

**M-3-1 ROAD AND SLOPE
WORK AND COST SUMMARY REPORT
WATERSHED REHABILITATION UNIT 83-2**

December 1983

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**REDWOOD N. P.
LIBRARY
South Operations Center**

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INTRODUCTION

The M-3-1 Rehabilitation Unit, 83-2, is located on the west side of Redwood Creek, roughly 16 miles upstream from Orick. The unit encompasses 470 acres of the eastern headwaters of Bridge Creek (refer to Map A). The unit is bordered on the south (upslope) by the Devils/Bridge Creek divide, on the east by Rehabilitation Unit 81-4, on the west by a broad, poorly defined drainage divide within Bridge Creek, and on the north by Rehabilitation Unit 83-3.

On this unit, hillslope relief ranges from 1,500 feet near the downslope boundary to 2,610 feet on the Devils/Bridge Creek divide. The rehabilitation work concentrated on the slopes below 2,300 feet. Hillslope gradients vary considerably, averaging 65 percent and ranging between 15 and 110 percent. Average hillslope gradients above the M-3-1 increase considerably from west to east. In drainages 8 through 11 slopes average 25 percent; in drainages 1 through 5 the average gradient is 70-85 percent. In general, hillslope gradients between drainages are convex, and become concave within the drainages. However the basin containing drainages 6 - 10 exhibits hummocky earthflow topography. The M-3-1 unit contains all first order streams. They have steep profiles, are shallowly to moderately incised, and are controlled by organic debris.

This rehabilitation unit lies within the schist unit of Redwood Creek. The schist displays intense shearing, and complex folding and faulting. Soil types and depths vary considerably within the unit. Lacks soils are commonly found on very steep, dry, forested slopes and narrow ridgelines. Copper Creek and Slide Creek soils are found on dry, moderately steep, forested slopes. Devils Creek soils are found on wet hillslopes and inner gorge positions along the Bridge Creek lineament on sheared schist. The Bridge Creek lineament may influence hillslope stability in this area, and appears to fork following drainages 4 and 5 (and possibly drainage 7). (Jim Popenoe has complete soils mapping.)

The mapped rehabilitation unit contains two major haul roads and one major skid road. Both the M-3-1 and M-3-1-2 traverse the unit nearly along contour. The M-3-1-2 contours Bridge Ridge at an elevation of 2,300 feet and extends around the nose along the Redwood Creek side and ends in the Devils Creek basin at the M-2 haul road. The M-3-1 contours Bridge Ridge at an elevation of 1,900 feet and becomes the M-7-5-2 which was rehabilitated in 1981. (Unit 81-4). The M-2 1/2 (a major skid road) runs along the south boundary ridge for approximately four miles before it intersects the M-3-1-2 near the nose of Bridge Ridge. Rehabilitation work in 1983 concentrated on the slopes below the M-3-1-2 and on 1.9 miles of the remaining 2.1 miles of the M-3-1 road, almost to the M-3-1-2 intersection.

(including the evaluation and documentation phases)
In summary, the total rehabilitation cost for the M-3-1 unit was \$ 151,740.04. Of this total, heavy equipment and labor intensive costs accounted for 84 percent and 8 percent, respectively. Primary treatments accounted for 76 percent of the total cost, while secondary treatments accounted for 6 percent.³ A total of 1.9 miles of haul road (M-3-1) was removed, involving over 16,019 yd³ of outsloped material. A total³ of 19,025 yd³ was excavated from eleven haul road stream crossings; and 2,935 yd³ from twenty-eight skid trail crossings. The grand total known cubic yards of material moved was 37,979!

* Refer to Table 2 (p.26) and Table 3 (p.27)

LAND USE HISTORY

Construction on both the M-3-1 and M-3-1-2 haul roads began in 1964, coinciding with the first logging in Rehabilitation Unit 83-2. By 1966, the M-3-1 had been built from the M-3 to beyond drainage 1, extending into what would become Rehabilitation Unit 81-4; the M-3-1-2 was built as far as drainage 2. By the following year, the M-3-1-2 was completed beyond drainage 1. In addition, the M-2 1/2 skid road along the ridge was built to beyond drainage 1.

Between 1964 and park expansion in 1978, 90 percent of the unit was logged, totaling 424 acres (refer to Map B). Seventy percent of this was tractor yarded, and 30 percent was cable yarded.

Most of the logging (80 percent or 345 acres) and virtually all of the tractor yarding (287 acres) occurred in a three year period following road construction (1964-1967). Tractor yarding was confined to slopes above the M-3-1. Two cable units (58 acres) below the road were also cut during this time. Following this were eight years with no timber harvest activity. Then in 1975 and 1976, the final two cable units (75 acres) were cut, along with a small (4 acre) tractor yarded area.

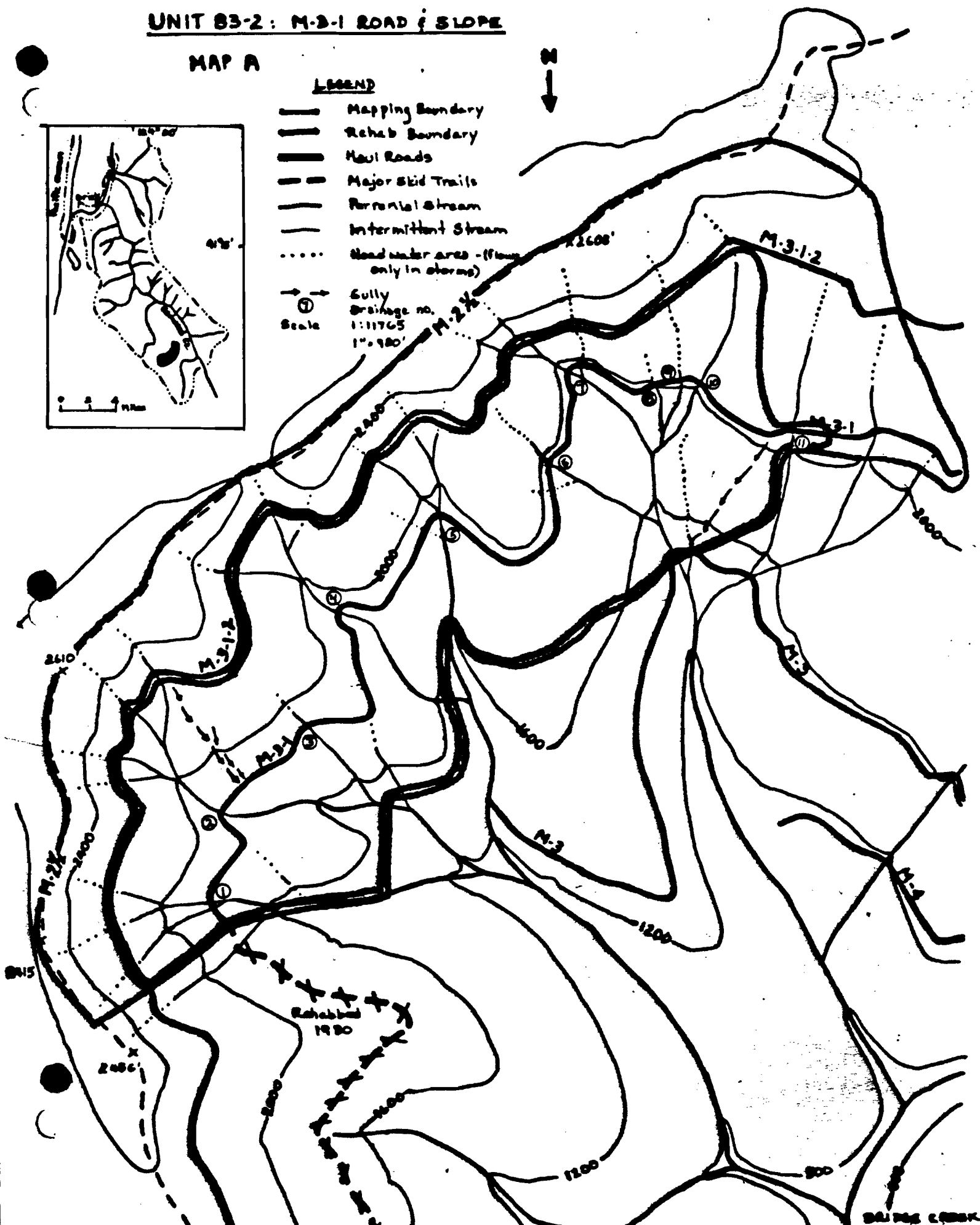
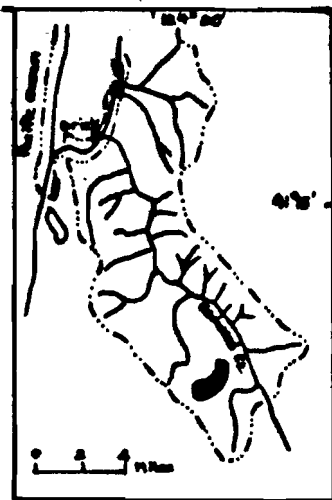
Only 46 acres of old growth remain on the unit in 2 small areas, known as the Terry Anne Spreiter Grove (drainage 7) and the Louise Evelyn Johnson Grove (drainage 4):

UNIT B3-2: M-3-1 ROAD & SLOPE

MAP A

LEGEND

- Mapping Boundary
- Rehab Boundary
- Haul Roads
- Major Skid Trails
- Perennial Stream
- Intermittent Stream
- Flood water area - (flow only in storms)
- Gully Drainage no.
- Scale 1:11765
1" = 980'



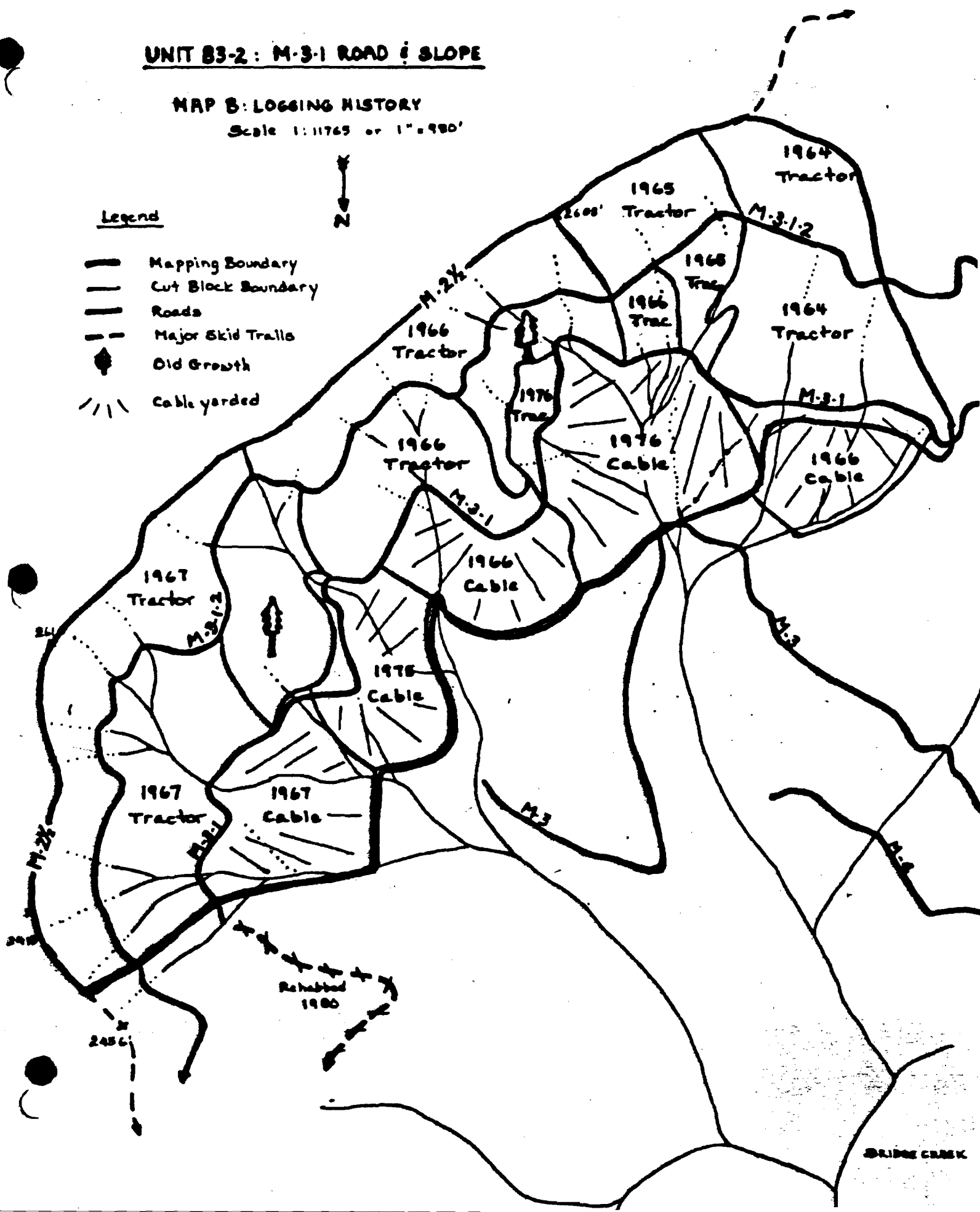
UNIT B3-2: M-3-1 ROAD & SLOPE

MAP B: LOGGING HISTORY

Scale 1:11765 or 1"=980'

