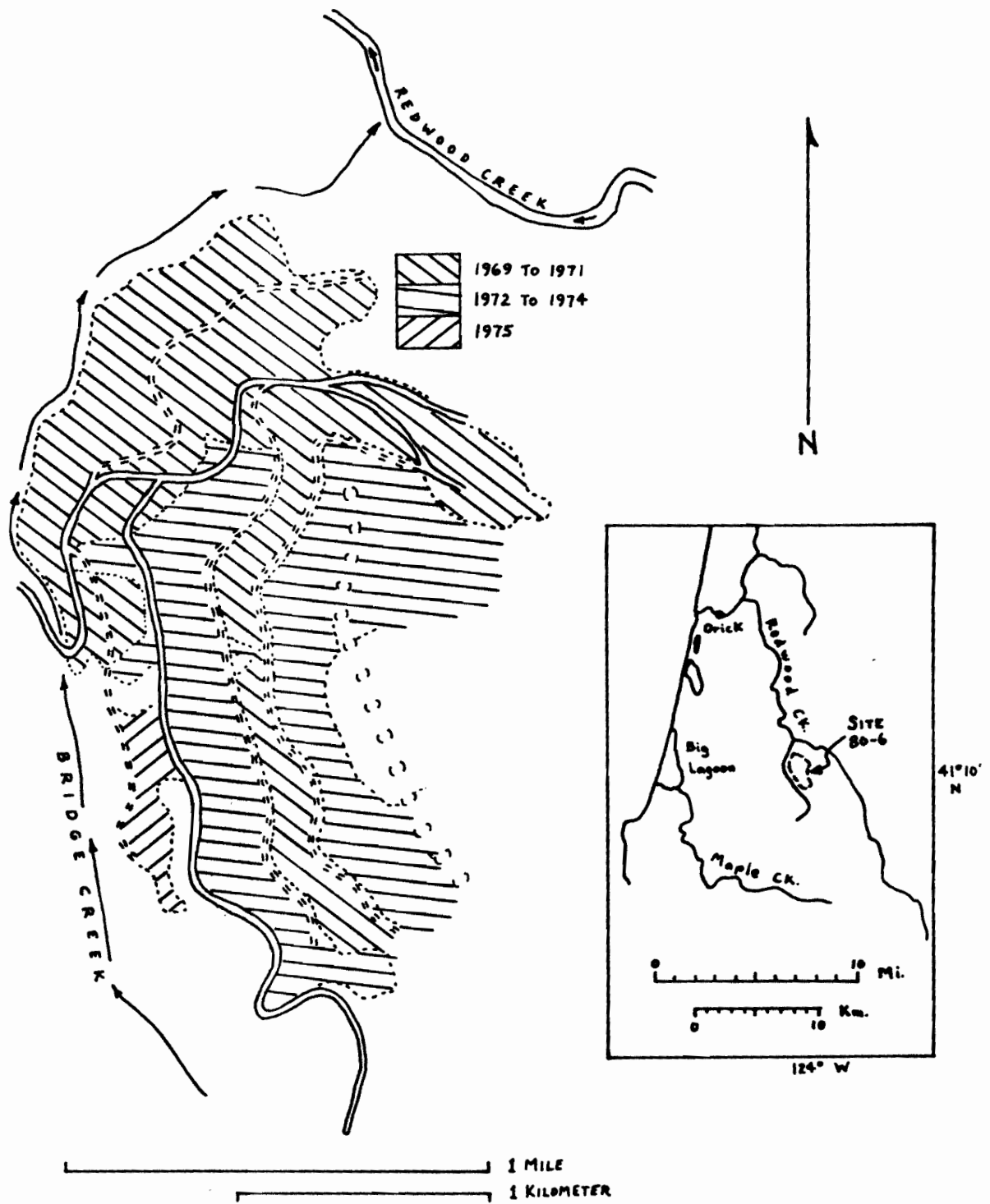


Figure 1. Location Map and Times of Logging with Respect to the Spring Storms of 1972 and 1975

INTRODUCTION TO SITE 80-6

Between March 1980 and January 1981, a 710 acre (290 hectare) site on the nose of Bridge Creek (site 80-6) was mapped and rehabilitated for erosion control and revegetation. The old growth redwood and fir forest on this site had been about 90 percent clearcut by tractor logging between 1969 and 1975 (see figure 1). Hillslopes are underlain by Redwood Creek Schist and range in steepness from 25 percent on the Redwood Creek side of the unit to 100 percent adjacent to incised tributaries in Bridge Creek drainage but are mostly around 40 percent.

The emphasis of mapping and rehabilitation in terms of person hours and expenses was: 1) documentation of natural and management related drainage networks and erosion features; 2) the restoration of small drainage networks to more nearly pre-logging conditions with heavy equipment; 3) the removal of earth fill from natural stream channels with heavy equipment; 4) revegetation and erosion control work by labor intensive techniques; and 5) documentation of costs and work accomplished at heavy equipment and labor intensive work sites. The overall expenditure of time and money on this site is summarized in table 1.

HAUL ROADS, SKID TRAILS, AND EROSION

Detailed mapping of stream channels, haul roads, culvert locations, inboard ditches, and erosion features at 1:1,800 (1 inch = 150 feet) was done by Pat Teti and Matt Horns between mid-March and the end of May 1980. This map (included as an appendix to this report) shows the locations and sizes of all gullies, active and inactive, that are larger than a few square feet in cross sectional area and most gullies larger than one square foot. The causes of all of these gullies can be explained by unnatural concentrations of storm runoff on forest soils (or sub-soils) that had not been subjected to such runoff before disturbance. The immediate cause of such disruption of the micro-drainage network is, in all cases, attributed to one or more of the following: 1) culvert under a haul road not placed in alignment with natural stream channel; 2) insufficient number of culverts; and 3) the interception and diversion of runoff by inboard ditches and skid trails. In all of these instances roads and skid trails are responsible for concentrating storm runoff in unnatural flow courses which are generally not protected against flows in the order of a few cfs.

Task	RNP Employees		Heavy Equipment	Labor Contract	Redwoods United and RNP Bio-Technicians	Sub-Total (less supervision by geologists)
	Geologists	Laborers				
Documentation of Drainage and Erosion Features Prior to Rehabilitation Work	\$5,690	---	---	---	---	\$5,690
Restoration of Small Drainage Networks	\$920	---	\$28,207	\$740	---	\$29,867
Physical Removal of Fill as a Sediment Source	---	---	36,447	833	---	\$37,280
Stream Bed and Bank Protection with Check Dams, Rocks, and Planting Side Slopes	12,768	---	2,770	10,633	---	\$26,171
Seeding, Fertilizing, Mulching and Planting Roads	960	---	---	1,260	\$4,851	\$7,071
Log Salvage (60,000 B.F.)	400	---	3,935	---	---	\$4,335
Miscellaneous Rehabilitation Costs	1,920	---	1,351	1,047	---	\$4,318
Cost Analysis	2,140	---	---	---	---	\$2,140
Totals	\$21,830	\$16,968	\$72,710	\$14,513	\$4,851	

14,000
(supervision)

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Table 1. The General Division of Rehabilitation Expenses on site 80-6
Grand Total = \$130,872

The density of skid trails on this unit is estimated to be about 635 linear feet per acre. It was a common practice for the tractor operators to dig deep cuts in the forest soils, thereby lowering the level of the skid trails as much as 15 feet below the level of original ground. The overlying earth material and logging slash was in many cases used as fill in the construction of roads and landings. In those instances in which the level of the skid trails were cut more than 4 or 5 feet below the original ground surface the skid trails act as troughs which intercept groundwater and concentrate storm runoff very quickly. This situation is exacerbated by the low permeability and poor revegetation that usually results from the stripping away of the upper soil horizons. This condition also rendered treatment of skid trails by waterbar construction impractical in many instances. The above practice was a double edged sword because there were three landings constructed of slash and earth fill that were actively failing largely due to the discharge of runoff from skid trails and culverts onto the landing surfaces.

Another major potential sediment source was earth fill under roads and skid trails where they cross natural and diverted stream channels. Six of these had already partially failed, each yielding at least 10 cubic yards of sediment as of spring 1980. However, most culvert crossings of haul roads were still intact and therefore still had 100 percent of their original erosion potential.

The total volume of gully erosion was calculated from mapped gully dimensions for the three largest gully networks on this unit. The locations and total volumes of these gullies are shown in figure 2. Within the drainage boundaries of stream "B" is a gully which originated on skid trails upslope from the M-7-5-2 road and which discharged onto the site 5 landing for at least ten years. Diversions of water from the flat surface of the landing onto different areas on the slope below caused at least three different gullies to form, two of which could have been easily prevented with some low cost road maintenance treatments. Such treatments could have easily prevented 2,000 cubic yards of gully erosion from occurring by confining storm runoff into the first large gully that formed. This entire unit is replete with examples of erosion features which (with 20-20 hindsight) could easily have been prevented at less cost than the cost of rehabilitation.

PRESCRIPTION METHODOLOGY

Possible treatments of specific sediment sources were considered after mapping of whole hydrologic units was complete. Only in this way could all possible treatments be considered. In general, land use related fluvial erosion on this site is due to: 1) surface runoff being diverted or concentrated onto soil or fill; and 2) earth fill being unnaturally emplaced next to or in flow courses. In simpler terms, all gullies were caused either by water being diverted someplace where it does not belong or soil being moved to a place where it does not belong. Treatments can therefore be classified mainly as either restoring part of the micro-drainage network (e.g. with waterbars) or excavating fill out of road and skid trail crossings. Another major expense was armoring the beds and banks of freshly excavated stream crossings and of gullies that could not be de-watered. The costs and effectiveness of these three major types of treatments are discussed in the next section.

Excavation of Fill by Heavy Equipment

All intact fill crossings of streams by skid trails and haul roads were considered for complete excavation if the stream was judged to be capable of eroding the fill during a large storm. In retrospect, it appears that such a stream can be described as one draining at least 10 acres or so, depending on the site. According to the rational formula and a runoff coefficient of .4, the 10 and 25 year peak flows from 25 acres in this area are 14 and 18 cfs respectively. However, streams draining less than 30 acres did not, in all cases, have well-defined natural channels so some peak flows may be less than predicted.