Legend

-  Mapping Boundary
-  Cut Block Boundary
-  Roads
-  Major Skid Trails
-  Old Growth
-  Cable yarded



EROSION FEATURES

(Map C)

Major sediment sources on Unit 83-2_A are skid trail crossings, surface erosion on skid trails, mass movement features, and misplaced culverts for haul road stream crossings on the M-3-1. The history of erosion features on Unit 83-2 is incomplete due to the poor quality of air photos (scale 1:15,000 with long afternoon shadows) prior to 1973. All slope erosion features (skid trail crossing failures and diversion gullies, and skid trail surface erosion) above the M-3-1 have occurred prior to the 1973 air photos, with no significant change up to 1983. There are no indications that any of the haul road stream crossings on the M-3-1 have failed ~~been~~ construction in 1964, and 1983; a few misplaced culverts have caused gully erosion downslope.

There are a number of mass movements on the site, most of which have been active during the last two winters. Mass movements have sculptured these steep head-water slopes, and are a part of the natural processes in the area. However, road building and timber harvest have re-activated^{or initiated} a number of these features. In addition, much of the unit is near the age of minimum root strength, when man-induced mass movements are most likely to occur.

FLUVIAL EROSION

Fifty-three skid trail stream crossings were mapped within the tractor yarded portion of Unit 83-2 (Map C-1), with a density of one crossing per 2.4 acres (logged area between the M-3-1 and the M-3-1-2 haul roads totals approximately 125 acres). Remnant crossing fill roughly totaled 7,000 cubic yards, with approximately 600 cubic yards of fluvial erosion having occurred. Sixteen crossings had greater than 10 cubic yards of fluvial erosion, with the highest being 75 cubic yards at one crossing. Erosion activity was rated high, medium and low (for a Q_{25} event) at all 53 crossings: 33 crossings were rated low,

9 crossings had medium ratings, and 11 were rated high (see TAS and LEJ erosion potentials for 83-2).

Twenty-eight of these 53 skid trail crossings were removed, totaling 2,935 cubic yards of excavated material. Twelve had low erosion activity ratings, 8 had medium and 8 had high ratings. The 16 crossings with medium and high erosion activity ratings had active stream channel diversions, collapsing fill prisms, and/or outboard edge debris torrent potentials. Of the 25 skid trail crossings that remain on the Unit (Map C-1), 21 have low erosion activity ratings, 1 had medium rating, and 3 have high ratings. The one crossing with the medium erosion activity rating is located directly upslope of the R-10 "Glacier" earthflow, and consists entirely of logs which could deflect stream-flow causing side bank erosion at highflow. The three remaining crossings with a high erosion activity rating are located in headwater regions. Two have high debris torrent potentials (and are accessible from the M-3-1-2). The other crossing has a high erosion potential, although low sediment yield would result compared to other high-rated crossings.

Significant fluvial erosion has occurred on approximately 12,000 feet of skid trails within the unit, with an estimated 875 cubic yards eroded (mainly skid trails between the M-3-1 and M-3-1-2 haul roads). In addition to this, major gullies and stream diversions in drainages 2 and 5 amount to approximately 1,500 cubic yards of erosion.¹ The amount of fluvial erosion per acre of logged land between the two major haul roads and within the unit boundaries equals 24 cubic yards per acre (2,975 cubic yards divided by 125 acres):

Haul road stream crossings on both the M-3-1 and M-3-1-2 were not active sediment sources. There is no indication that any of these crossings have failed since their construction in the early 1960's. Small sediment source

¹ Footnote on p. 8

areas associated with a few of the haul road crossings on the M-3-1 were due to misplaced channel culverts. Three crossings (Rx-1, 3 and 8) had culverts misplaced 100-175 feet down the road, causing an estimated 250 cubic yards² of erosion. Two of these (Rx-1 and 3) have short diversions with the flow re-entering the drainage a few hundred feet downslope; one (Rx-8) is diverted out of its drainage, but with only minor erosion resulting. Another crossing with a misplaced culvert (Rx-11) caused major gully erosion, estimated at 3,000 cubic yards³. The flow was diverted out of its drainage, and discharged onto an earthflow slope. No obvious erosion occurred until 2 years after the earthflow slope was harvested (cable yarding was used), but now the presence of the gully has undermined portions of the slope, and may be re-activating the earthflow.

Potential erosion for all haul road crossings would have been failure of the culverts (due to ^{debris and/or} sediment plugging the inlets), with resulting overflow and gullying across the road prism. On Rx-2 and 4 this could have resulted in a major amount of erosion because the crossing road prism was composed entirely of clean fill with minimal amounts of organics, and the drainage areas are 49 and 50 acres, respectively. The remaining crossings had fill prisms consisting almost entirely of organics (many being 1 to 4 foot diameter logs) with the drainage areas ranging between 4 to 40 acres. It is likely that little erosion, proportional to the size of the crossing, would have occurred.

All haul road crossing culverts were correctly sized for a major storm event (Q_{25}), except the four crossings with misplaced culverts. The size of the inboard ditch and of the culverts down the road at these crossings could have carried the expected runoff, though the chance for failure along the way and resulting gully erosion were very high. Where misplaced culverts existed, the

^{2,3} Footnotes on p. 8

inboard ditch flow was adding to saturation of the road prism causing slumps to occur, and could have resulted in debris torrents down the steeper hillslopes. Also, where these roads were slumping, inboard ditch flow was being captured and sent across the road.

¹Gullies and Stream Diversion Volumes:

Rx-2 Drainage:

$$\begin{aligned} 2'/2' \text{ for } 700' &= 2,800 \div 2 \\ 40'/15' \text{ for } 100' &= 60,000 \div 2 \\ 7'/5' \text{ for } 75' &= 2,625 \div 2 \\ 4'/2' \text{ for } 350' &= 2,800 \div 2 (\div 27) \\ \hline &1,263 \text{ yd}^3 \end{aligned}$$

Rx-5 Drainage:

$$\begin{aligned} 3'/2' \text{ for } 500' &= 3,000 \div 2 \\ 8'/5' \text{ for } 200' &= 8,000 \div 2 \\ 6'/6' \text{ for } 100' &= 3,600 \div 2 (\div 27) \\ \hline &270 \text{ yd}^3 \end{aligned}$$

Rills and Gullies on 11,650 feet skid trail, with an average size of $2' \times 1' = 2 \text{ ft}^2$ (assume a square cross section) $= 23,300 \text{ ft}^3 \div 27 = 863 (875 \text{ yd}^3)$

²Rx-1 gully $4'/2'$ for 100' $= 15 \text{ yd}^3$

Rx-3 gully $15'/8'$ for 100' plus $3'/1'$ for 200' $= 233 \text{ yd}^3$

Rx-8 gully has minimal erosion.

³Volume 300' below M-3-1 $= 1,120 \text{ yd}^3$

Volume 550' above M-3 $= 1,210 \text{ yd}^3$

Volume in between estimated to be 750 yd^3 , based on size comparisons.

There are a few sediment source areas, along and above the M-3-1-2 with only minimal amounts of material being transported below the haul road. Active erosion is occurring on several skid trails where runoff has concentrated forming rills and small gullies, though the sediment is not being transported below the M-3-1-2 road. Several cutbanks have slumped onto the M-3-1-2 due to

seeps and rills upslope, with no erosional impact. Waterbars placed in 1981 along the entire length of the M-3-1-2 above Sites 81-4, 83-2 are the only significant sediment sources. The concentrated flow from these waterbars extends up to 300 feet downslope, causing small gullies (2/1 to 6/4) before the flow enters a stream channel.

On the slopes above the M-3-1-2 haul road, there are numerous skid trails that cut across the slope, intercepting ground water, and collecting surface flow. This water ponds in low areas on skid trails, saturating the fill and in several locations the skid trails have slumped. Fill failures will probably continue to occur.

There are two potential debris torrent zones associated with the M-3-1-2 haul road. One area is where the road crosses the headwaters of the Rx-4 drainage along steep slopes (80-90 percent) and no culverts exist (though waterbars were placed in 1981). The second area is a large complex skid trail crossing above the M-3-1-2 road (L.E.J.'s E.P. #30) located on the main tributary to Rx-7. The crossing fill has slumped up to 4 feet, with the potential to fail onto the haul road, and possibly causing the haul road to fail.

MASS MOVEMENTS

The headwaters of Bridge Creek are an inherently unstable area, sculptured by mass movement. The slopes are extremely steep, often 50-75%, and locally up to 110%. In many areas, especially lower on the slope, the bedrock is sheared black schist, with a veneer of Devils Creek soil. The Bridge Creek lineament(s) pass through the site, further weakening the rock. Road building and timber harvest have re-activated some dormant features and have caused a number of fill failures. Other mass movement features are still dormant, but renewed

activity is likely as cut blocks pass through the period of minimum root strength (10-20 years after harvest). In addition new mass movements may be initiated whenever the ground reaches saturation levels, given the right conditions.

Sixteen mass movements related to timber harvest activities were mapped below (See Map C and Table 1).
the M-3-1-2_A. All but one have been active during the past two winters.

Five of these ^{mass movements} have contributed a minimum of 430 yd³ to streams capable of significant sediment transport, and 3 have high potential for contributing sediment in the future. The other 11 remain on the slope and have varying amounts of displacement to date: Six have moved less than 2 feet; five have dropped between 3 and 12 feet. Two of these have high potential to fail into a stream capable of significant sediment transport. One may be contributing to instability of an earthflow slope between the M-3-1 and the M-3. The other 8, if they failed as a debris flow, would impact smaller tributaries. All would destroy 10-20 year old regrowth, contribute fine sediment from surface erosion off the bared slope and possibly trigger additional slope failures.

Fifteen of the mass movements were treated. Ten were total outsloped, removing a total of 10,284 yd³ from potentially unstable areas. In total outsloping, the cut begins at the inboard ditch and all fill is pushed or endhauled to a stable location. Total outsloping usually cuts into original ground on the inner part of the road, and may expose new springs. This may actually help stabilize the area by releasing some of the ground water to faster flowing surface runoff. However, the possibility also exists that cutting into original ground may destabilize steep slopes above.

The other 5 mass movements were treated by dewatering (S.T. above Rx-1), outsloping (S.T. to R of Sx-2A, R-6 ST. 63⁰⁰ to 63¹⁵), bench outsloping (R-5 CBF ST. 37⁰⁰ to 38⁵⁰), or restoring diverted drainages (R-10 Glacier).

One mass movement, the landslide in drainage 2, was not able to be treated cost effectively due to its size.

The mass movements on Unit 83-2 can be broadly categorized in 2 groups: road fill failures (may also include logging debris) and original ground or slope failures which may or may not include road fill. The fill failures are most common where the road cuts through steep wet headwater areas, or where large volumes of slash and fill are perched on extreme (steep) slopes. The slope failures, involving original ground for the most part, are found in the steep inner gorges of the larger streams, drainage 2 and the "earthflow bowl" (drainages 6-10).

In looking at the soils map with respect to failure location and type of failure, a definite correlation can be seen. Nine of the 16 mass movements were in Devils Creek soils. Seven of these ^{nine} involved original ground as well as fill. All but one were in springy, wet areas, and five of these were underlain by sheared black (or gray) schist.

Five of the 16 failures occurred in Copper Creek soils. These five were purely fill failures. Three of them occurred in relatively dry areas (no springs) and failed due to their perched location on steep slopes and possibly also in part due to the lower clay content (and hence less cohesion) of Copper Creek ? soils.

Copper Creek soils are commonly underlain by relatively dry coherent bedrock. In contrast Devils Creek soils develop on wet sheared schist, an inherently unstable material. Fill failures in Devils Creek soils seem to more readily incorporate the underlying material than failures in Copper Creek soils. Thus in terms of prescriptions, a standard outslope may be sufficient for potential failures in Copper Creek soil, but total outslipping should be done in potential

failure locations in Devils Creek soil.

Another correlation noted is that the five failures which contributed sediment to major streams have north to north-east exposures, and occurred in steep, inner gorges. Three of them were in Devils Creek soil, and involved original ground as well as fill. The one in Copper Creek soil involved only fill. One was in Boyes Creek soil and involved both fill and original ground.

Thus it seems that roadcuts through the north-northeast facing steep inner gorges in Devils Creek soil are the most prone to large failures involving original ground which contribute sediment to the creeks! These should receive the most complete treatment: total, or bench outslipping, depending on whether fill or cutbank failure is likely to be more damaging. Roads through north to north-east facing inner gorges in Copper Creek soils may be stabilized by standard outslipping.

Details of Large Active Mass Movements

The largest active feature ^{on the unit} is an "ancient" landslide amphitheater in drainage 2. It is approximately 500 feet wide by 800 feet long. The only 2 remaining old growth trees on the slope are bowed and leaning, indicating it was active prior to logging. The M-3-1 cuts through the toe of this feature, and cutbanks are lined with perennial springs. Two large gullies have formed since logging, fed by springs at the base of the steep "crown scarp" slopes. They are eating their way through the deep colluvial deposits at the outer break in slope of the toe, and caused a continual maintenance problem by depositing their load in the in-board ditch. The ditch filled regularly and all gully and cutbank spring flow ran across the road, gullying off the out-board edge. In the winter of 82-83, the toe portion, above and to the left of Rx-2 and Sx-2A, began to move: numerous cracks and scarps, and grabens up to 4 feet appeared. The gullies were

both very active as well. (The park backhoe cleared the ditch in January 1983, prior to road closure at R-10 and R-11).

This feature is bounded by and toes into drainage 2. Continued movement of the slide is likely and will contribute an undetermined volume of sediment to the creek, but no treatment was considered economically feasible. Instead precautionary measures were taken: rock was imported and placed in Rx-2 below the toe of the slide, partially in hopes of minimizing channel erosion (in the case of only small landslide movements), and drains were provided for the cut-bank springs and gullies.

A 75' high, 100' long cutbank failure occurred on the north (left) bank of Rx-4, on March 31, 1983 following 4.59 inches of rain in 3 days (in Orick).

This area had already been mapped; no springs were present along the cutbank and there were no signs of potential failure. The slide brought down several hundred cubic yards of logs and stumps; ^{most} piled up on the road but overflowed approximately 50 yd³ into the creek. Most of this debris was caught by a log jam, and was removed during channel excavation. The slide initiated on a skid trail; there was a small spring in the cutbank of the skid trail and for several days following ^{the failure} a spring was visible 3 - 4 feet below the top of the scarp. A similar failure happened in 1972 about 100 feet down the road. Both slides are in Devils Creek soil. The slide adjacent to the crossing was bench outsloped, as it seemed likely that additional, hopefully smaller slides and raveling would occur as the main feature stabilized. The older slide, further from the stream, was total outsloped.

The "Glacier" on R-10 was also extremely active in late March of 1983. This feature is an earthflow, approximately 200 feet wide by 900 feet long, bounded on the mid and lower sides by streams. This feature is located in the "earth-flow bowl," ^(drainages 6-10) and is by far the most active, distinct flow since the bowl was logged and cable yarded in 1976. It showed no signs of activity until 1983, and

appears to have been covered with average density old-growth prior to 1976.

Movement was first noticed on February 15; the road had dropped 2 - 4 feet, but was still driveable. Flow from Rx-10 was going down the inboard ditch to the culvert at Rx-9 (as it had since road construction), but was beginning to pond in the ditch. Flow from culvert 9 discharges into the right lateral scarp of the earthflow.

On February 22, scarps had grown to 4 - 5 feet, and the water from Rx-10 was now flowing down the right lateral scarp. Shovel work was done to direct Rx-10's flow straight across the road into its natural channel.

On February 23, the park backhoe enlarged this cross road drain, plugged up the old inboard ditch flow route, and attempted to make the road driveable. The right lateral scarp was now about 5 feet vertically at mid road.

The next observations were made on March 18: the right lateral scarp was 6' 3". The crossroad drain had downcut 2 - 4 feet.

By March 30, the right lateral scarp had grown to 9 feet, with no major changes on the left side. The right side was continually the most active, probably due to drainage 9's culvert dumping flow directly into the lateral scarp. Also, as scarps above the road grew, drainage 10's channel was severely disrupted. Some of this flow soaked in, re-emerging as springs in the cutbank of the road on the down dropped block. This flow was also captured by the right lateral scarp.

On March 31, with 4.59 inches of rain in Orick in the preceeding 3 days the earthflow began to accelerate. That morning, the right scarp was 10.5 feet. By afternoon, it was 11.5 feet. Horizontal displacement was about 20 feet. By the next morning, the vertical displacement on the right scarp was 16 feet.

Downslope, 2 dumps and a large outcrop were ripped apart. Subsurface flow within a foot of the ground surface was visible in virtually all cracks.

Total rainfall for the storm was 5.01 inches in Orick, with 3.31 inches in the 3 days of greatest activity of the earthflow. (The large cut bank failure by Rx-4 also occurred at the tail end of this storm.) Very little rain fell after this storm, and there was no further movement of the earthflow.

The earthflow was mapped in detail, but no treatment other than attempting to maintain drainages in their channels was considered economically feasible. The most likely cause of the movement was the combined flow of drainages 9 and 10 discharging into the right lateral scarp. Other contributing factors include ground saturation, road construction across the landslide, a skid trail with humboldt crossing on drainage 10 above and paralleling the haul road, and the underlaying sheared black schist.

The other major failure on the M-3-1 was on R-11. Approximately 250 feet of road dropped 2 - 5 feet in mid February, 1983. During the previous winter, it had dropped 3 - 4 feet ^(recon. by M. Horns). There is an older cutbank failure above the road here (which heads on a drainage divide), but there are no signs of recent movement directly below the road.

This feature has not contributed any sediment directly to a stream, but may be contributing to the overall instability of the entire slope between the M-3-1 and the M-3. This slope is underlain by the infamous sheared black schist, and has very little soil development. There is topographic expression of 2 earthflows on the slope; they may actually be the lateral earthflow/gullies of one much larger earthflow, whose crown scarp would be the cutbank failure above R-11 ^(in appendix). (refer to mylar overlay of 1978 color airphoto number 8-17 _A). This large compound earthflow would feed directly into one of the main forks of Bridge Creek if re-activated. The left lateral earthflow/gully was active in 1983, in part due to the drainage diversion at Rx-11 discharging flow onto and gullying the slope below and to the left of the slide.

Since logging in 1976, an estimated 3,000 yd³ has eroded^{from this gully.} The gully has cut into the sheared black schist, exposing springs, and promises to remain active in spite of correcting the diversion. Down-cutting in the gully has undermined the adjacent slopes, and they will also continue to move. The toe of the slope has also been undermined by the M-3 road cut and the stream itself (although not recently).

In prescribing treatment for R-11, the review group felt that the presence of an unstable fill on the head region of a large compound earthflow could increase overall mass movement potential of the slope. Thus a total outslope was prescribed, with the fill to be endhailed to a stable deck 650 feet away.

Overall, the earthflow bowl (drainages 6 - 10) showed the greatest history of, and potential for mass movement on the site. During the last two winters, it was the most active area along the M-3-1. Much of the bowl is underlain by sheared black schist with Devils Creek soil, and it has a northern exposure. There is one distinct and 2 compound earthflows between the M-3-1 and M-3. The distinct flow is the R-10 glacier. Its distinctiveness is most likely due to its recent activity! The slope below R-6 and Rx-6 is a compound, dormant earthflow. There were 3 fill failures (with displacements up to 12 inches) along this road reach, all in 1983. The slope below R-11 is the other compound earthflow, also active in 1983. Another major failure occurred in the earthflow bowl, on R-8, in December 1981. This slope is not an obvious earthflow, but much of the upper portion of the slope is still forested, and thus obscured from airphoto viewing. On-the-ground mapping indicates this slope has been active in the not-too-distant past. There is typical benchy landslide topography, very few trees over about 3 feet in diameter, and numerous springs along the base of the steep "crown scarp" region. In addition the stream

below is curved to the right as if it was forced to cut around a depositional toe. There is also a less incised, abandoned channel at a higher elevation and to the left of the present channel. This may have been an initial channel cut through the landslide deposit, and since then the stream has found easier route around the deposit.

The earthflow bowl was harvested only six years ago. Activity of all mass movements in this steep area will likely increase as the stumps and other vegetation pass through the period of minimum root strength, 10 - 15 years after logging. An undetermined volume of sediment is likely to be introduced to the stream systems as a result.

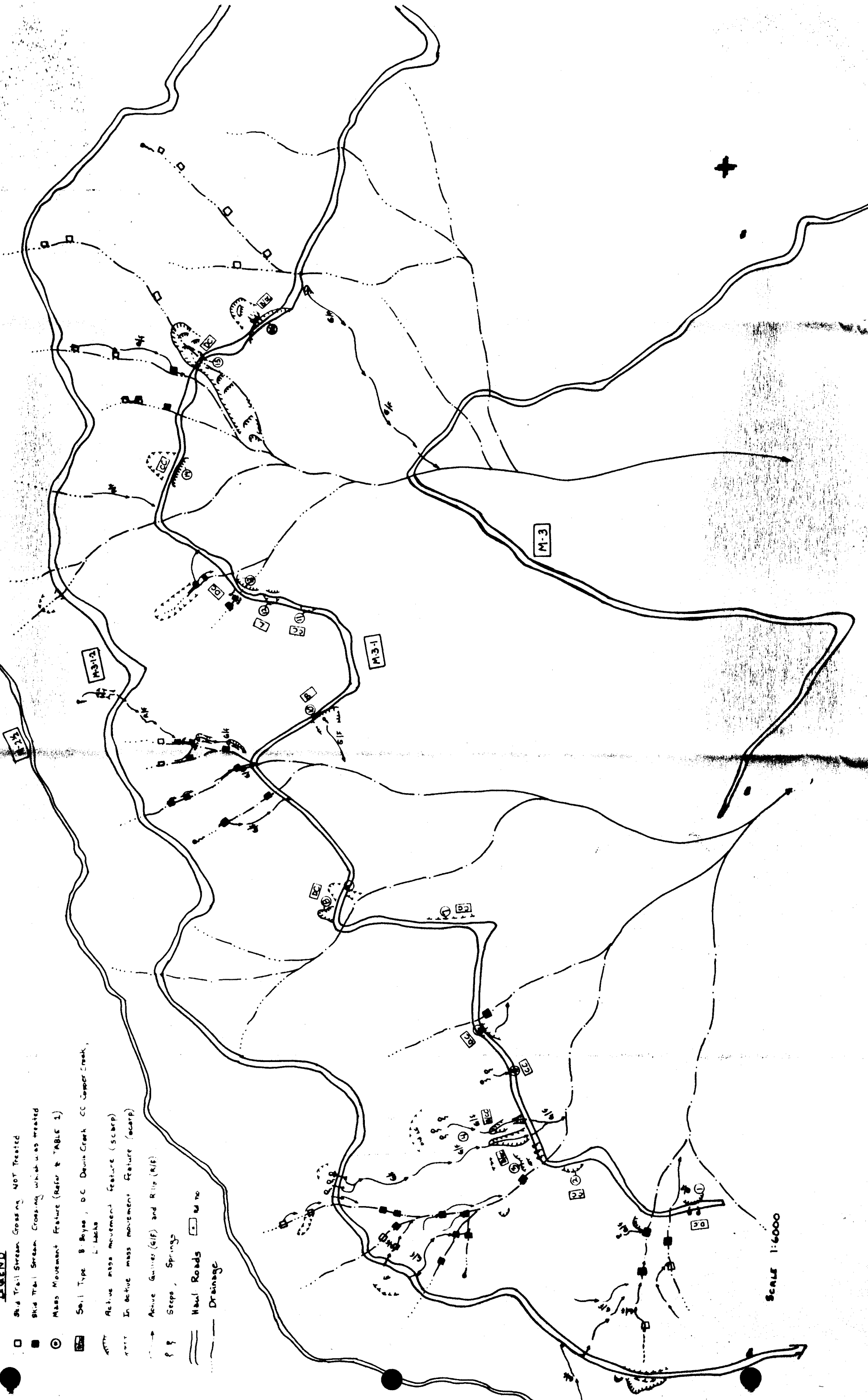
Control of mass movement features is difficult. Our treatments leave much to be desired in terms of prescribing the most effective treatments and even in identifying the mass movements with the highest potential for introducing sediment to the streams.