The following discussion provides an example of the decision making criteria for treating sites that can not be easily included or excluded from treatment. Along the main channel of stream "A" (figure 2) are two haul road crossings and two skid trail crossings that were considered for full excavation. At this stream's mouth (drainage area about 100 acres) is a haul road crossing from which about 160 cubic yards has already failed. There is a potential for a roughly equal amount of fill failure before the sideslopes and channel bed become fully vegetated and stable. However, this fill was not excavated because the M-7-5-A road would have needed to have some major repair in the vicinity of site 32 (10 ft. deep gully) and at a few locations where the cut bank and road fill have failed. The impact and cost of reconstructing this road were not considered acceptable as part

of accessing that fill crossing. On the other hand, a partially failed crossing on the M-7 road (site 33, drainage area 69 acres) was accessed and excavated by heavy equipment because almost no preliminary road work was necessary. Due to the extensive natural revegetation by alder trees on the M-7-5-A road and the M-7 road north of site 33, these sections of road totalling 1.6 miles, were left completely untreated. Approximately 125 feet upstream from site 13 are two skid trail crossings (drainage area about 35 acres) on stream "A". Both of these crossings each have the potential for perhaps 50 cubic yards of sediment yield. However, neither was excavated primarily due to access trails that were of questionable safety for backhoe access. In any event, sediment release from these crossings will probably occur only during infrequent large storms (perhaps 25 year return period) due to slash content and revegetation by alders and willows.

Four of the largest excavations were intact fill crossings on the M-7-5-1/2 road which had volumes between 500 and 1,500 cubic yards (sites 22-25). All of these would have failed sooner or later due to discharge exceeding the culvert capacity, plugging of the intake, or culvert disintegration. Sites 5 and 9 on the M-7-5-1 1/2 road were large excavations in landings in order to make a channel for runoff that had been concentrated onto the landings by inboard ditches, culverts, and skid trails upslope. The edges of both of these landings were actively failing by gullying and mass movement processes due largely to unnatural concentrations of runoff. Stream channels were excavated into these landings directing runoff onto more stable soils and eliminating the edges of the landings as sediment sources.

Restoration of Small Drainage Networks

The diversion of surface water by inboard ditches and compacted road surfaces were treated on haul roads by ripping (D-8 with ripper teeth), followed by installation of cross road drains and waterbars (tractor and backhoe). This treatment tends to increase infiltration, may improve revegetation, and helps keep surface runoff dispersed, thereby reducing erosion. The M-7-5-2, M-7-5-1 1/2, and M-7-5-1/2 roads were treated by this method and had a total of 170 cross road drains plus waterbars installed.

Some skid trails were specially selected for waterbar installation. These were skid trails with slopes of 20 to 50 percent and signs of active rilling. The rill networks and very poor revegetation contributed to very flashy runoff and gullying downslope. One of the largest gully systems on this unit can be partially attributed to a large skid trail network in the headwaters of stream "B". This skid trail network acted like a funnel in concentrating runoff into an M-7-5-2 culvert and contributing to 7,000 cubic yards of management related soil erosion. A total of 68 waterbars were placed on these and other skid trails, mostly by backhoe and tractor. Waterbars were also placed on skid trails that were used for access to the heavy equipment work sites. However, these are not considered treatments in the same sense as the above mentioned skid trail treatments and are not shown on the figure.

Certain site specific treatments served to restore drainage networks on a larger scale than that achieved by waterbar construction. Site 2 and site 5 are example of fill excavations which de-watered large active gullies. The installation of an additional culvert in the M-7-5 road at site 31 had a similar effect by reducing the amount of area drained by an active gully system from 24 acres to 2.5 acres. Other work which involved putting a stream back into its original channel or re-routing gullying flow courses onto more stable areas is included under sites 6, 9, 11, 17, 18, 19, 20, and 24.

Secondary Treatments

Secondary treatments, as used here, are defined as any treatments that increase the stability of earth material adjacent to flow courses and include rock, check dams, submerged spillways, bank protection boards, energy dissipation mats as well as mulching, fertilizing, and planting side slopes next to flow courses. All side slopes of excavated stream crossings were mulched with straw (1-2 tons/acre, except site 19 - no straw) and planted with alder (alder, whippiea, coyote brush mix at sites 1 and 2) seedlings. Additionally, all excavated side slopes of 60 percent or more that were at least 15 feet long were mulched with "Curlex" before planting.

Fifteen sites had bed and bank protection by imported rock, check dams, staked and rockbed, or a combination of these treatments. Site 5 had a combination of all three. Sites 11, 19, and 33 are excavated stream channels with no bed and bank protection other than rock unearthed locally and mulched

and planted sideslopes. Sites 11 and 12 provide a side by side comparison of two excavated channel fills on similar reaches of the same stream, one with check dams and one with no added rock or check dams.

REHABILITATION TREATMENTS

Heavy Equipment Work

The general division of heavy equipment work according to different tasks is shown in table 1. This includes all costs, including transportation in and out. Restoration of drainage networks and excavation of fill from flow courses required 39 and 51 percent of the heavy equipment expenses respectively. A description of the equipment used, the costs per piece, and the operators are listed in table 2. This work was supervised by Pat Teti and Matt Horns.

Labor Intensive Work

Two park laborers, Jinkie Boyce and Jim Brobisky were assigned to this site from June through November 1980. Additional person hours were provided by Peter Bretnall and Roger Lemstrom. Matt Horns put in several hundred hours as supervisor during the construction of waterbars, check dams, channel rocking, and other erosion control devices and assisted in the manual labor on a regular basis. About \$2,000 worth of his time spent laboring are included in table 1 under the in-house labor column. An hourly wage of \$8.00 was used as a basis for all in-house labor costs.

A labor contract was awarded to NRG, Inc. under IFB 8480-1-03 for an amount of \$12,497 which was later amended to a total of \$14,513. This work consisted of mainly stream bank stabilization and gully armoring by mulching and planting side slopes, check dam construction, and headcut treatments. Pat Teti was the contracting officer's representative for the park and NRG was officially represented by Randy Stemmler and Dusty Escano.

Photo Points

Photo points were established at selected excavations before rehabilitation to provide before and after documentation. One large excavation (site 22) was photographed before, during, and after heavy equipment from

Description of Equipment	Owner/Operator	\$ per hr.	Total hrs.	Total Cos
Case 850-B Tractor with 6-way blade	Carl Kjer/Ted Helm	\$55.00	451	\$24,805
25B crane with 1½ yd. bucket and clamshell	Carl Kjer	95.00	209.5 ₁	19,468
Case 580-B extendahoe	Keith Parker	32.40	417	13,511
Case 880 excavator	Ted's Const./David Felt	69.50	62.5	4,344
TD-15 Tractor	Marvin McGaughey	40.00	78	3,120
D-8 with rippers	Dutra Trucking/Dick Ryan	75.00	29.5	2,213
10 cubic yard dump truck	Keith Parker, Frank Viskocyl, and Lyle McGaughey	32.58 ₂	48.5	1,580
D-4 Tractor	Marvin McGaughey/Rusty Vorous	32.00	29.5	944
Case 680-B extendahoe	Keith Parker/Steve Hoops	56.00	10	560
Low-Boy Truck	Dutra Trucking	45.00	33 ₃	<u>1,500</u>
TOTAL HEAVY EQUIPMENT COST				\$72,045

1. Includes 8 hrs. at \$40.63 per hour.
2. Average cost per hour.
3. Estimated.

Summary of Heavy Equipment Costs
Table 2

two different vantage points providing good temporal resolution to the process of stream fill excavation. Other photo points include: gullies and rills that were de-watered by rehabilitation; a skid trail crossing that was left unexcavated; and treated haul roads. Photo points descriptions and locations are given in table 3 and in the appendix.

Revegetation

The bulk of revegetation work on this site was done by NRG, Inc. under labor contract. Most side slopes adjacent to disturbed crossings were planted with alder seedlings on one foot centers. Alder transplants from the G-line deck were planted in eight's next to each check dam and submerged spillway to provide root strength to stream banks as quickly as possible. The M-7-5-2 road (1.8 miles) and the ripped part of the M-7-5-1 1/2 road (1.3 miles) were fertilized (250 lbs/acre, 16-20-0), and seeded (50 lbs/acre, grass, legume, and alder mix) by a Redwoods United crew and Redwood National Park Biological Technicians, Roy Martin, Neil Sugihara, and Vern Mirante. All ripped roads, including .8 miles of the M-7-5-1/2 road, were mulched with straw at an average rate of one ton per acre. These road reaches were then planted on 8 foot centers with mixed fir and redwood seedlings by NRG. Some skid trails used for access by heavy equipment were also planted as described in the site specific descriptions of work.

<u>Photo Point No.</u>	<u>Subject/Location</u>	<u>Dates of Photos</u>	<u>Film/Lens</u>	<u>Comments</u>
80-6-1	Site 33/top of stump, left bank, upstream	23 June 1980 9 March 1981	slide/50mm, 35 mm	Before and after treatment
2	Site 22/base of 5 ft. diameter RW tree, left bank, below road prism.	24 June 1980 31 July to 5 August	slide/50 mm	Sequence of photos during excavation.
3	Site 23/top of stump, right bank, outboard edge of road.	24 June 1980 9 December 9 March 1981	slide/50mm, 35 mm	Before and after treatment
4	Site 19/corner of 8 foot boulder, right bank, below skid trail.	24 June 1980 9 December	slide/50mm	Before and after treatment
5	Site 19/next to 20 inch hemlock tree, left bank, above skid trail.	24 June 1980 9 December	slide/50mm	Before and after treatment
6	Site 20/a few feet from channel right bank, downstream end of check dam reach, stake in ground.	29 July 1980 18 August	slide/50mm	Before and after excavation. Backhoe assisting in check installation.
7	Gully at outfall of culvert 600 feet down the M-7-5 road from site 31/left bank, 50 feet from the road.	24 June 1980		This gully was de-watered by installation of culvert at site 31.
8	Site 9/on top of fir stump, left bank, downstream end of excavation.	24 June 1980 27 October		Before and after treatment.
9	Site 9/50 ft. upslope from road on top of 8 ft. diameter RW stump, view west across landing.	24 June 1980 27 October	slide/50 mm	Before and after treatment

Table 3. Photo Point Descriptions

<u>Photo Point No.</u>	<u>Subject/Location</u>	<u>Dates of Photos</u>	<u>Film/Lens</u>	<u>Comments</u>
80-6-10	Gullied skid trail/on top of 4 ft. diameter fir stump at top of M-7-5-2 cut bank about 300 ft. from north end of road.	25 June 1980	slide/50mm	De-watered with waterbars.
11	Photo of haul road between M-7-5 and M-7-5-2/ on top of 5 ft. diameter stump immediately above culvert #2, 1,500 feet east of site 31.	25 June 1980 11 September	slide/50mm	Before and after waterbar construction.
12	M-7-5-1 1/2 road/on top of 5 ft. RW stump at top of cut bank, 1,250 feet from north end of road.	25 June 1980 3 September 27 October		Before, during, and after cross road drain construction.
13	Site 14/80 feet upstream from site 13, top of 5 ft. RW stump, left bank, downslope side of skid trail.	25 June 1980		Skid trail crossing not excavated.
14	Gullied skid trails/on top of root wad, 40 ft. downslope from road, 950 feet east of site 31.	30 June 1980	slide/50mm	Before de-watering by waterbar construction.
15	Site 11/on top of left bank at upstream end of excavation.	23 July 1980 29 October 17 Feb. 1981	slide/50mm	Before and after excavation.
16	Site 11/on top of stump, left bank, downstream end of excavation.	23 July 1980 29 October 17 Feb. 1981	slide/50mm	Before and after excavation.
17	Site 12/on top of stump, left bank	23 July 1980 17 Feb. 1981	B&W/35, 50 mm slide/35 mm	Before and after excavation.

Table 3 (cont.). Photo Point Descriptions

<u>Photo Point No.</u>	<u>Subject/Location</u>	<u>Dates of Photos</u>	<u>Film/Lens</u>	<u>Comments</u>
80-6-20	Site 5/top of left bank, outboard edge, 5 ft. diameter RW stump.	27 October 9 March 1981	slide/50mm	During and after secondary treatments.
21	Site 8/two views from top of RW log at downstream end of excavation.	27 Oct. 1980	slide/50mm	After treatment.
22	Site 22/about 100 ft. north of excavation on top of large stump on outboard edge of road.	1 to 5 Aug. 1980	slide/50mm	Sequence during excavation.

Table 3 (cont.). Photo Point Descriptions

Descriptions of Treatments by Site

This section describes erosion control and revegetation work organized according to specific sites, haul road treatments, and then skid trail treatments. This encompasses all work except for \$2,064 worth of labor contract work that is listed separately. Then there is a breakdown of total costs and unit costs for a variety of labor intensive and heavy equipment treatments including check dams, rocking, excavation of fills, and a comparison of secondary treatments at excavated stream crossings.

All numbered heavy equipment work sites and haul roads are identified on figure 3. This figure has symbols which distinguish among crane excavations, backhoe excavations, and backhoe trenches. The locations of major gullies, de-watered gullies, streams, and waterbarred skid trails are also shown. Labor intensive work sites are not shown explicitly but instead are described in relation to numbered heavy equipment work under sites 1 through 33. Figures 4 through 7 are replications of portions of the detailed geomorphic map in the appendix and show the gullies, diversions, photo points, and other descriptions for sites 1-8, 11, 12, 17, 20, and 24.

Site 1

Heavy Equipment Work: Crossing excavated by backhoe 7 and 8 July. Fill spread locally by tractor. Fill volume approximately 70 cubic yards. Also, about 60 cubic yards were pulled back from the outboard edge of the road.

Secondary Treatments: 2 cubic yards of local rock placed by hoe and hand. 210 seedlings of coyote brush, whipplea, and alder. Seeded and strawed.

Photo Points: None.

Equipment Costs:

Backhoe, 13.1 hours.....	\$423.00
Tractor, 4.2 hours.....	232.00

Labor, in-house:

Placing rock, 6 hours.....	48.00
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Labor, contract:

Item 44, planting.....	<u>29.40</u>
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Total Cost.. \$732.00

Site 2

Heavy Equipment Work: Crossing excavated by backhoe on 8 July. Fill spread locally by backhoe. Fill volume approximately 120 cubic yards.

Secondary Treatments: 10 cubic yards of rock (one truck load) placed by backhoe. 216 seedlings of mixed coyote brush, whipplea and alder. Seeded and strawed.

Photo Points: None

Equipment Costs:

Backhoe, 7.7 hours.....	\$249.00
Rock, 10 cubic yards.....	120.00

Labor, contract

Item 45, planting.....	<u>30.24</u>
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Total Cost.. \$399.00

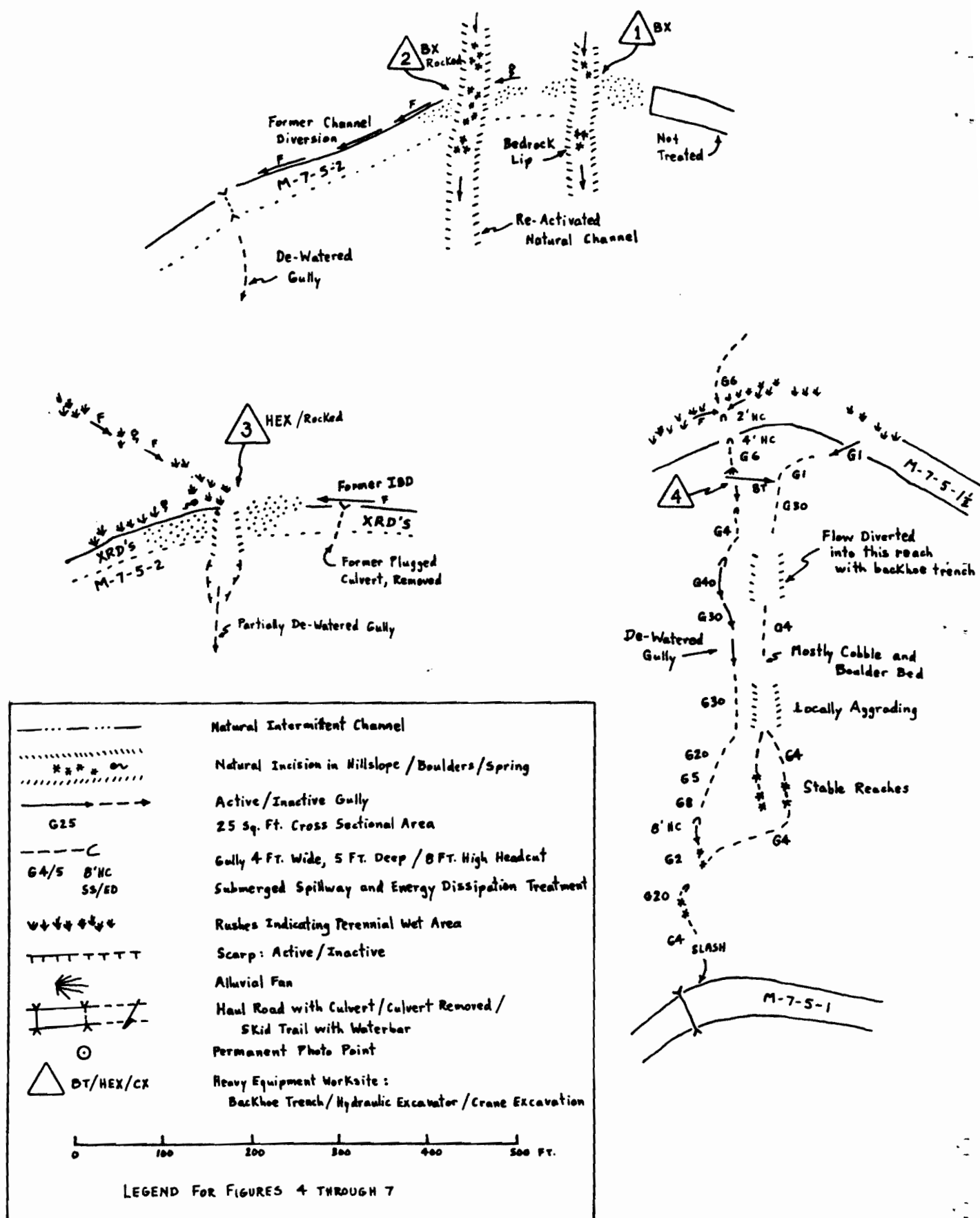


Figure 4. Geomorphic Features: Sites 1, 2, 3, and 4

Site 3

Heavy Equipment Work: Excavated by hydraulic excavator on 7 August.
Backhoe did finishing work and placed 15 cubic yards of rock on
29 August. Volume = 100 cubic yards.

Secondary Treatments: 15 cubic yards of rock placed by backhoe. Seeded
and strawed.

Photo Points: None.

Equipment Costs:

Excavator, 8 hours.....	\$556.00
Backhoe, 6.3 hours.....	205.00
Rock, 15 cubic yards.....	<u>180.00</u>

Total Cost.. \$941.00*

*Labor Costs: Lumped as part of seeding and strawing the M-7-5-2 Road.

Site 4

Heavy Equipment Work: Access trail by tractor and manual brushing.
Trench was excavated by backhoe on 18 July to divert flow out of
active gully into the more stable flowcourse about 15 yards to the south.

Secondary Treatments: None.

Photo Points: None.

Equipment Costs:

Tractor, 2 hours.....	\$110.00
Backhoe, 2.9 hours.....	<u>93.00</u>

Labor, in-house:

Brushing Access, 6 hours.....	<u>48.00</u>
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Total Cost.. \$251.00

Site 5

Heavy Equipment Work: Landing excavated by crane in order to accomodate surface
runoff originating at M-7-5-2 Road. Active gullying immediately downslope
from the landing amounted to about 270 cubic yards prior to treatment.
Active gullies were de-watered by excavating a stream crossing into landing
on 20 to 22 August. Boulders were uncovered during excavation and were
placed in channel by crane. Flow was re-routed downslope into an inactive
gully with a rock bed. Volume = 1170 cubic yards.

Site 5 (cont.)

Secondary Treatments: Bed and banks were protected by alternating boulders, check dams and staked rocks. Side slopes were seeded, strawed and planted with alder. Curlex was applied to the left bank only.

Photo Points: PP-20 at the top of left bank, downstream end.

Equipment Costs:

Tractor, winching logs, spreading fill, 22.7 hours.....	\$1249.00
Crane, 27 hours.....	2565.00
Backhoe, finishing work, 5.3 hours.....	171.00

Labor, in-house:

13 check dams, 5' X 1' spillways, 46 days.....	3680.00
Rock and stake bed and banks, 11 days.....	880.00
Miscellaneous, 1 day.....	80.00

Labor, contract:

Item 41, 1860 sq. feet of Curlex applied to left bank..	148.36
1700 alder seedlings.....	255.00
104 alder transplants next to check dams.....	144.56

Curlex, 2.6 rolls.....	<u>77.50</u>
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Total Cost.. \$9251.00

Site 6

Heavy Equipment Work: Access trail by trail. Backhoe trench with dimensions 4' X 2' X 40' was dug 20 to 22 July to divert flow from Site 5 out of an extremely active gully into a more stable gully.

Secondary Treatments: 4 waterbars were placed on access trail, two by equipment and two by contract. Sides of trench were planted with alder and 2 cubic yards of local rock were placed in trench by hoe and by hand.

Photo Points: None.