Total outslipping is presently a "blanket prescription" for fills which show signs of instability. It certainly can not hurt the situation, however it may not be necessary in all cases. In other cases, more complex engineering techniques may be in order. Hopefully the ongoing research on landslides in the park will lead the way to better, more cost effective treatments, and to preventative treatments instead of post-mortems of disasters.

MAP C: Erosion Features
Plus TABLE 1 and MAP C-1

LEGEND

- Skid Trail Stream Crossing NOT Treated
- Skid Trail Stream Crossing which was treated
- ⊙ Mass Movement Feature (Refer to TABLE 1)
- ⊞ Soil Type B Boyas, D.C. Dennis Creek, CC Copper Creek, L Lake
- Active mass movement feature (Scarp)
- In Active mass movement feature (Scarp)
- Active Gullies (GIF) and Rills (RIF)
- Steeps, Springs
- Haul Roads
- Drainage



SCALE 1:6000

Scale 1:6000

MAP C-1: Skid Trail Crossings only

LEGEND

- * Skid Trail Stream Crossing NOT Treated
- * Skid Trail Stream Crossing Treated
- == Haul Roads [] Rd. no.
- - - Drainage

Scale 1:6000

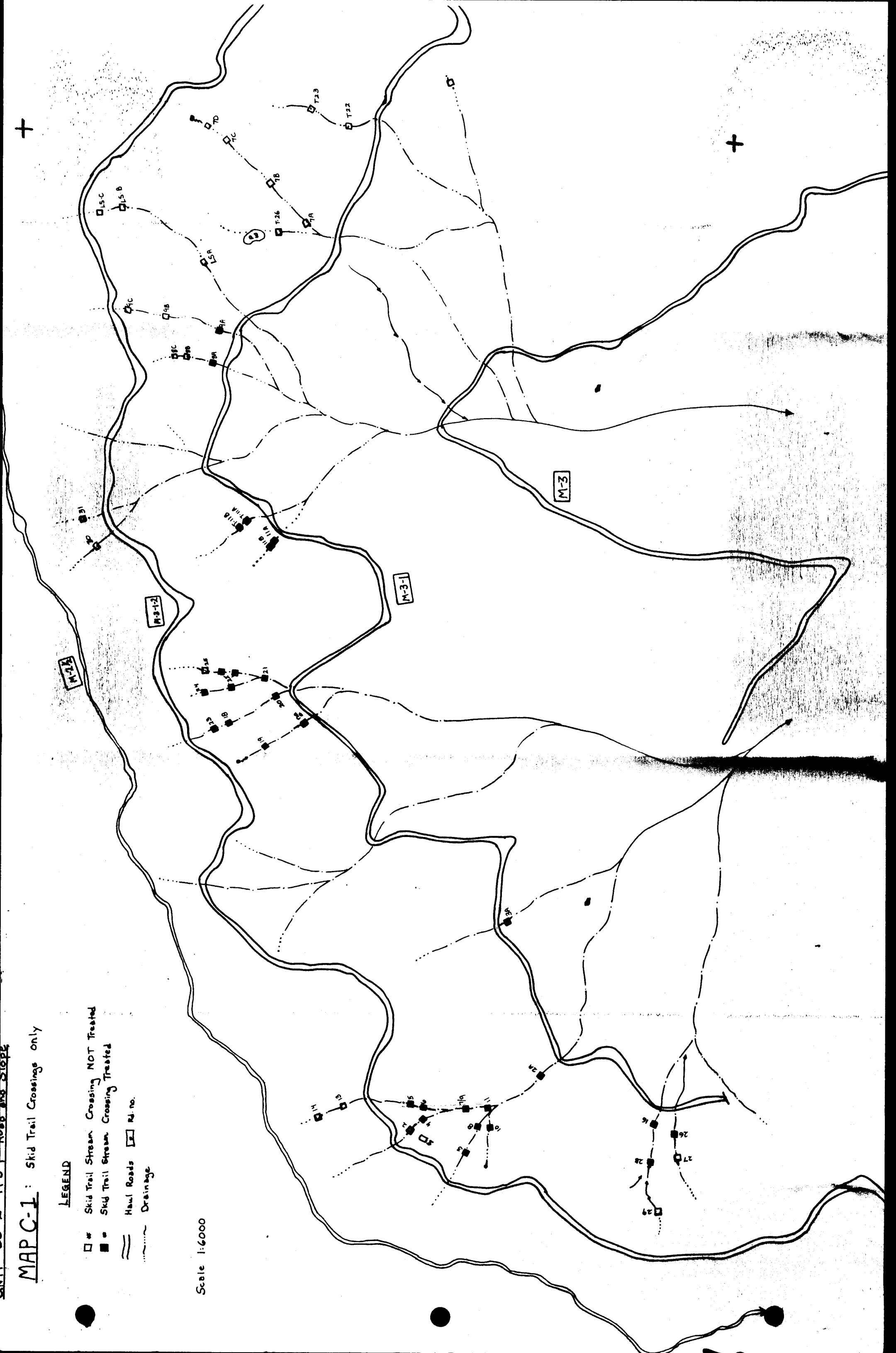


Table 1: SUMMARY OF MASS MOVEMENTS
83-2

Site Number (*) Refers to Map C	Station Numbers	Road Length (ft)	Vertical Displacement	Potential for failure to creek. -or- Volume in creek ¹	Date(s) of Movement ²	Local Slope	Soil Series	Type of Failure ³	Slope Aspect	Other
R-1 TOS ①	150 → 250	100'	12 ft.	Mod.	12-81	60-70%	Devils	FF+OG(s)	W	Sheared gray schist, wet headwaters, buried springs.
S.T. above Rx-1 ②	--	25'	7 ft.	Low	83	58%	Devils	FF	NW	Springs, diverted flow.
S.T. to R of Sx-2A ③	--	50'	4 ft.	Low	75	65%	Copper	FF	SW	Steep fill slope, undercut by haul road.
Drainage 2 ④	Left side	500' (800' long)	up to 4 ft. scarps & grabens	High	> 81	15-80%	Boyes & Copper	OG (D)	N	Large, deep seated rotational landslide, active pre-logging, reactivated by logging and road cut through toe.
R-3 TOS #1 ⑤	1825 → 1900	75	--	Low	--	65-80%	Copper	--	NW	Springs.
R-3 TOS #2 ⑥	2110 → 2400	290	2-12 in.	Mod.	> 82	75%	Devils	FF+OG(s)	NW	Sheared black schist, springs, ponded water in IBD.

Table 1: SUMMARY OF MASS MOVEMENTS (CONT'D.)
83-2

Site Number	Station Numbers	Road Length (ft)	Vertical Displacement	Potential for failure to creek. -or- Volume in creek	Date(s) of Movement	Local Slope	Soil Series	Type of Failure	Slope Aspect	Other
R-4 Landing Edge ⑦	27 ⁰⁰ → 29 ⁵⁰	350 (edge dist. > ST. # dist.)	2 ft.	High	3-82 (?)	88%	Copper	FF	W	Oversteepened slash and fill.
R-5 CBF/BOS ⑧	37 ⁰⁰ → 38 ⁵⁰	150	75-150 ft.	41 yd ³ (s) High	3-31-83	72-76%	Devils	FF+OG(s)	N	Buried springs, road cut undermined slope above.
R-5 TOS ⑨	38 ⁵⁰ → 39 ⁵⁰	100	To creek 4-8 in.	50 yd ³ (E) Mod.	72 83	75 + %	Devils	FF+OG(s)	N	Springs along IBD, very steep ground.
R-6 TOS #1 ⑩	53 ²⁵ → 55 ⁵⁰	225	300 ft. to creek Road: cks-6 in. Lower slope: 4-7 ft.	High 139 yd ³ (G)	72 >81	?	Boyes (?)	FF+OG(s)	NE	Buried springs, headwaters.
R-6 OS ⑪	63 ⁰⁰ → 63 ⁷⁵	75	cks on OER	Low	>81	50-70% (fillslope)	Copper	FF	W	Springs, head-water area, earth-flows below.
R-6 TOS #1 1/2 ⑫	65 ⁰⁰ → 65 ⁷⁵	75	3-6 in. mid. road	Low-Mod.	>81	50-85% (fillslope)	Lacks & Devils	FF	W	Springs, head-water area, earth-flows below.

Table 1: SUMMARY OF MASS MOVEMENTS (CONT'D.)
83-2

Site Number	Station Numbers	Road Length (ft)	Vertical Displacement	Potential for failure to creek. -or- Volume in creek	Date(s) of Movement	Local Slope	Soil Series	Type of Failure	Slope Aspect	Other
R-6 TOS #2 (13)	66 ¹⁰ → 68 ⁰⁰	190	6-12 in. IBD	Mod.	12-81	80-85% (fillslope)	Devils	FF + OG (s)	NW	Sheared black schist, springs, headwater area, ponded water in IBD, earthflows below.
R-8 TOS (14)	76 ⁰⁰ → 78 ⁵⁰	250	200 ft. to creek	Low-Mod. 100 + yd ³ (E)	12-81	45-75%	Copper	FF	N	Oversteepened fill, CBF above.
R-10 Glacier (15)	83 ⁰⁰ → 85 ⁰⁰ (900' Long)	200	15 ft.+	High 100 + yd ³ (E)	3-83	5-70% benchy	Devils	OG (D)	NE	Very active, earthflow, bounded by channels, sheared black schist.
R-11 TOS (16)	86 ⁵⁰ → 91 ⁵⁰	500	3-4 ft. 2-5 ft.	Mod.- High	B1 83	60-70%	Boyes & Devils	FF + OG (D)	NE	Sheared black schist, wet headwater area, CBF above, earthflow below recently activated by diversion gully.

See Footnotes on next page.

Footnotes for Mass Movements, Table 4:

- ¹For volume of sediment in a creek, "(S)" is a surveyed volume, "(E)" is an estimated volume, "(G)" is a volume calculated by gully void.
- ²For Date(s) of movement, ">" means since that year. ^{"72"}₈₃ means first active in 72, reactivated in 83. "12-81" means Dec, 1981.
- ³For type of failure, "FF" means fill failure, "OG" means original ground. For those involving OG, "(S)" means shallow failure, "(D)" means deep seated failure.

EROSION CONTROL REHABILITATION WORK

INTRODUCTION

Logging has greatly accelerated erosion on the slopes of the Redwood Creek basin. The objective of the watershed rehabilitation program is to minimize man-induced erosion, particularly that occurring in or adjacent to stream channels, and to restore the area as much as possible to its pre-logging condition. On Rehabilitation Unit 83-2, this was achieved by removing actual and potential sediment sources from the stream-side environment, returning drainage networks to their original configuration, attempting to stabilize or prevent mass movements, and minimizing road scars.