Equipment Costs:

Tractor, access trail, backhoe support on trail, 5.8 hrs....	\$319.00
Backhoe, 4.2 hours.....	136.00

Labor, in-house:

Rocking, 4 hours.....	32.00
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Labor, contract:

Item 14, remove log from gully.....	55.20
Item 22, 675 alder seedlings on sides of trench.....	101.25
Item 26, 27, two waterbars on access trail.....	<u>111.81</u>

Total Cost.. \$755.00

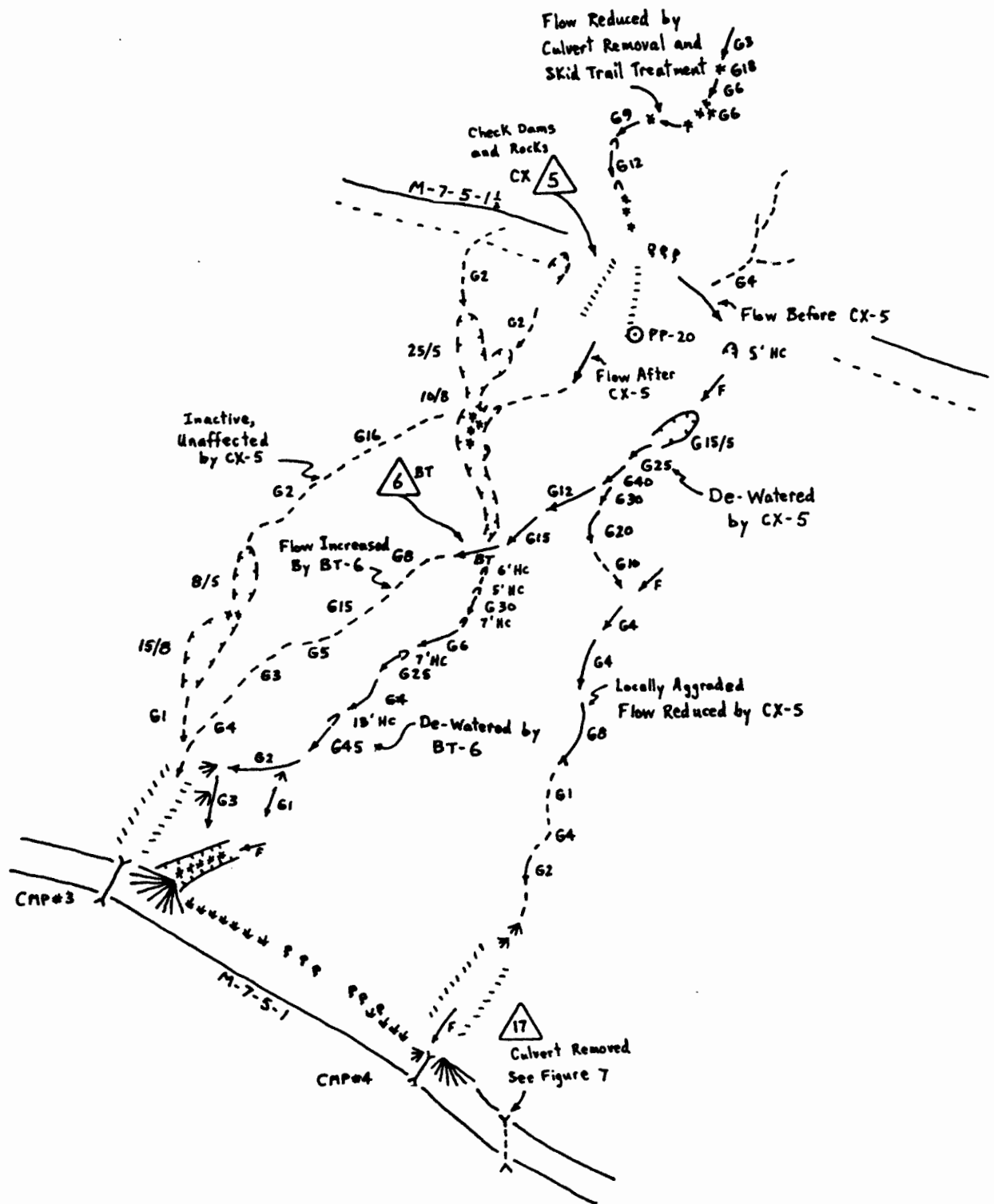


Figure 5. Geomorphic Features: Sites 5 and 6

Site 7

Heavy Equipment Work: A 5 foot headcut in the M-7-5-1 1/2 Road was pulled back by backhoe on 21 July.

Secondary Treatments: With the assistance of the backhoe, four check dams were installed. Downslope from the check dam reach, where the flow goes down a skid trail, a channel 2' X 1' was dug, rocked and staked for a distance of 40 feet. Alder were planted next to check dam reach.

Photo Points: None.

Equipment Costs:

Backhoe, 10.5 hours.....	\$341.00
Tractor, 8.4 hours.....	464.00

Labor, in-house:

Dig, rock and stake a 2' X 1' X 40' channel, 10 days.....	800.00
Install four check dams with help of backhoe.....	32.00
Install check dam energy dissipation, 2 days.....	160.00
Channelize flow upstream from check dams.....	240.00

Labor, contract:

Item 43, 1400 alder seedlings near check dams.....	210.00
32 alder transplants immediately adjacent to check dams	<u>44.88</u>

Total Cost..\$1487.00

Site 8

Heavy Equipment Work: Skid trail crossing of a stream draining 58 acres was excavated by backhoe 16 to 18 July. Fill was spread locally by tractor.

Secondary Treatments: Excavation was seeded, strawed and planted with alder.

Photo Points: PP-21 in the center of the channel at the downstream end of the excavation, on top of the redwood log. Two views, one of the surface and one of the center of the swale.

Equipment Costs:

Backhoe, 16.2 hours.....	\$ 524.00
Tractor, 15.2 hours.....	841.00

Labor, in-house:

Not itemized, estimated five person days.....	400.00
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Labor, contract:

Item 23, 1200 alder seedlings on sideslopes.....	<u>180.00</u>
--	---------------

\$1945.00

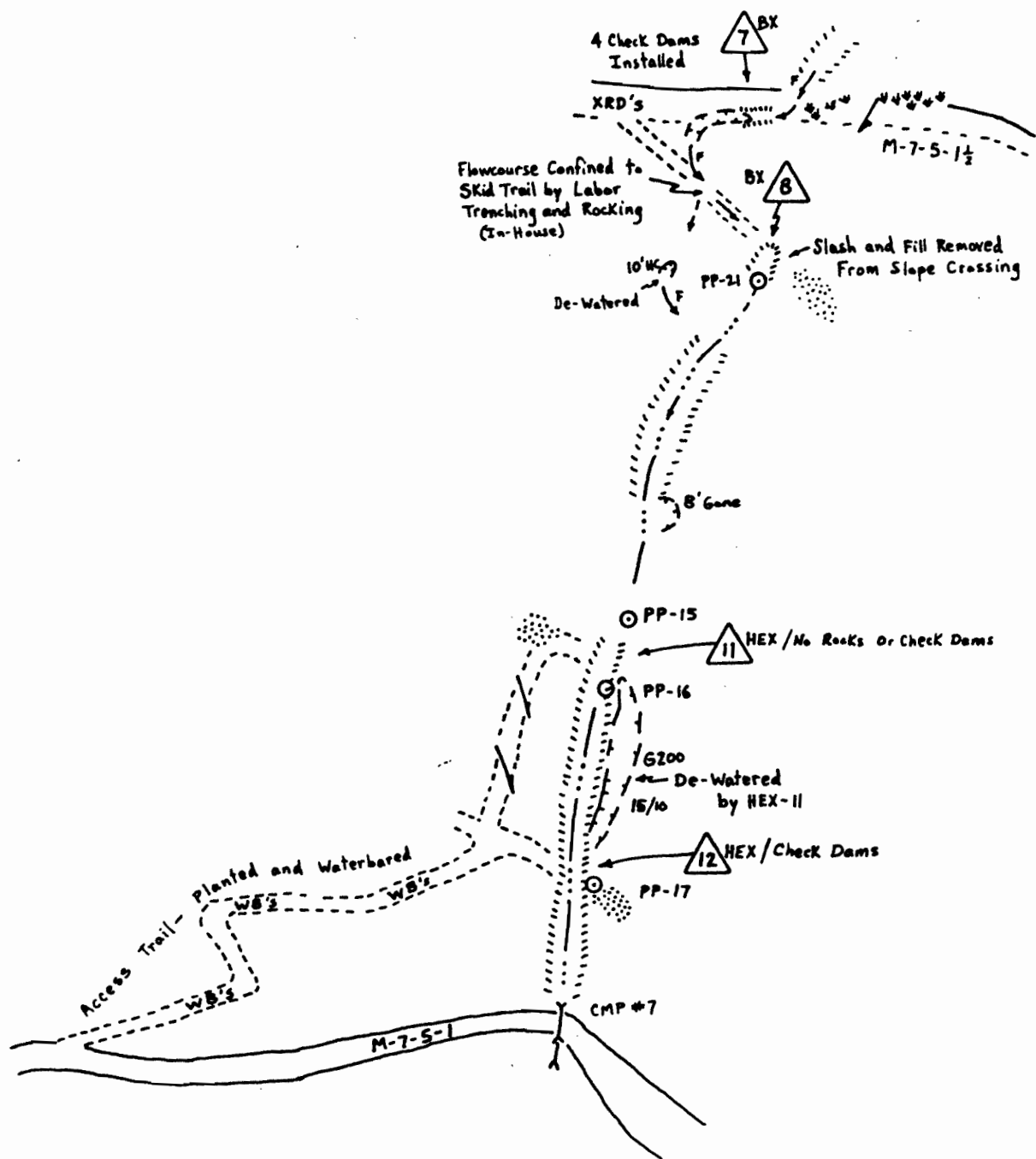


Figure 6. Geomorphic Features: Sites 7, 8, 11, and 12

Site 9

Heavy Equipment Work: A landing on the M-7-5-1 1/2 Road was excavated by crane. A stream crossing for a channel draining about 10 acres was excavated into the south end of the landing and the edge of the rest of the landing was pulled back. Fill was spread locally by tractor. Volume of crossing = 600 cubic yards. Volume of rest of excavation = 560 cubic yards.

Secondary Treatments: The stream channel was excavated down to the original ground with high residual root strength so no secondary channel treatments were prescribed. The disturbed area of the landing (about an acre) was seeded, strawed and planted. A trench was dug by hand downstream from the landing in order to de-water a large gully. The left side slope of the channel excavation was covered with Curlex.

Photo Points: PP-8 on top of stump at downstream end of stream excavation and PP-9 on top of stump about 100 feet south of center of landing, upslope from stream excavation.

Equipment Costs:

Crane, 39.5 hours.....	\$3753.00
Tractor, 850 B, 21.1 hours.....	1160.00
Tractor, TD 15, 13.6 hours.....	544.00

Labor, contract:

Item 25, Trench to de-water headcut.....	81.00
Item 42, Spread 6 straw bales.....	50.76
Cover 1050 sq. feet of slope with Curlex.....	97.36
Plant 675 alder on crossing side slopes.....	121.94
Plant 780 mixed alder, fir and redwood on former landing	111.80

Curlex, 1.7 rolls.....	50.70
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Total Cost. \$5971.00

Site 10

Heavy Equipment Work: Two headcuts on a large gully upslope from Site 13, were to be pulled back and have check dams installed. Job was not done due to poor access and questionable cost-effectiveness.

Site 11

Heavy Equipment Work: Skid trail crossing of stream draining 61 acres was excavated by hydraulic excavator on 11 and 12 August. Fill was spread locally by tractor. Downstream end was left with a good base level on boulders and roots giving a low gradient reach.

Site 11 (cont.)

Secondary Treatments: This crossing was to be left unprotected as a control. However, the excavation and the early December storm triggered a headcut at the upstream end and energy dissipation was performed in-house. Side slopes were strawed and planted.

Photo Points: PP-15 on left bank, upstream end. PP-16 on left bank, downstream end on top of stump.

Equipment Costs:

Excavator, 8.5 hours.....	\$ 591.00
D-4 Tractor, 2.2 hours.....	70.00

Labor, in-house:

Two water bars on access trail.....	120.00
Headcut treatment with boards and stakes.....	320.00

Labor, contract:

Item 21, Transport and spread 2 straw bales.....	16.92
Plant 260 alder seedlings on side slopes.....	<u>39.00</u>

Total Cost... \$1157.00

Site 12

Heavy Equipment Work: Skid trail crossing of stream draining 61 acres (same as Site 11) was excavated by hydraulic excavator on 11 and 15 August. Fill volume = 390 cubic yards.

Secondary Treatments: 12 check dams with 5 1/2' X 1' spillways were installed in-house. 10 cubic yards of fill that could not be pulled back far enough from the excavation by the excavator were moved about 25 feet by labor contract. Both side slopes were seeded, strawed, fertilized, Curlexed, and planted with alder by contract.

Photo Points: PP-17, left bank, top of stump.

Equipment Costs:

Excavator, 14 hours.....	\$ 973.00
Tractor, D-4, spreading fill, 22.6 hours.....	723.00
Tractor, 850 B, winching large fir log from excavation.....	208.00

Labor, in-house:

Carry 24 large check dam boards and tools to site, 6 days....	480.00
Stake splitting and check dam construction, 26 days.....	2080.00
Channelize and stake springs and small flowcourses on side slopes of excavation, 3 days.....	240.00

Site 12 (cont.)

Labor, contract:

Item 20, Move 10 cubic yards of fill an average of 25 feet.....	\$ 363.40
Carry 3 straw bales to site and spread.....	25.38
Carry 2086 sq. feet of Curlex to site and spread on 1800 sq. feet of channel side slope.....	166.90
Plant 112 alder transplants at check dams.....	155.68
Item 33, Plant access trail with 600 mixed alder and fir.....	87.00
Curlex, 2.9 rolls.....	<u>86.90</u>
	\$5589.00

Site 13

Heavy Equipment Work: Backhoe trenched skid trail, 2' X 1' X 100' in order to capture flow and de-water headcut on the cut bank of the M-7-5 Road. This flow was directed toward the center of a natural swale immediately upslope from Culvert #4. Backhoe excavated a notch of about 10 cubic yards in the center of the swale and replaced locally derived boulders. An additional 5 cubic yards of imported rock were placed in channel. Some of the steeply perched fill was pulled back from the trash rack.

Secondary Treatments: Trench cleaned out by hand. A total of 10 cubic yards of rock placed in flowcourse.

Photo Points: None.

Equipment Costs:

Backhoe, 28.5 hours.....	\$ 924.00
Tractor, 16.9 hours.....	929.00
Rock, 10 cubic yards delivered, 5 cubic yards used.....	120.00

Labor, in-house:

Clean loose dirt out of backhoe trench, 1.5 days.....	<u>120.00</u>
Total Cost..	\$2093.00

Site 14

Heavy Equipment Work: Job not done due to poor access, skid trail too steep. Slash and fill in skid trail crossing is probably not very unstable anyway. 100 feet upstream from Site 13.

Photo Points: PP-13 on left bank, downstream end.

Site 15

Heavy Equipment Work: Partial excavation of road fill downstream from Site 12 was not excavated by crane due to the high cost of transporting the crane to site and due to the marginal benefit. M-7-5-1 Road is to be pulled in 1981 anyway.

Site 16

Heavy Equipment Work: Inboard ditch near culvert #6 was not enlarged due to plans for pulling the M-7-5-1 Road in 1981.

Site 17

Heavy Equipment Work: Culvert #5 in the M-7-5-1 Road was removed by hydraulic excavator de-watering a 1200 cubic yard gully. Flow is diverted into Culvert #4. The diversion at Site 5 reduced the flow to this inboard ditch.

Secondary Treatments: None.

Photo Points: None.

Equipment Costs:

Excavator, 8 hours (operator's first time using this piece)... \$ 556.00

Site 18

Heavy Equipment Work: A 24 inch culvert was installed in the M-7-5-1 Road in order to reduce the flow to culvert #2 and the gully associated with it. Flow is being added to a dormant gully, thereby indicating secondary treatment downslope. A sediment trap with about 3 cubic yards capacity was dug at the culvert intake.

Secondary Treatments: Trash rack and experimental energy dissipation at the upstream and downstream ends of the culvert were done in-house. Treatment of 525 feet of gully downstream was done by labor contract.

Photo Points: None.

Equipment Costs:

Excavator, 5 hours.....	\$ 347.00
Truck, deliver culvert, 1.6 hours.....	52.00

Labor, in-house:

Trash rack, 6 hours.....	48.00
Energy dissipation boards at bottom of downspout, 15 hours....	120.00

Site 18 (cont.)

Labor, contract: Items 1 through 8

Downspout installation.....	\$ 249.00
Removal of small fir log from gully.....	95.00
5 submerged spillways.....	239.00
4 energy dissipation mats, 96 sq. feet total area.....	407.00
15 check dams, 4' by 1' spillways.....	1706.60
20 linear feet of stream bank protection boards.....	231.00
Manual excavation of 18.3 cubic yards.....	444.60
224 alder transplants next to check dams and spillways.....	311.36

Total Cost... \$4252.00

Site 19

Heavy Equipment Work: Backhoe excavated skid trail crossing of stream draining 70 acres upslope from the M-7-5-1/2 Road. Tractor spread fill locally. An overflow channel onto this skid trail was responsible for about 150 cubic yards of gullying between this site and the haul road downslope.

Secondary Treatments: Due to boulders being exposed in the bottom of the excavation, additional bed and bank armoring were not prescribed. Both side slopes were planted with alder.

Photo Points: PP-5 upstream from excavation, left bank. PP-4 downstream from excavation, right bank.

Equipment Costs:

Backhoe, Case 680, 3.2 hours.....	\$ 178.00
Tractor, 4.2 hours.....	232.00

Labor, contract:

Item 34, 1200 alder seedlings on side slopes.....	180.00
300 mixed alder and redwood seedlings on access trail.....	43.50

Total Cost... \$ 634.00

Site 20

Heavy Equipment Work: A 6 foot headcut in a gully being treated to handle increased flow was pulled back. Backhoe assisted in check dam installation.

Secondary Treatments: 9 check dams were installed in the reach of the former headcut. Upstream, a diversion trench was dug to de-water an active gully to the south and to direct flow into the check dam reach. 2 headcuts were treated and waterbars were dug into the access trail.

Photo Points: PP-6 at the downstream end of the check dam reach on the right bank.

Site 20 (cont.)

Equipment Costs:

Backhoe, 9.5 hours.....	\$ 307.00
Tractor, access trail only, 1 hour.....	55.00

Labor, in-house:

7 check dams, 2 1/2' X 10" spillways, with assistance of backhoe, 2 days.....	160.00
2 energy dissipation structures under headcuts, 1 day.....	80.00

Labor, contract:

Items 16 and 17, 2 submerged spillways with alder transplants.	\$ 108.44
Item 18, 2 check dams and alder transplants for 9 check dams	211.08
150 alder seedlings on side slopes.....	22.50
Item 19, divert flow from culvert #6 with trench.....	97.00
Item 32, 2 waterbars and 200 mixed alder and redwood seedlings on access trail.....	93.26

Total Cost... \$1134.00

Site 21

Heavy Equipment Work: Excavation in gully downslope from the added culvert at Site 18 was accomplished by labor contract as listed under Site 18. Done by labor due to poor equipment access.

Site 22

Heavy Equipment Work: Haul road crossing of stream draining 23 acres excavated by crane. 1540 cubic yards of fill were removed, of which about 785 cubic yards were trucked to a landing about 250 feet to the south. Backhoe did final excavation in preparation for check dam installation.

Secondary Treatments: 7 check dams with 5' X 1' spillways were installed on the upstream end of the 70 foot long reach. The rest of the reach was treated with 20 cubic yards of rock placed by crane and by hand. Some of the steep side slopes were treated with boards and stakes used as retaining walls.

Photo Points: A sequence of photos before and during excavation was taken from two photo points. PP-2 on left bank at downstream end of excavation next to 4 foot live redwood tree. PP-22 on top of large stump about 100 feet north of excavation.

Equipment Costs:

Crane, 30 hours.....	\$2850.00
Tractor, 31.6 hours.....	1739.00
Backhoe, 16 hours.....	518.00
Dump Truck, 23.9 hours.....	784.00
Rock, 30 cubic yards delivered, 20 cubic yards recovered.....	360.00

Labor, in-house:

Deliver boards, 1 day.....	\$ 80.00
Split stakes, build 7 check dams, 15 days.....	1200.00
Construct 50 linear feet of retaining walls, 3 days.....	240.00
Arrange rock, 2 days.....	160.00

Labor, contract:

Item 36, 3000 alder seedlings on side slopes.....	571.18
64 alder transplants next to check dams	88.96
Apply 7128 sq. feet of Curlex to 6150 sq. ft. of slope	570.23

Curlex, 9.9 rolls.....	297.00
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Total Cost.. \$9458.00

Site 23

Heavy Equipment Work: Haul road crossing of stream draining 72 acres excavated by crane. 530 cubic yards of fill were removed and spread locally by tractor. Backhoe prepared bed for placement of rock.