Specifically, the erosion control work involved removing all haul road and ^{many?} most skid trail stream crossings, pulling back landing and road fill where perched over stream channels, outsloping drainage headwater areas, totally outsloping active and potential fill failures, and improving drainage by channelizing flow on landslides. Fill was placed in stable locations, and these storage areas were contoured to blend with surrounding topography, minimizing the road and landing scars. Straw, and in some cases seed, was spread on the bare ground to reduce surface erosion and to aid revegetation. Trees will be planted this winter. For information on revegetation work, refer to Bonnie Griffith's report for this unit.

There are four phases of rehabilitation work: evaluation, heavy equipment, labor intensive and documentation. Evaluation of the site consists of detailed geomorphic and hydrologic mapping, inventorying erosional problems and sediment sources, and prescribing treatments as necessary. In the latter part of the phase, worksites are surveyed and photographed, and costs are estimated. Finally equipment is procured. On the M-3-1 Unit, mapping was done between

January and mid April. Prescriptions, surveying, cost estimating and equipment procurement were completed by the end of June. Photographs were taken periodically in July and August. The heavy equipment and labor intensive phases occurred, simultaneously during July, August and September. Documentation consists of more surveying and photographing, tabulating and analyzing all costs, and writing the annual report. This took place between October and mid December.

Costs for each phase of the project are shown in Table 2 . The grand total for the project was \$151,740.04. Of this, 8 percent was spent on the evaluation and documentation phases, and 92 percent on the actual implementation of erosion control work. Of the actual erosion control work, 92 percent was spent on heavy equipment and 8 percent on labor intensive work. Table 3 summarizes total and average heavy equipment costs. Table ^(p. 73) 8 shows all labor intensive costs. Map D shows worksite locations.

TABLE 2
SUMMARY COSTS OF EROSION-CONTROL REHABILITATION WORK, UNIT 83-2

	Task	RNP Employees Geologist & Technician	Laborers	Heavy Equipment Rentals	YCC	Redwoods United	Total Task Costs	% Total Cost	Phase Totals	Phase %
EVAL- UATION PHASE	Mapping	\$3,885.53 ✓					\$3,885.53	3%		
	Prescription	2,904.56 ✓					2,904.56	2%	\$6,790.09	5%
HEAVY EQUIPMENT PHASE	Primary Treatment	7,081.16 ✓ (H.E. Supervision)		\$108,611.43			115,692.59	76%		
	Secondary Treatment	--		3,413.41				2%	128,252.63	84%
	Miscellaneous	--		9,146.63				6%		
LABOR INTENSIVE PHASE	Travel		\$1,583.73		\$857.60	\$886.07	3,327.40	2%	✓	
	Secondary Treatments		3,094.73		857.60	1,348.95	5,301.28	4%	11,594.40	8%
	Miscellaneous		1,656.44		--	1,309.28	2,965.72	2%	DOES NOT INCLUDE STRAW ACQUISITION → + 3392 -	
DOCUMENTATION PHASE	Cost Analysis and Report	5,102.92 ✓					5,102.92	3%	5,102.92	3%
TOTALS:		\$18,974.17	\$6,334.90	\$121,171.47	\$1,715.20	\$3,544.30	GRAND TOTAL:		\$151,740.04	
% OF TOTAL:										

TABLE
SUMMARY OF AVERAGE COSTS OF HEAVY EQUIPMENT TREATMENTS
83-2

Treatment	# of Work-Sites	Total Quantity	Total Cost	Average Costs:		Cost/Quantity Range
				Work-Site	Quantity	
Opening M-3-1	--	--	2,337.50	--	--	--
Rip Roads	--	9,700'	~~2,671.375~~	--	.28/LF	--
Haul Road Crossings	11	19,025 yd ³	~~64,773.925~~ X	\$6,000	\$3.40/yd ³	<u>.81 - 4.58</u> yd ³
Skid Trail Crossings	28	2,935 yd ³	4,911.00 X	175	1.67/yd ³	<u>.59 - 4.91</u> yd ³
Outsloping (known volume)	2,855 ft.	5,735 yd ³	7,274.75 y		1.27/yd ³	<u>.99 - 1.93</u> yd ³
Total Outsloping	1,905 ft.	10,284 yd ³	18,782.385 X		1.83/yd ³	<u>.77 - 3.69</u> yd ³
Misc. Outsloping ¹	11	2,450 L.F.	6,522.75 X	--	2.66/LF	<u>.54 - 7.42</u> LF
Landings	4	750 L.F.	1,337.75 X	--	1.78/LF	<u>.90 - 2.84</u> LF
TOTAL PRIMARY TREATMENT			= \$108,611.435			
Channel Rocking ²	2	210 yd ³	2,134.50 X	555	5.29/yd ³	<u>4.15 - 5.75</u> yd ³
Straw Distribution	--	--	856.75 X	--	--	--
TOTAL SECONDARY TREATMENT			= \$2,991.25			
Miscellaneous Heavy Equipment Costs (See Table __ for Details)	--	--	9,568.785 X	--	--	--

TOTAL HEAVY EQUIPMENT COSTS = \$121,171.47

¹Includes other misc. road treatments.

²Includes quarry, transport and placement.

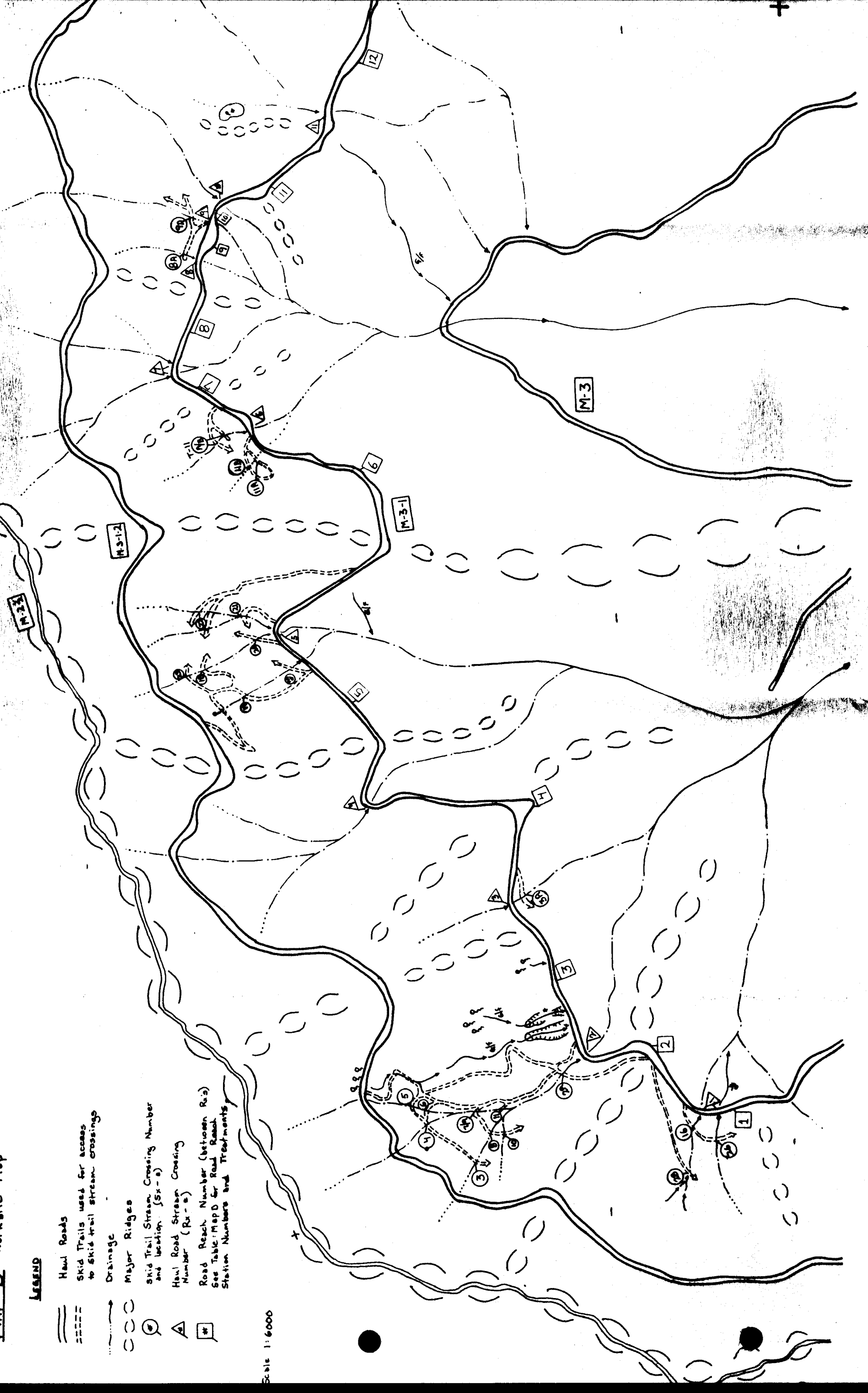
83-2: M-3-1 Road & Slope

Map D: Worksite Map

LEGEND

-  Haul Roads
 -  Skid Trails used for access to skid trail stream crossings
 -  Drainage
 -  Major Ridges
 -  Skid Trail Stream Crossing Number and Location (Sx-a)
 -  Haul Road Stream Crossing Number (Rx-a)
 -  Road Reach Number (between Rx)
- See Table: Map D for Road Reach Station Numbers and Treatments

Scale 1:6000



UNIT 83-2
D ROAD REACH TREATMENT TABLE

Road Reach Number	Station Number	Type of Treatment
R-6	50.50 - 53.25	OS: Type 4 (slight OS, bury IBD)
	53.25 - 55.50	TOS #1
	55.50 - 57.75	Fill Site (shaping)
	57.75 - 66.10	Swaley OS (w/minor TOS)
	66.10 - 68.10	TOS #2
	[68.00 - 69.00 Rx-6]	
R-7	69.00 - 73.00	Fill Site (shaping)
	[73.00 - 74.00 Rx-7]	
R-8	74.00 - 76.00	Intact IBD bermed
	76.00 - 78.50	TOS
	78.50 - 79.25	Fill Site (shaped)
	79.25 - 80.25	Swaley OS
	[80.25 - 80.75 Rx-8]	
R-9	80.75 - 82.50	Fill Site (shaped)
	[82.50 - 83.00 Rx-9]	
R-10 The Glacier	83.00 - 85.00	Removal of road constructed to gain access to the Rehabilitation Site.
	[Rx-10 included in the Glacier]	
R-11	85.00 - 86.50	OS: Landing to drain only
	86.50 - 91.50	TOS: End-hauled to following fill Sites
	[91.50 - 92.00 Rx-11]	
R-12	92.00 - 95.00	Enlarged IBD and built 2 XRD's.
	95.00 - 98.00	Fill Site (shaped)
R-13	107.00 - 108.00	Fill Site (shaped)

nd deck

taked)

d)

deck edge

HEAVY EQUIPMENT PHASE

HEAVY EQUIPMENT USED

The heavy equipment used on Unit B3-2 is shown in Table . The choice of these pieces of equipment was based on the anticipated working conditions, including size and type of the worksites, length of push, wetness of ground, type of material to be moved, etc.

The excavator was used mainly in the late stages of haul road stream excavations, to define the channel, and place organics or rock. It also did all skid trail crossings, assisted on outsloping (especially around trees and stumps), and loaded dump trucks (at R-11). An excavator with a bucket clamp was chosen because the clamp expedites removal or placement of organics in stream excavations. Most of the skid trail crossings were done by the excavator alone, hence it was necessary that he be able to effectively deal with all organics and logs encountered. Many of the skid trail crossings were small and on steep ground, with limited working space. The John Deere 690 B is a relatively small excavator and was best suited for the job.

Two large bulldozers were used on the unit: one worked primarily on haul road stream excavations, the other mostly on haul road outsloping. Both bulldozers were CAT DBH 46A's with 270 horsepower. Each had special features which helped do its primary tasks.