Secondary Treatments: 25 cubic yards of rock placed by clamshell and by hand. Both side slopes strawed and planted. Left slope treated with Curlex.

Photo Points: PP-3 at top of right bank, downstream end.

Equipment Costs:

Crane, 18.5 hours.....	\$1757.00
Tractor, 16 hours.....	880.00
Backhoe, Case 680, 6.4 hours.....	357.00
Rock, 25 cubic yards recovered from 30 cubic yards delivered..	360.00

Labor, in-house:

Placing rock, 3 days.....	240.00
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Labor, contract:

Item 37, Apply 927 sq. feet of Curlex to 800 sq. feet of slope	74.18
Plant 2700 alder seedlings.....	420.76

Curlex, 1.3 rolls.....	38.60
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Total Cost... \$4128.00

Site 24 (2 crossings, north and south)

Heavy Equipment Work: Two haul road crossings about 100 feet apart were excavated by crane. The drainage areas of the north and south streams were estimated to be 7 acres and 45 acres from aerial photos. However, drainage areas may not differ by this much due to ambiguity of the divide. Excavated volumes equal 160 and 300 cubic yards.

Site 24 (2 crossings, north and south - cont.)

Secondary Treatments: 10 cubic yards of rock placed in each crossings. 1350 and 1400 alder seedlings in the north and south crossings. Curlex applied to the left side slope of the north crossing and to both side slopes of the south crossing.

Photo Points: None.

Equipment Costs:	24S	24N
Crane, 15 hours, 10.5 hours.....	\$1425.00	\$ 998.00
Tractor, 6.5 hours, 5 hours.....	358.00	275.00
Backhoe, 5 hours, 5 hours.....	162.00	162.00
Rock, 20 cubic yards.....	120.00	120.00
Labor, in-house:		
Placing rock, 1 day each.....	80.00	80.00
Labor, contract:		
Items 38 and 39, Curlex side slopes.....	132.13	30.13
Plant alder seedlings.....	238.08	208.90
Curlex, 2.8 rolls.....	<u>68.90</u>	<u>15.70</u>
Total Cost..	\$2584.00	\$1890.00

Site 25

Heavy Equipment Work: Haul road crossing of stream draining 49 acres was excavated by crane. About 1070 cubic yards were removed, most of which was trucked to the north end of the M-7-5-1/2 Road in order to build up the inboard edge and give the road a slight outslope. This hauling of the fill replaced the job that was originally identified as Site 29.

Secondary Treatments: 15 cubic yards of rock placed by crane and positioned by hand. Both side slopes were planted and treated with Curlex.

Photo Points: None.

Equipment Costs:	
Crane, 24.5 hours.....	\$2328.00
Backhoe, 6.9 hours.....	222.00
Tractor, 850 B, spreading fill, 31.6 hours.....	1739.00
Dump Trucks, 14 hours total.....	463.00
Tractor, TD 15, 5.8 hours.....	230.00
Rock, 15 cubic yards.....	180.00
Labor, in-house:	
Rocking, 2 days.....	160.00

Site 25 (cont.)

Labor, contract:

Item 40, Spread 2550 sq. ft. of Curlex on 2200 sq. ft. of slope. \$ 203.98
Plant 2350 alder seedlings on side slopes..... 395.85

Curlex, 4.1 rolls..... 123.20

Total Cost... \$6045.00

Site 26

Heavy Equipment Work: Cross road drain dug by backhoe, rocked with 5 cubic yards of rock.

Equipment Costs:

Backhoe time lumped with XRD construction along the M-7-5-1/2 Road.

Rock, 5 cubic yards..... \$ 60.00

Total Cost.. \$ 60.00

Site 27

Heavy Equipment Work: Backhoe excavated trench 4' X 1' X 100' to divert flow away from a headcut on the M-7-5 Road cut bank and onto a lower gradient slope. There is increased flow in this gully reach due to culvert installation at Site 18.

Secondary Treatments: None.

Photo Points: None.

Equipment Costs:

Tractor, access trail, 1.6 hours..... \$ 87.00

Backhoe, 2.8 hours..... 89.00

Labor, in-house:

Clean trench by hand, 6 hours..... 48.00

Total Cost... \$ 224.00

Site 28

Heavy Equipment Work: Headscarp in the M-7-5 Road was to be de-watered by excavating a trench and backfilling with pea gravel. Job not done.

Site 29

Heavy Equipment Work: Job of shaping the north end of the M-7-5-1/2 Road was done with fill from Site 25.

Site 30

Heavy Equipment Work: Job of repositioning 30 inch culvert into the center of the stream declivity was not done.

Site 31

Heavy Equipment Work: A 120 foot long culvert was added to the M-7-5 Road in order to partially de-water a culvert downslope that is responsible for about 1450 cubic yards of gullying (average gully cross section of 10.7 sq. ft., 3650 ft. long). The drainage area to the problem culvert was reduced from 26 acres to about 2.5 acres. The new culvert discharges onto a slope of 25% which has a dense ground cover of whipplea and aerially seeded fir.

Secondary Treatments: Trash rack, downspout, sediment trap and diversion ditch were added.

Photo Points: None.

Equipment Costs:

Excavator, 12 hours (40" X 9' X 100' trench).....	\$ 834.00
Backhoe, 3.2 hours.....	103.00
TD 15 Tractor, 1 hour.....	42.00
Park-owned backhoe, re-grade settled fill and clean out sediment trap around trash rack, 4 hours.....	

Labor, in-house:

Construct trash rack, 10 hours.....	80.00
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Labor, contract:

Item 24, Downspout installation.....	97.00
Sediment trap below downspout.....	158.00
Trench, 102 cubic feet.....	91.00
Bank protection, 6 linear feet.....	69.30

Total Cost.. \$1475.00

Site 32

Heavy Equipment Work: Gully sides were pulled back by backhoe. This gully, which was partially de-watered by the culvert installation at Site 18, had already eroded as much as 100 cubic yards and was still very active.

Secondary Treatments: Several cubic yards of local rock were placed by backhoe and by hand. Four check dams with 4' X 10" spillways were installed.

Equipment Costs:

Backhoe, 9.5 hours.....	\$ 307.00
Tractor, access trail, 1.6 hours.....	87.00

Labor, in-house:

Clean loose debris from excavation, rocking, install 4 check dams, 12 days.....	<u>960.00</u>
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Total Cost.. \$1354.00

Site 33

Heavy Equipment Work: Approximately 140 cubic yards of fill was excavated from a haul road crossing of the M-7 Road from which about 30 cubic yards had already failed. Fill was spread locally by tractor.

Secondary Treatments: A few cubic yards of rock were placed on the left bank at the site of a spring. Armoring of the bed and banks was not prescribed due to a low gradient reach with a good base level control.

Photo Points: PP-1 upstream from crossing, left bank, top of stump.

Equipment Costs

Backhoe, 25.1 hours.....	\$ 813.00
Tractor, 17.9 hours.....	985.00

Labor, contract:

Item 46, 1300 alder seedlings planted on side slopes.....	<u>195.00</u>
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Total Cost... \$1993.00

Labor Contract Items not included under heavy equipment worksites:

Item 9: Gully upslope from equipment site 18

Submerged spillway	\$ 43.10
Energy Dissipation, 25 sq. ft.	106.00
Excavate 50 cu. ft. from gully	99.00
Install 12 ft. flow deflector board	130.00
Backfill de-watered gully with 10 cu. ft. of fill	24.00
Alder transplants at submerged spillway, 8	11.12

After a headcut slump the following items were added:

Excavate 27.5 cu. ft. from around SS-6	24.75
Remove submerged spillway and splashboard and re-install submerged spillway 3 feet upstream	17.00
Construct flume	272.00

Items 10 & 13: Gullies upslope from equipment site 18

Install 4 submerged spillways	172.40
Install 4 energy dissipation mats, 72 sq. ft. total	305.28
Plant 8 alder transplants at each submerged spillway	44.48

Item 15: Submerged spillway, energy dissipation and alder trans. 122.06

Items 28-31:

Install 4 waterbars on 2 skid trails about 500 feet south of equipment site 9, average 17 ft. long	208.08
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Item 35: Deleted from contract, work included under amended item 23,
site 7.

Item 47: Ripped roads

Plant 3.9 miles of ripped road surface with 9000 mixed redwood and fir seedlings, 8 ft. spacing	1,260.00
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Item 48: Gully upslope from equipment site 18

2 waterbars to partially de-water gully	99.45
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Item 49: Wet area above cut bank, SE of equipment site 18

2 waterbars to drain groundwater discharge	48.96
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Item 50: Cross road drains

Plant 714 alder seedlings in 13 cross road drains	107.10
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Administrative charges due to contract amendments:

20 person hours at \$17 per hour	340.00
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Haul Road Treatments (except excavated crossings)

M-7-5-2, M-7-5-1 1/2, M-7-5-1/2; 3.9 miles fully ripped and drained.

	<u>Total</u>	<u>Unit</u>
Remove 25 CMP's by backhoe and truck	\$ 1,337	\$53.50 each
Rip, D-8	1,160	\$297/mile
Shape one landing (M-7-5-2), D-8	376	\$376/each
Shape, WB, XRD; Mainly backhoe and tractor . . .	13,980	\$3,585/mile ₁
Strawing, seeding and fertilizing by Redwood United, supervised by in-house vegetation technicians (includes hourly wage of supervisors).	482	\$124/mile
Plant 9,000 mixed fir and redwood seedlings at 8 ft. spacing - labor contract	1,260	\$323/mile
Plant 714 alder seedlings in 13 cross road drains	107	\$8/XRD
Open Access, maintain	1,054	\$270/mile
Total for full treatment	\$19,756	\$5,066/mile

M-7, .3 miles partially treated

Open access	\$116	----
Remove 1 CMP	69	----
WB's and XRD's (14)	273	20/each
Total for partial treatment	\$458	\$1,375/mile

M-7-5 and M-7-5-1, 3.0 miles, remains open

Break through berm at about 100' intervals, by tractor	\$1,245	\$415/mile
Clean out inboard ditch, other maintenance . . .	458	153/mile

M-7-5-2 access road, unnumbered, .7 miles, remains open

Construct and maintain 7 WB's	738	105/each
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Total Cost of Haul Road Treatments	\$22,700
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1 157 cross road drains and waterbars

Skid Trail Treatments

	<u>Total</u>	<u>Unit</u>
48 WB's by tractor and backhoe on 6,750 ft. of trails, not counting WB's on access trails to work sites	\$1,451	\$30/each
8 WB's by in-house labor, 48 hours at \$8/hr . .	384	48/each
12 WB's by contract labor, average 1.8 sq. ft. by 16.2 ft. long, \$1.53/cu. ft.	535	45/each
Cleaning 25 equipment WB's by hand, 32 hrs at \$8/hr.	256	10/each
Total Cost for 68 Waterbars	\$2,656	\$39/each

Check Dams (costs exclusive of salvage and milling)

A) Single Board Dams

Sites 7 and 20, 11 dams, 80 in-house person hours plus 7.3 hrs. backhoe, does not include ED	\$408	\$37/each
Site 32, 4 check dams, cost not itemized Labor contract, 27 dams	\$1,817	\$67/each

B) 2 and 3 Board Dams

Site 5, 13 dams, in-house	\$2,912	\$224/each
Site 12, 12 dams, in-house	2,016	168/each
Site 22, 7 dams, in-house	1,008	144/each

Rock and Stake Bed and Bank Protection

Site 5, first size rocks available within 100 ft. A 49 ft. reach was treated with a 5 ft. width of rocks and stakes	\$2,940	\$12/sq. ft. 60/lin. ft.
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Bank Retaining Walls

Site 22, 50 linear ft., 1 ft. high, with redwood stakes	\$240	\$4.80/lin. ft.
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Excavation of Fills does not include all of the smaller excavated fills.