The outsloping bulldozer (owned by Twin Parks Lumber Company) had an angle blade, which reduces the need for "quartering", and hence expedites the outsloping process. It also had rippers, with two 36" long teeth, and 24" wide tracks. The tracks, 2" wider than standard tracks, provided added flotation which helped compensate for the extra weight of the rippers and angle blade. Initially a ripping bulldozer was to open the roads, rip and then leave. However, ^{from the same contractor} a bulldozer (but with a winch instead of rippers, and a lower

hourly rate) was hired for the rest of the site work. Once that was known, we opted to keep the rippers, since the other bulldozer had a winch. This enabled us to rip the road just prior to it being worked on, making site travel much easier on park vehicles, dump trucks and fuel trucks. The higher rate was charged only when the rippers were in use.

The other bulldozer (owned by Tim Crowley), working mainly on stream excavations, was equipped with a winch and a straight blade. Many stream excavations required long pushes; a straight blade is better for this than an angle blade. The winch was used on stumps, logs and other debris buried in the fill. This CAT had standard 22" tracks.

Once the Crowley CAT was finished on the unit, the other bulldozer contractor decided to bring out one of his winch CATs at his own expense. He was worried about getting stuck with nothing around big enough to pull him out (as happened during the first week). (Also should his angle CAT break down, he would have another one there ready to go, eliminating any down time.) This CAT had a straight blade, winch and 28" wide tracks. It was used only intermittently during the two weeks that it was on site. During this time a storm dropped over 4 inches of rain on the area, saturating the fills, and causing channels which had dried up to begin flowing vigorously. Mud was over knee deep in many places. The extra wide tracked CAT was the only piece of equipment able to push effectively out of the crossing in progress (Rx-7). Its presence on the site minimized stand by (rained out) costs: the other bulldozer was able to push fill along the level haul road to the fill site, and fortunately the excavator was on vacation. The 28" wide tracks provide flotation approaching that of a Case 1450, and are an excellent option when wet ground conditions are anticipated, and a large powerful bulldozer is needed.

The other bulldozer used on the site was a CAT D7E. The use of this CAT was not initially anticipated, however near the end of the project we knew we had more road to work on, and this bulldozer had hours left over from the adjacent project. It worked out well for everyone concerned! This CAT is smaller, quicker and lighter than the D-8's but it can not push as much and has less power. The D-7 size bulldozer works well when space is limited and/or push distance is short. This matched the conditions along the stretch of road the D-7 was used on, and work proceeded very efficiently.

The CAT 977 K loader, used exclusively to load dump trucks, was chosen mainly because of being track mounted. The loading area at the two end hauled crossings was not large enough for operation of a wheel loader. Also wet fill was anticipated, which would make the loading area mucky. A track mounted loader would be able to work in these conditions. The 4 in 1 bucket proved useful for a number of odd jobs: smoothing the loading area for the trucks, moving logs, crushing culverts and pulling back berms.

The dump trucks used on the site were basically all the same: old, slow, and low bid!! A locking differential was specified to improve operation on steep roads. All had a 10 cubic yard capacity. Chaffee and Cossairt were brought in temporarily due to schedule conflicts with 2 of the Parker trucks on another site. The truck driven (and owned) by Marvin Hendricks (sub-contracted to Parker) was the best of all the trucks used: it never broke down and the driver concentrated on efficient coordination of the trucks (via his CB). The number of dump trucks needed was calculated by estimating round trip and loading time for each truck. In actuality we were limited not by trucks, but by how long it took to get the fill up to the loader. Trucks ended up waiting in line to be loaded, and periodically one was put on standby.

Further evaluation of the performance of each piece of equipment is contained in the section "Evaluation of Heavy Equipment Techniques and Costs".

TABLE 4. HEAVY EQUIPMENT USED
83-2

Equipment Type	Owner (Operator)	Hourly Rates				Remarks:
		Regular	Standby w/oper.	Standby w/out oper.	Weeks in use	
Excavator: John Deere 690B	Larry Lambert	\$75.00	\$43.50	\$31.50	2-10	Bucket clamp
Bulldozer: CAT D8H 46A ¹	Twin Parks Lumber Co.	110.00	67.73	42.28	1-8,10	36" Rippers (2)
	Jay Franke	90.00	57.73	32.28	2-10	Angle blade, 4 way hyd. 24" wide tracks 270 HP
Bulldozer: CAT D8H 46A	Tim Crowley	78.50	45.00	33.00	3-8	Winch
	Emmett Wilkinson					Straight blade, 4 way hyd. 22" wide tracks 270 HP
Bulldozer: CAT D8H 46A ²	Twin Parks Lumber Co.	90.00	57.73	32.28	9-10	Winch
	Jay Franke					straight blade, 4 way hyd. 28" wide tracks 270 HP
Bulldozer: CAT D7E ³	Wendell Larkin	78.50	42.25	33.25	9-10	Rippers straight blade, 4 way hyd. " wide tracks 180 HP

¹Higher rate paid while ripping (see text)

²Brought in at owners expense; used interchangeably with Ripper/Angle Cat as need arose (see text).

³No move in/out - was previously in use on Unit 83-3.

TABLE 4 HEAVY EQUIPMENT USED (CONT'D.)
83-2

Equipment Type	Owner (Operator)	Hourly Rates			Weeks in use	Remarks:
		Regular	Standby w/oper.	Standby w/out oper.		
Loader: CAT 977 K	Paul Johnson Jack Dore	\$75.00	\$45.00	\$30.00	3-6	4 in 1 bucket, 3-4 yd ³ Track mounted
Dump Trucks (3)	Keith Parker Greg Parker Marvin Hendricks	32.95	23.98	8.98	3-6	10 yd ³ capacity Locking differential
Dump Truck	Diamond R. Logging Numerous drivers	33.00	25.00	7.50	3-6	10 yd ³ capacity Locking differential
Dump Truck	Neil Chaffee	34.00	24.36	9.64	3-4	10 yd ³ capacity Locking differential
Dump Truck	Dwain Cossairt	34.00	23.00	11.00	3-4	10 yd ³ capacity Locking differential

HEAVY EQUIPMENT WORK SEQUENCE

Heavy equipment work began on July 6 and was completed on September 11, taking a little over 10 weeks. In general work progressed from east to west across the unit. The three end hauled sites were done consecutively to avoid multiple move in/out charges. This affected scheduling of other work as they were located at the middle and end of the unit. A separate set of equipment was brought in for the endhauling, so that the excavator and other CAT could continue to do outsloping, slope work and other haul road crossings simultaneously. It was also anticipated that some excavator assistance would be needed on the endhauling. Having two sets of equipment working allowed the greatest flexibility in having the right equipment there when needed, and eliminated any standby time (except on dump trucks).

During the first week, work was limited to opening roads and producing rock, using the CAT D8H with rippers. The excavator joined the CAT in the second week, and the pair began to work their way down the road, outsloping and excavating channels. In the third week, end hauling began. The CAT D8H with winch was brought in to work with the loader and dump trucks.

The plan was to schedule the equipment work so that as each endhauled site neared completion, the outsloping bulldozer and excavator would be finished with all work beyond that point. Then the end hauled crossing could be completed and access permanently removed to the preceeding work sites. This was hoping for too much! The excavator and outsloping bulldozer were needed at the end hauled crossings more than was anticipated and hence they were unable to complete their other work. A narrow access road was left through each end hauling site, with end hauling removing about 90 percent of the volume. Once all end hauling was completed, the excavator and two bulldozers came back and finished the unit sequentially.

Slope work was done by the excavator with occasional bulldozer assistance as time permitted while the equipment was working in that area. Usually several crossings were done on each trip up the slope to minimize travel time.

Towards the end, the hours ran out on the winch CAT_A and it was uncertain whether we could complete the necessary work. The CAT D7E from Unit 83-3 had unused hours on the purchase order, and it was brought up to help complete the work.

For further details of heavy equipment sequencing the reader is referred to the Daily Heavy Equipment Record.

HEAVY EQUIPMENT COSTS

Opening the M-3-1 and Ripping

During the winter of 1983, the M-3-1 was blocked by a cut bank failure and 2 landslides which prevented vehicular access to all but 800 feet of the rehabilitation unit. A week prior to the beginning of the main equipment work, a bulldozer (CAT DBH 46A) with rippers was brought out to the site to reconstruct the road and then to begin ripping. Total road reconstruction cost was \$2,337.50. The majority of this, \$2,007.50, was spent rebuilding the road across the R-10 'Glacier'. This is discussed in detail below. The landslide at R-11 cost \$110.00, and the cut bank failure by Rx-4 cost \$220.00.

No problems were anticipated or encountered at the R-11 landslide or the cut bank failure, however, it was obvious that road reconstruction across the 'Glacier' would be difficult (and it was worse than anyone expected!). There was up to 16 feet of verticle displacement, and over 30 feet of horizontal movement, and it was still wet in July. There were no reasonable alternatives to road reconstruction: adjacent skid trail access routes were too steep for fuel, straw and dump trucks. Ramping down to the down-dropped road section appeared to be the least damaging and quickest way to re-open the road. However, unexpected problems appeared in the initial stages of the work. A culvert had been installed by the park's backhoe a few weeks earlier (cost (operator's wages only) included in labor intensive phase) and was capturing most of the flow from drainage 10. Although the landslide was still wet and seeping in many areas, the down dropped road segment appeared relatively solid.

However, in ramping down onto the slide, the bulldozer exposed a zone of sub-surface flow, and the ground beneath him liquified. In a matter of minutes, the CAT sank: mud was up to the running boards on one side, and the tracks were nearly submerged on the other. Water was running everywhere. A D-8 stuck in

the mud with no winch and no other equipment within miles is not a welcome sight (especially on the first day of rehab!). It took 7 hours to break free of the mud. This is included under miscellaneous heavy equipment costs (in the category "stuck, or helping others get unstuck"). At that point, due to the extremely wet muddy conditions, it was decided that the only way to insure having a drivable road was to build a corduroy road. The logs would help support the equipment weight, and, if carefully placed, would allow drainage under the fill. Without a winch, this was a slow process: logs had to be individually pushed or drug with a tow chain from up to 1,000 feet away. Each log was placed so as to insure that spring and diverted channel flow could pass beneath without saturating the fill. Once a solid road was completed on the down dropped block, the bulldozer was able to begin work knocking down the 16 foot right lateral scarp.

Once the road was open, the bulldozer began ripping. This was a straight forward task, costing a total of \$2,671.375, or \$1,478.40 per mile. In board ditches were ripped (except where they were to be left intact to drain springs), and ripping furrows were evenly spaced across the remainder of the road surface.

Haul Road and Skid Trail Stream Crossings

Thirty-nine haul road and skid trail crossings were treated on Unit 83-2, for a total cost of \$69,684.925 (Table 5). The overall average unit cost is \$3.17 per cubic yard, with an average excavation rate¹ of 18 cubic yards per hour. The total amount of material excavated from stream channels is 21,960 cubic yards!

Haul Road Stream Crossings

Eleven haul road crossings were excavated of which two were end-hauled (Table 6 & 8). The end-haul costs will be dealt with later in this discussion. The other 9 haul road crossings have a total cost of \$15,458.75; 6,147 cubic yards of material was excavated. The average unit cost is \$2.51 per cubic yard, with an average excavation rate of 32 cubic yards per hour. Two of these crossings were rocked using 210 cubic yards of rock for a total cost of \$2,134.50 (Table 7). Rock was quarried from the M-3 rock pit for a cost of \$412.50, and transported for a cost of \$610.50. Rock placement cost is \$1,111.50, with an average unit cost of \$5.29 per cubic yard. Not included in these costs is 13 1/4 hours of park backhoe time loading dump trucks in the M-3 rock pit.

The three small haul road crossings (100-400 yd³) had the lowest average unit cost at \$1.07 per cubic yard, and the highest excavation rate at 76 cubic yards per hour. The reason for this is that the fill storage locations were adjacent to the crossings, with an average push distance of 100 feet.

The medium (400-800 yd³) and large-sized (800-2,000 yd³) crossings had an average unit cost of \$2.77 and \$2.65 per cubic yard respectively. The excavation rates were much lower at 29 and 30 cubic yards per hour respectively. The shortest push distance to a fill site was 100 feet, and the longest 600 , with an overall average of 300 feet. All six of these crossings were dished down

¹Excavation rate = Volume ÷ total equipment hours.

using a bulldozer which removed up to 75 percent of the volume. The excavator and bulldozer then finished the excavation together. At crossings where the push distance was greater than 150 feet, two bulldozers were used to relay the fill from the crossing to the fill site.

Two extremely large haul road crossings (5,320 and 7,558 yd³) were end-hauled for a total cost of \$49,315.175, with an average unit cost of \$3.83 per cubic yard. The excavation rate is 14 cubic yards per hour, or 112 cubic yards per hour, if one multiplies this rate by the total number of pieces of equipment used during the excavation (eight: 4 dump trucks, 2 bulldozers, an excavator, and a loader). The average end-haul distance was 850 feet, and the push distance averaged around 350 feet. Ninety-three percent of the total excavated volume was end-hauled, and the remaining 7 percent was removed during the final clean-up phase of the excavation.

Neither end-hauled crossing was rocked. At Rx-5 organics (1-2 feet diameter logs) were placed by the excavator at the steep upper end of the excavation in a herringbone pattern. In both, natural channel rock was re-positioned, and other rocks were hand-rolled into the channel from the side banks.

Skid Trail Stream Crossings

Twenty-eight skid trail crossings were excavated for a total cost of \$4,911.00; 2,935 cubic yards of material was excavated. The overall average unit cost is \$1.67 per cubic yard, with an average excavation rate of 46 cubic yards per hour (Tables 9 and 10). In addition to the above excavation cost, the total cost to move the equipment between hillslope worksites is \$1,162.50. This increases the average unit cost to \$2.07 per cubic yard, and decreases the excavation rate to 37 cubic yards per hour. The travel cost only includes excavator travel time (15 1/2 hours), since the three crossings where the bulldozer assisted are adjacent to the haul road and travel time was minimal

BLE 5
TRAIL CROSSING EXCAVATION COSTS¹
B3-2

al es st	Average Cost/ Worksite	Range: Cost	Total yd ³	Average: Cost/ yd ³	Range: Cost/ yd ³	Average Rate: yd ³ /Hr.
.875	\$72	\$19 - 344	1,075	\$1.35	\$.59 4.91	56
.75	190	94 - 382	1,386	1.24	.78 - 1.88	63
.00	1,400	663 - 2,475	3,366	2.55	1.02 - 4.58	32
1.125	4,300	3,400 - 5,200	3,255	2.65	2.47 - 2.78	30
5.175	25,000	21,000 - 28,000	12,878	3.83	3.70 - 4.01	14 (or 112 cy/hr using 4-DT, 2 Dozers, 1 Excav, and 1 loader)
1.925	\$1,800	\$19 - 28,000	21,960 yd ³	\$3.17/ yd ³	\$.59 4.58/yd ³	18 yd ³ / Hr.

TABLE 6
ROAD CROSSING EXCAVATION COSTS¹
83-2

Total Sites Cost	Average Cost/ Worksite	Range: Cost	Total yd ³	Average: Cost/ yd ³	Range: Cost/ yd ³	Average Rate: yd ³ /Hr.
\$736.75	\$245	\$152 - 382	687	\$1.07	\$.81 1.37	76
6,109.875	1,527	663 - 2,475	2,205	2.77	1.02 - 4.58	29
8,612.125	4,306	3,400 - 5,212	3,255	2.65	2.47 - 2.78	30
49,315.175	25,000	21,000 - 28,000	12,878	3.83	3.70 - 4.01	14 (or 112 cy/hr using 4 DT, 2 Dozers, 1 Loader and 1 Excav.)
\$64,773.925	\$6,000	\$152 - 28,000	19,025 yd ³	\$3.40/ yd ³	\$.81 - 4.58	17 yd ³ / hr.

TABLE 7
STREAM CROSSING ROCK COSTS
83-2

Site Number	Quantity yd ³	Quarry Cost/yd ³	Transport Cost/yd ³ ¹	Average Placement Cost/yd ³	Average Total Cost/yd ³	Rock Placement Cost/Site	Total Rock Cost	Total Excavation Cost	Total Site Cost
Rx-2 ²	150	\$1.96	\$2.91	\$5.75	\$10.62	\$862.50	\$1,593.21	\$3,400.25	\$4,993.25
Rx-7 ³ (Cascade channel)	60	1.96	2.91	4.15	9.02	249.00	541.29	268.625	809.825
TOTALS:									
2	210 yd ³	Average \$1.96/ yd ³	Average \$2.91/ yd ³	Average \$5.29/ yd ³	Average \$10.16/ yd ³	\$1,111.50	\$2,134.50	\$3,668.875	\$5,803.375

Not included in the Transport Cost is 13 1/4 hours for Redwood National Parks Backhoe loading the Dump trucks.

This channel was completely rockd.

Four rock aprons were constructed in Cascade RX-7 channel.

TABLE 8
HAUL ROAD CROSSING EXCAVATION COSTS
83-2

Site Number	Equipment	Hours	Cost	Site Cost	Quantity yd ³	Cost/ yd ³	Total Site Cost	Rate: yd ³ / Hour	(P) (E) Push/End-Haul Distance	
Rx-1	Excavator	13 3/4	\$1,237.50	\$2,475.00	540	\$4.58	\$2,475.00	18	600' (P)	
	Bulldozer	16 1/2	1,237.50							
Rx-2	Excavator	16 3/4	1,256.25	3,400.25	1,378	2.47	4,262.75	32	350' (P)	
	Bulldozer	7 1/4	652.50							
	Bulldozer	19	1,491.50							
	Rock:									
	Excavator	11 1/2	862.50	862.50	150	5.75	--	13	--	
Rx-3	Excavator	3	225.00	382.50	326	1.17	382.50	69	150' (P)	
	Bulldozer	1 3/4	157.50							
Rx-4	Excavator	35 3/4	2,681.25	21,352.86	5,320	4.01	21,352.86	13	900' (E) [5,123 yd ³]-968 D.T. Loads	
	Loader	65	4,875.00							
	Bulldozer	15 1/2	1,395.00						350' (P) [197 yd ³]	
	Bulldozer	66 1/2	5,220.25							
	6-Dump trucks	232 3/4	7,181.36							→ includes \$294.51 of stand-by cost, and \$501.00 move in/out costs (see text)
Rx-5	Excavator	51	3,825.00	27,962.315	7,558	3.70	27,962.315	15	800' (E) [6,886 yd ³]-1,167 D.T. Loads	
	Loader	66 1/4	4,968.75							
	Bulldozer	55 1/4	4,972.50						300-500' (P) [672 yd ³]	
	Bulldozer	88 1/4	6,927.625							
	4-Dump trucks	257 1/4	7,268.44							→ includes \$356.25 of stand-by cost

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TABLE 8
HAUL ROAD CROSSING EXCAVATION COSTS (CON'T.)
83-2

Site Number	Equipment	Hours	Cost	Site Cost	Quantity yd ³	Cost/ yd ³	Total Site Cost	Rate: yd ³ / Hour	(P) (E) Push/End-Haul Distance
Rx-6	Excavator	11 1/2	\$862.50	\$2,193.75	575	\$3.82	\$2,193.75	21	150' (P)
	Bulldozer	7 1/2	588.75						
	Bulldozer	8 1/4	742.50						
Rx-7	(Main channel)			4,943.25	1,722	2.87	5,460.875	29	200-400' (P)
	Excavator	17	1,275.00						
	Bulldozer	23 3/4	2,137.50						
	Bulldozer	19 1/2	1,530.75	268.625	155	1.73	--	44	150' (P)
	(Cascade channel)								
	Excavator	1 3/4	131.25						
	Bulldozer	1 3/4	137.375	249.00	60	4.15	--	18	--
	Rock:								
	Excavator	1 3/4	131.25						
Rx-8	Bulldozer	1 1/2	117.75	777.625	440	1.77	777.625	44	150' (P)
	Excavator	3 3/4	281.25						
	Bulldozer	1/2	45.00						
Rx-9	Bulldozer	5 3/4	451.375	663.50	650	1.02	663.50	84	100' (P)
	Excavator	1 1/2	112.50						
	Bulldozer	5 1/4	472.50						
Rx-10	Bulldozer	1	78.50	151.75	111	1.37	151.75	56	200' (P)
	Excavator	1 1/2	112.50						
	Bulldozer	1/2	39.25						

TABLE 8
HAUL ROAD CROSSING EXCAVATION COSTS (CON'T.)
83-2

Site Number	Equipment	Hours	Cost	Site Cost	Quantity yd ³	Cost/ yd ³	Total Site Cost	Rate: yd ³ / Hour	(P) (E) Push/End- Haul Distance
Rx-11	Bulldozer	2 1/4	\$202.50	\$202.50	250	\$.81	\$202.50	111	50' (P)
TOTALS									
Excavation:									
11 Crossings	Excavator	157 1/4		\$64,773.925	19,025 yd ³	\$3.40/yd ³ Ave.		17 yd ³ /hr Ave.	245' (P) Ave.
	Loader	131 1/4							
	Bulldozers (3)	346							850' (E) Ave.
	Dump trucks (6)	<u>490</u> 1,124 1/2 hrs.							
Rocking:									
	Excavator	13 1/4		1,111.50	210 ₃ yd ³	5.29/yd ³ Ave.			
	Bulldozer	<u>1 1/2</u> 14 3/4 hrs.							
GRAND TOTALS:									
11 Crossings	1,139 1/4 Heavy Equipment Hours		\$65,885.425						

TABLE 9
AVERAGE SKID TRAIL CROSSING EXCAVATION COSTS¹
83-2

Type of Worksite	# of Work-sites	Range: vol. fill yd ³	Equip.	Range: Hours [Total]	Total Sites Cost	Average Cost/ Worksite	Range: Cost	Total yd ³	Average: Cost/ yd ³	Range: Cost/ yd ³	Average Rate: yd ³ /Hr.
EXTRA-SMALL 1-100 yd ³	20 $\frac{1}{19}$	13-93	Excav (91%) Dozer (9%)	1/4 - 2 3/4 1 3/4 [19 1/4 hrs] - 4.5 = 14 3/4 hrs	1,449.875 1106.25	\$72 \$58	\$19-344	1,075 $\frac{10}{1005}$	\$1.35 1.10	\$.59-4.91	56 68
SMALL 100-400 yd ³	6	100-150	Excav (100%)	1 1/4 - 3 [13 hours]	975.00	163	94-225	699	1.39	.78-1.88	54
MEDIUM 400-800 yd ³	2	419 - 742	Excav (59%) Dozer (41%)	6 3/4 - 11 3/4 5 3/4 - 7 [31 1/4 hrs]	2,486.125	1,243	980 - 1,505	1,161	2.14	2.03 - 2.34	37
LARGE 800-2000 yd ³	None										
EXTRA-LARGE 2000 yd ³	None										
TOTALS:	28 Crossings	13-742 yd ³	Excav (77%) Cat (23%)	1/4 - 11 3/4 1 3/4 - 7 <u>63 1/2 hours</u>	\$4,911.00	\$175	\$19 - 1,505	2,935 yd ³	\$1.67/ yd ³	\$.59 - 4.91	46 yd ³ / hour

Does not include travel costs. (see table 10)