<u>Site</u>	<u>cu. yds.</u>	<u>Excavation Cost</u>	<u>\$/cu. yard</u>
3	100 ₁	\$ 556 hex	\$5.56
5	1170 ₁	3985 crane, tractor, hoe	3.41
9	1160 ₁	5457 crane, tractor	4.70
12	390 ₁	1904 hex, tractor	4.88
19	170 ₁	410 large hoe, tractor	2.41
22	(1540 ₁) 998 ₂	5891 crane, tractor, truck, hoe	3.83
23	530 ₁	2994 crane, tractor, hoe	5.65
24S	(420 ₁) 297 ₂	1945 crane, tractor, hoe	6.55
24N	160 ₁	1435 crane, tractor, hoe	8.97
25	(1070 ₁) 1166 ₂	4982 100% end-hauled	4.27
33	140 ₁	1798 hoe, tractor	12.84
Total	6138	\$31,357	Avg. \$5.11/cu.yd.

1. Rough survey with tape and clinometer
2. Survey by tag line, rod, and clinometer

Rocking

Total rock from M-6-1 rock pit, 130 cu. yds. Cost per yard,
sorted by backhoe and 955 loader plus delivery to site \$12/cu. yd.

Secondary Treatments of Excavated Stream Crossings

<u>Site</u>	<u>Rock Delivery</u>	<u>Rock Application</u>		<u>Check Dams</u>	<u>Mulching and Planting Sideslopes</u>	<u>Other</u>
		<u>Equipment</u>	<u>Labor</u>			
1		\$60	\$48		\$29	
2	\$120	90			30	
3	180	120	10			
5				\$3680	626	\$960
8					180	
9					270	
11					56	320
12				2560	348	240
19					224	
22	360	270	160	1280	1527	240
23	360	270	240		534	
24N,S	240	200	160		694	
25	180	200	160		723	
33					195	
Totals	\$1440	\$1210	\$778	\$7520	\$5556	\$1760

Grand Total of Secondary Treatments at Stream Crossings = \$18,264

1. Does not include rock found locally.

Cost Effectiveness

In this section an attempt is made to estimate the cost effectiveness of some specific treatments. The preceding sections on haul road treatments, skid trail treatments, check dams, excavation of fills, etc. give the unit costs of a wide variety of rehabilitation treatments. While these figures are useful for comparing similar treatments performed by different means and on different sites, they do not contain any explicit information about erosion control effectiveness. This aspect of cost effectiveness can be defined as cost per unit of erosion prevention in terms of dollars per cubic yard and is most useful for ranking different treatments according to their erosion control effectiveness. However, it is recognized that a high cost per unit of erosion prevention should not necessarily be used as a criterion for eliminating a specific type of treatment and that other factors such as aesthetics are important aspects of rehabilitation in a National Park.

Three major categories of erosion control on this site were: 1) de-watering of active gullies; 2) excavation of stream channel fills; and 3) armoring of the beds and banks of freshly exposed channels by mulching, planting, rocking, check damming, etc. Examples of each of these types of treatments are given and estimates of their cost per unit of erosion prevention are made below.

1. De-watering of Active Gullies

Sites 2 and 31 involved essentially totally de-watering 6,000 feet of gullies which carried runoff draining 14 and 24 acres respectively. It is estimated that 3,100 cubic yards of soil had been eroded by these gullies as of the spring of 1981. The presence of vertical, unvegetated banks, and headcuts up to 10 feet deep at regular intervals indicated the potential for continued extensive soil erosion over the next decade or more. The 17 headcuts in the two gully systems and the high probability for future avulsions¹ in the gully treated by site 31 were particularly strong indicators of future gully

¹The spontaneous abandonment of one segment of a gully and initiation of a new gully segment during storm runoff.

enlargement. Estimates of non-treatment erosion scenarios are based on bank sloughing back to 100 percent side slopes, upstream migration of active head-cuts for a distance of 50 to 150 feet, and an enlargement in bed width to 5 feet. These estimates are 2,100 cubic yards and 4,700 cubic yards for the gullies de-watered by sites 2 and 31 respectively. Assuming that the diversion of flow associated with site 31 does not cause additional gullying, these erosion potential estimates yield a cost effectiveness of \$1874 for 6,800 cubic yards of erosion prevention, or 28 cents per cubic yard (19 and 31 cents per cubic yard respectively, for the two sites).

2. Excavation of Stream Channel Fills

By assuming a complete failure of road or skid trail fill over a period of decades one can make a simple estimate of potential erosion from stream crossings, had they not been excavated. The volume excavated from a channel is an index of the amount of erosion that would have eventually occurred. However, side slopes were excavated to about 55 percent compared with natural channel side slopes which are 70 to 100 percent adjacent to first order tributaries in this area. Potential erosion can then be determined to be about 70 percent of the volume that was excavated, assuming that the excavation is a good mimic of the original channel geometry. Using these criteria and the volume estimates on page 39, the cost effectiveness of the stream fill excavations is calculated to be \$31,357 for 4,297 cubic yards of erosion prevention or an average cost of \$7.30 per cubic yard saved. This is considered to be a conservative overall estimate since it does not account for potential flow diversions by inboard ditches and the initiation of new gully systems as a result. The actual cost of these excavations per cubic yard saved is therefore considered to be somewhat less than \$7.30.

3. Armoring of Excavated Beds and Banks

The beds and banks of fourteen excavated stream crossings were treated to reduce erosion from freshly disturbed soil by the methods shown on page 40. While all of these secondary treatments reduce erosion and most are considered well justified, their costs per unit of erosion prevention are high. The main benefits of such treatments are expected to be noticeable within the first decade after rehabilitation, after which time they would be nearly indistinguishable from sites with no secondary treatments. This assumes excavation down to the location of the original channel thalweg and assumes that natural boulders

or bedrock would be exposed after a few feet (or less) of downcutting. While this is considered applicable on almost all streams on this site, it might not apply to slopes with thick earthflow or other unconsolidated deposits in which pre-logging channel stability was provided by roots and buried logs.

A total of \$8,160 was spent installing 46 check dams (page 38) compared with \$3,428 developing, delivering, and applying 130 cubic yards of rock. The effectiveness of check dams is particularly dependent upon the magnitude of the storm for which they are designed, whereas rocked reaches are not so vulnerable to complete failure. The table below shows estimates of the design storms for the check dam reaches, as well as 10 and 25 year storm flows in stream reaches without check dams. Check dams at sites 7 and 12 appear to have been underdesigned based on this analysis since there is a virtual certainty of their capacity being exceeded within the life of the redwood boards ($P = .97$ in a 5 year period). The most effective way to remedy this situation would probably be to increase the spillway heights. For example, the capacity of the site 12 check dams could be increased to the 25-year storm by raising the spillway heights by 6 inches.

The haul road crossing at Site 7 (figure 6, p. 23) was treated by attempting to stabilize the present, diverted channel with rocks and check dams instead of by excavating the road fill from the original thalweg. This treatment was prescribed before the magnitudes of the 10 and 25 year peak flows were calculated. It is now apparent, that the check dams and the diverted channel are not designed to contain the flows with a recurrence interval of much more than two years. This will almost certainly lead to reactivation of a ten foot headcut with an ultimate sediment yield of up to 170 cubic yards. This site could have been more effectively treated by re-establishing the natural channel gradient, especially considering the lesser need for labor intensive work associated with de-watering the headcut and skid trail compared with armoring them. This is a good example of a site where treatment might have been more effectively prescribed, had the rational method for peak flow estimation been implemented earlier.

Site	Drainage Area (acres)	Spillway Width/Depth (feet)	Spillway Capacity (cfs)		Peak Runoff (cfs) with		Approximate Design Storm
			at Approach 3 ft/sec.	Velocity 5 ft/sec.	Recurrence Interval 10 yr.	25 yr.]	
1	19	2 cu. yds. local rock			11 cfs	14 cfs	
2	14	10 cu. yds. rock added			8	10	
3	25	15 cu. yds. rock added			14	18	
5	19	5/1	19 cfs	26 cfs	11	14	50 yr.
7	51	2.5/.8	7.6	10	28	37	2
8	59	Not armored			33	42	
9	10	Not armored			6	7	
11	62	Headcut only, treated			34	45	
12	65	5.5/1	21	28	36	47	2
18	10	4/1	15	20	6	7	50+
19	70	Not armored			39	50	
20	18	2.5/.8	7.6	10	10	13	10
22	23	5/1	19	26	13	17	25
23	71	Natural rock plus 25 cu. yds.			39	51	
24S	45	10 cu. yds. rock added			25	32	
24N	7	10 cu. yds. rock added			4	5	
25	49	15 cu. yds. rock added			27	35	
26	12	5 cu. yds. rock added			7	9	
31	24	Not armored			13	17	
32	13	4/.8	12	16	7	9	50
33	69	Not armored			38	50	

1. Based on Nugent, R.M., 1972, Rainfall Frequency in Humboldt Co., CA., M.S. thesis, H.S.U. and rational formula with runoff coefficient at .40, $T_c = 10$ minutes.

Expected 10 and 25 Year Peak Flows at Stream Crossings in Site 80-6

The cost effectiveness of rocks, check dams, and other secondary treatments is hypothesized by envisioning erosion with and without such treatments. On this unit it is estimated that downcutting would average 2 to 3 feet at most, without rocking or check damming and average lateral erosion would probably not exceed 5 feet due to wide channel bottoms. The effect of not mulching and planting channel side slopes is based on an assumption of an average difference in soil loss between treatment and non-treatment of 1/2 inch. The cost effectiveness of rock and check dams are not listed for individual sites because of their highly subjective nature. The average costs per yard saved, however, are estimated to be \$45 for rocking, \$70 for check damming, and \$80 to \$160 for mulching and planting side slopes (depends on mulching method).

CONCLUSION

Estimations of the unit costs and cost effectiveness of different treatments are considered an important step in improving the methodology of erosion control work in the Park. These indicate a range of up to three orders of magnitude in the cost per unit volume of erosion prevention by different treatments applied at a single site, such as a stream crossing. However, it is not suggested that treatments with a high cost per unit volume of erosion prevention necessarily be avoided since there is, not yet, an established cost effectiveness threshold, below which possible treatments are excluded from prescriptions. Rather, such an analysis identifies those treatments that are particularly cost effective and implies techniques for improving overall cost effectiveness in the future. For example, it is more beneficial to reconstruct the gross geometry of a channel that has been bridged with fill than it is to try to armor an inadequately excavated channel with check dams. In general, any heavy equipment work that reduces the amount of labor intensive work required at a site improves the cost effectiveness. This does not necessarily mean that there will be a reduction in the overall number of person hours available to workers but does have the potential to increase worker satisfaction and efficiency by reducing the time spent at repetetive tasks and by increasing the variety of labor intensive work sites.

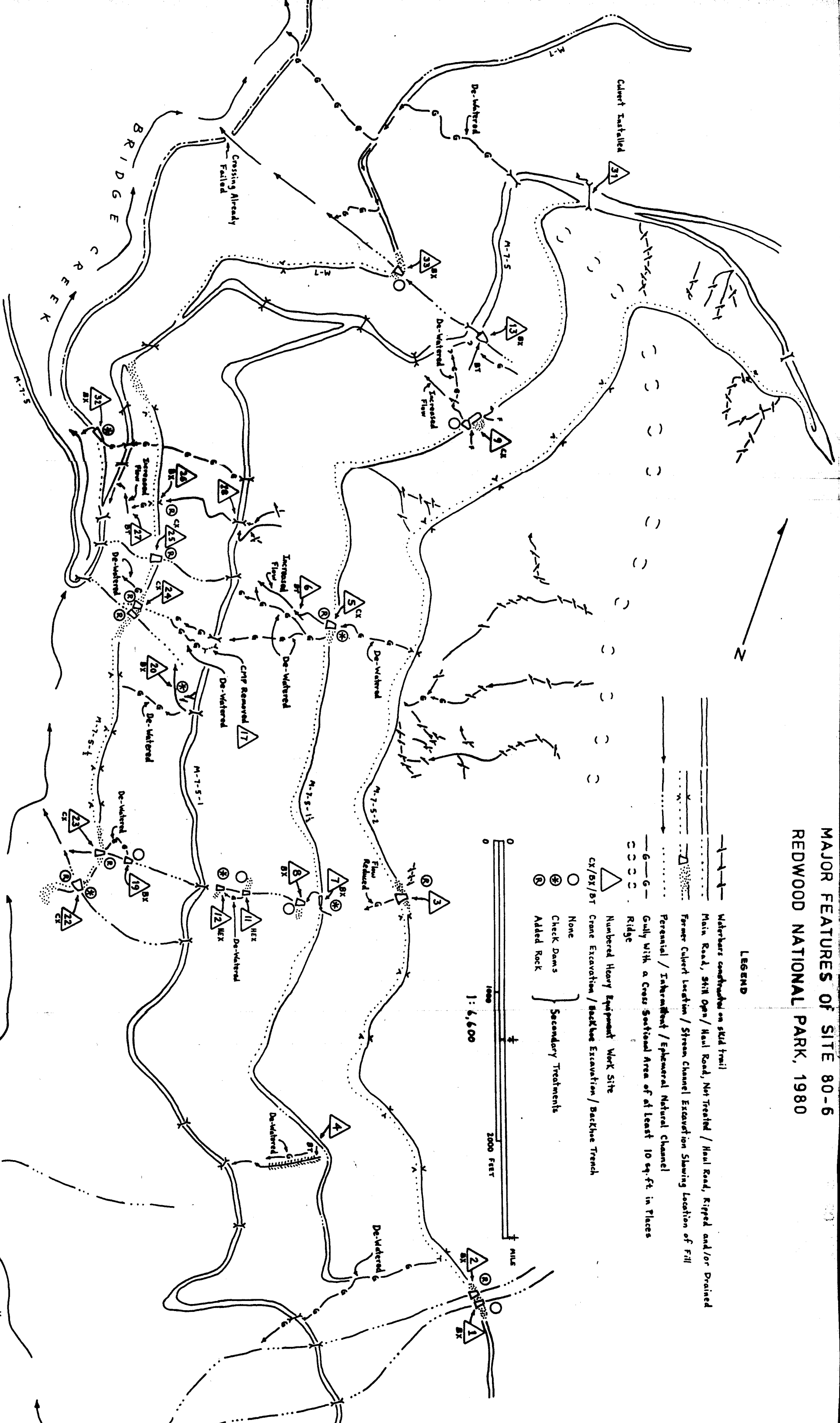
The Park now has access to a wide variety of heavy equipment and labor intensive erosion control techniques. Furthermore, the relative cost effectiveness of these treatments have been estimated. The greatest room for improvement now lies in the methods by which these treatments are prescribed. These methods include such elements as: 1) incorporation of cost analysis information from past rehabilitation work into prescriptions for and supervision of the current year's work; 2) evolution and clarification of rehabilitation goals with respect to aquatic and riparian habitat from the mouth of Redwood Creek to the smallest tributaries; 3) incorporation of information on sediment routing within the basin into site selection and prescription methodologies as it becomes available; and 4) the establishment of guidelines for possibly allowing short term, low magnitude sediment yield as an alternative to the performance of some secondary treatments with poor cost effectiveness.

The value of detailed mapping (1:1,800) of geomorphic and hydrologic features during the rainy season is considered critical to a sound formulation of prescriptions for a given area. However, smaller scale (1:6,000) mapping for reconnaissance purposes also proved useful this year as part of the site selection process. This scale of mapping is ideal for locating culverts, larger drainages, and major erosion features. It can aid in determining what boundaries should be placed on the larger scale maps and can clarify the process of choosing one site over another for treatment in a given year. The resource management geologist should not overlook the importance of such reconnaissance level mapping as part of his or her overall prescription methodology.

MAJOR FEATURES OF SITE 80-6 REDWOOD NATIONAL PARK, 1980

LEGEND

- +—+— Waterbars constructed on skid trail
- ==== Main Road, Still Open / Haul Road, Not Treated / Haul Road, Ripped and/or Drained
- Former Culvert Location / Stream Channel Excavation Showing Location of Fill
- Perennial / Intermittent / Ephemeral Natural Channel
- G—G— Gully with a Cross Sectional Area of at Least 10 sq ft in Places
- Ridge
- △ Numbered Heavy Equipment Work Site
- △ CX/BX/BR Crane Excavation / Backhoe Excavation / Backhoe Trench
- None
- ⊕ Check Dams
- ⊙ Added Rock
- } Secondary Treatments





Unit: 80-6 PP#8 6/24/80 P.T.



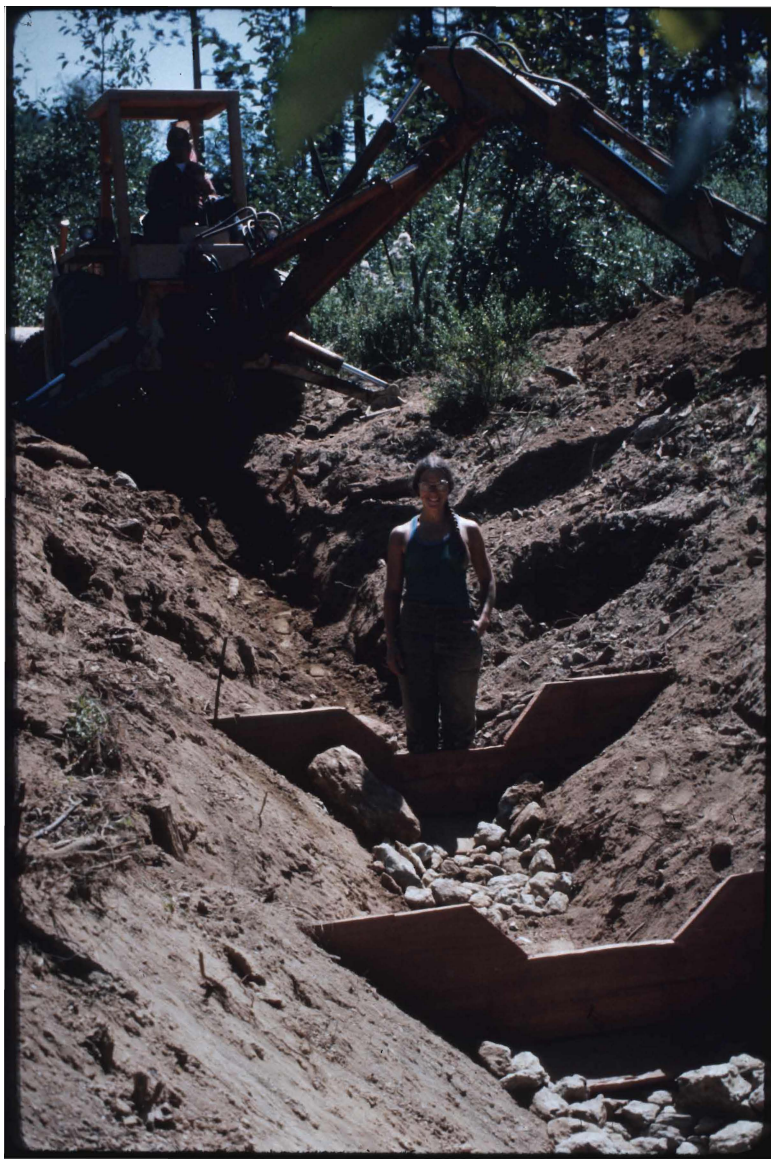
Unit: 80-6 PP#8 10/27/80



Unit: 80-6 PP#8 8/17/82



Unit: 80-6 Checkdams 3/27/84



Unit: 80-6 Site 20 8/18/80



Unit: 80-6 PP#7 Gully at culvert outlet, Pre H.E. 1980



Unit: 80-6 PP#17 sx-4 8/17/82



Unit: 80-6 PP#17 Site 12. 2/17/81



Unit: 80-6 PP#12 12/4/80