TABLE 10
SKID TRAIL CROSSING EXCAVATION COSTS
83-2

Site Number	Equipment	Hours	Cost	Site Cost	Quantity yd ³	Cost/ yd ³	Total Site Cost	Rate: yd ³ / Hour	Remarks:
Sx-2A	Excavator	6 3/4	\$506.25	\$1,130.50	567	\$1.99	\$1,505.50	41	Combined cost per cubic yard is \$2.03.
	2-Bulldozer	7	624.25						
	(TOS) Excavator	5	375.00	375.00	175	2.14	--	35	TOS on right bank for 75 feet.
SxEP-3	Excavator	1	75.00	75.00	80	.94	75.00	80	
Sx-3A	Excavator	1/2	37.50	37.50	30	1.25	37.50	60	
SxEP-4	Excavator	2 1/4	168.75	168.75	100	1.69	168.75	44	
SxEP-5	Excavator	1	75.00	75.00	65	1.15	75.00	65	
SxEP-6	Excavator	1/4	18.75	18.75	13	1.44	18.75	52	
SxEP-7/9	Excavator	1 1/2	112.50	112.50	125	.90	112.50	83	
SxEP-8	Excavator	1	75.00	75.00	55	1.36	75.00	55	
Sx-8A	Excavator	2 3/4	206.25	343.625	70	4.91		16	1
	Bulldozer	1 3/4	137.375						
Sx-9A	Excavator	6 3/4	506.25	980.625	419	2.34	980.625	34	
	Bulldozer (2)	5 3/4	474.375						
SxEP-10	Excavator	1	75.00	75.00	93	.81	75.00	93	
SxEP-11	Excavator	2 1/2	187.50	187.50	104	1.80	187.50	42	Located in Drainage Rx-2
Sx-11A	Excavator	1/2	37.50	37.50	20	1.88	37.50	40	Located above R-6, 49

TABLE 10
SKID TRAIL CROSSING EXCAVATION COSTS (CON'T)
83-2

Site Number	Equipment	Hours	Cost	Site Cost	Quantity yd ³	Cost/ yd ³	Total Site Cost	Rate: yd ³ / Hour	Remarks:
Sx-11B	Excavator	1 1/4	\$93.75	\$93.75	50	\$1.88	\$93.75	40	Located above R-6, TOS #2
SxT - 11A & B	Excavator	3/4	56.25	56.25	50	1.13	56.25	67	Located above Rx-6 Two excavations
SxEP-16	Excavator	1 1/4	93.75	93.75	67	1.40	93.75	54	
SxEP-18	Excavator	1	75.00	75.00	40	1.88	75.00	40	2
SxEP-19	Excavator	1 1/4	93.75	93.75	120	.78	93.75	96	
SxEP-20	Excavator	3	225.00	225.00	150	1.50	225.00	50	
SxEP-21	Excavator	3/4	56.25	56.25	45	1.25	56.25	60	
SxEP-22	Excavator	1 3/4	131.25	131.25	222	.59	131.25	127	Three separate channel excavations.
SxEP-23	Excavator	2 1/2	187.50	187.50	100	1.88	187.50	40	2
SxEP-26	Excavator	1	75.00	75.00	89	.84	75.00	89	
SxEP-28	Excavator	3/4	56.25	56.25	44	1.28	56.25	57	
Sx- No. # R-5	Excavator	1	75.00	75.00	42	1.79	75.00	42	
TOTALS (excluding travel):									
28	Excavator	49 hrs		\$4,911.00	2,935 yd ³	\$1.67/ yd ³		46 yd ³ /hour	
ssings						Average		Average rate	
	Bulldozer	14 1/2 hrs							
		63 1/2 hrs							

TABLE 10 (cont)

PLUS TRAVEL TIME:

Excavator	<u>15 1/2 hours</u>	<u>1,162.50</u>		
~~Tools including travel:~~	79 hours	\$6,073.50	<u>\$2.07/yd³</u>	<u>37 yd³/hour</u>

- ¹ Bulldozer was used to push the fill 100 feet away and to construct an inboard ditch drain. The excavator also spent one hour redoing and rock scavenging.
- ² Time and Cost includes outslowing 100 feet of skid trail on the right bank.

and included in the cost of the excavation. The travel rate for the excavator on a 25 - 55 percent slope is .2 mile per hour, and on a haul road is 1.2 miles per hour.

Twenty extra-small (13 - 93 yd³) and 6 small-sized (100 - 150 yd³) skid trail crossings were excavated using only the excavator (Sx-8A was included in this grouping because bulldozer time was minimal). These 26 crossings have the lowest average unit costs at \$1.35 and \$1.39 per cubic yard, and the highest excavation rate at 56 and 54 cubic yards per hour. Using the excavator only, on crossings less than 150 cubic yards in size, is most cost efficient excavation method. The two medium-sized (419 - 742 yd³) crossings have an average unit cost of \$2.14 per cubic yard, with an excavation rate of 37 cubic yards per hour. The bulldozer spent significant time on these. The cost for these crossings could have been reduced if the percent of bulldozer time had been increased to 60 - 70 percent, instead of only 41 percent.

All 28 skid trail crossings were left unprotected. Only minimal natural rock was uncovered in the excavations, and some smaller organics were left in most of the channels.

Haul Road Treatment Costs

One and a half miles (7,960 feet) of the M-3-1 haul road were outsloped to varying degrees for a total cost of \$33,917.635 (Table II). The overall average cost per linear foot is \$4.26, with a production rate¹ of 27 linear feet per hour. This includes one end-hauled reach (500 feet long) which accounts for 25 percent of the total haul road treatment cost. Volume of material moved was calculated² for 60 percent (4,760 feet) of the road, and totals 16,037 yd³. This volume includes all total outsloping (fill pushed or end hauled to stable locations) and a little over half (54 percent) of the standard outsloping.

¹ Production rate = linear feet or cubic yards ÷ total equipment hours.

² ...

Outsloping with Known Volume (Table 12)

For standard outsloping with known volume, cost is \$7,274.75, yielding an average cost of \$1.27 per cubic yard, and a production rate of 67 cubic yards per hour. Ranges are \$.99 - 1.93 per cubic yard, and 43 - 90 cubic yards per hour respectively. In linear feet, average cost is \$2.55 and production rate is 33 feet per hour. Five of the seven road reaches outsloped (2,555 feet) cost between \$.99 and \$1.25 per cubic yard, with an average of \$1.19 per cubic yard. Production rate for these 5 ranged from 66 - 90 cubic yards per hour, with an average of 72 cubic yards per hour. The 2 road reaches eliminated had inordinately unusually high costs due to a high density of stumps and old growth along the edge of the road (R-1) and inaccurate time records (R-4).

Total Outsloping (Table 13)

The cost for totally outsloping 1,905 feet of road is \$18,782.385. Total volume removed from unstable areas is 10,284 cubic yards costing an average of \$1.83 per cubic yards. This can be broken into 2 categories depending on whether fill was pushed or end hauled to the storage area.

The cost for total outsloping where fill was pushed to storage areas is \$10,329.125. A total volume of 7,562 cubic yards of fill was pushed an average¹ of 300 feet to a stable location; push distance ranged from 100 to 600 feet. The average cost was \$1.37 per cubic yard; range was \$.77 - \$3.69 per cubic yard. Production rate averaged 63 cubic yards per hour; range was 22 - 103 cubic yards per hour. There is a wide range in these values, with the shortest push (R-1) actually costing the most per cubic yard. This is due to the density and location of stumps in the working area, and was possibly further complicated by being the first worksite of the season. The next most costly per cubic yard (\$2.91) was the 2nd total outslope of the season. From there, efficiency increased. Eliminating these two, the average cost becomes \$1.14 per cubic yard, with a range

1 Average push distance = $\frac{\Sigma (\text{volume} \times \text{push})}{\text{Total volume}}$ - for each work site.

of \$.77 to 1.72 per cubic yard. The costs of five of the road reaches were even more tightly clustered = \$.77 - \$1.16 per cubic yard, averaging \$1.02 per cubic yard, with production rates between 73 and 103 cubic yards per hour, averaging 88 cubic yards per hour. Push distance varied between 125 and 600 feet for these five, with an average of 351 feet. Eighty-eight percent of the equipment hours were bulldozer.

Comparing these five most efficient road reaches with the 4 less efficient ones, some interesting things come to light. The less efficient ones had a shorter average push distance (160 feet), and the excavator was needed for 40 percent of the total equipment hours (as opposed to only 12 percent on the more efficient ones). These 4 less efficient reaches generally had a number of stumps along the outside edge, which definitely slowed the work.

There was only one total outslope that required end hauling of fill. Five hundred feet of road were treated for \$8,453.26. This amounts to 25 percent of the total road treatment cost but only 6 percent of its length. However, its cost was reasonable for end hauling: 2,722 cubic yards were moved an average of 1,118 feet for \$3.11 per cubic yards. For most of the excavation, the excavator was used to load the dump trucks, with a bulldozer pushing fill as needed to the excavator. Some fill was pushed by bulldozers to the storage location, after the dump trucks hours expired.

Add 5.1. → All Other Road Treatments (Tables 14, 15 and 16)

No volumes were measured for the remaining 3,200 feet of road. Of this, 1,175 feet were outsloped for a cost of \$3,165.125, averaging \$2.69 per linear foot. Production rate was 31 feet per hour. Miscellaneous road treatments, covering 1,275 feet, include fill outsloping and removal of the access road across the R-10 glacier. The total cost was \$3,357.625, averaging \$2.63 per linear foot. Production rate was 33 feet per hour. The edges of 4 landings (750 feet total) were pulled back for a cost of \$1,337.75, averaging \$1.78 per foot of landing edge.

TABLE 11
SUMMARY OF ROAD TREATMENT COSTS
83-2

	Total Length	Total Volume	Total Cost	Range	Average Cost	Average Production Rate	Average Push Distance
Outsloping (with known volume)	2,855	5,735	\$7,274.75	\$.99 - \$1.93/yd ³	\$1.27/yd ³	67 yd ³ /hr	--
Total outsloping (pushed)	1,405	7,562	10,329.125	.77 - 3.69/yd ³	1.37/yd ³	63 yd ³ /hr	300 ft.
Total outsloping (trucked)	500	2,722	8,453.26	--	3.11/yd ³	17 yd ³ /hr	1,118 ft.
Outsloping (no volume)	1,175	--	3,165.125	.54 - 3.51	2.69/LF	31 LF/hr	--
Landing edge outsloping	750	--	1,337.75	.90 - 2.84/LF	1.78/LF	--	--
Miscellaneous road treatments	1,275 (+)	--	3,357.625	.84 - 7.42/LF	2.63/LF	33 LF/hr	--
ALL ROADS	7,960 ft.	--	\$33,917.635		\$4.26/LF	27 LF/hr	
ALL ROADS WITH KNOWN VOLUME (excludes endhauling)	4,260 ft.	13,315	\$17,603.875		\$1.32/yd ³	65 yd ³ /hr	

TABLE 12
COSTS of OUTSLOPED ROADS WITH KNOWN VOLUMES
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Volume yd ³	Unit Cost \$/yd ³	Production Rate yd ³ /hr	Percent Bulldozer	Remarks
R-1 (2.50 - 3.50)	D-8 A Exc	1.00 2.50	\$277.50	100 ft	178	\$1.56	51	29%	Type 1 (+) stumps and trees OER
R-2 (6.25 - 8.50)	D-8 A Exc	6.00 0.50	577.50	225	509	1.14	78	92%	Type 4 (50%) Exc time spent on stumps OER
R-3 (18.90 - 21.10)	D-8 A Exc	3.25 0.25	311.25	220	314	.99	90	93%	Type 1 & 2 Grade staked
R-4 (24.00 - 26.00)	D-8 A D-8 S Exc	3.75 7.50 0.25	945.00	200	489	1.93	43	98%	Type 1 (includes, moving 133 yd ³ of push berm from R-3 TOS to fill site before actual out-sloping.)
R-4 (29.50 - 34.50)	D-8 A D-8 S Exc	12.25 12.25 7.50	2,626.625	500	2,099	1.25	66	77%	Type 2 Grade staked ¹
R-5 (41.00 - 46.00)	D-8 A D-8 S	9.25 0.25	852.125	500	750	1.14	79	100%	Type 4 (75%)
R-6 (50.50 - 53.25)	D-8 A D-8 S Exc	1.00 3.50 0.25	383.50	275	325	1.18	68	95%	Type 4 (25%) Slight OS-bury IBD, leave to drain.

TABLE 12
COSTS of OUTSLOPED ROADS WITH KNOWN VOLUMES (CONT)
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Volume yd ³	Unit Cost \$/yd ³	Production Rate yd ³ /hr	Percent Bulldozer	Remarks
R-6 (57.75 - 66.10)	D-8 A Exc	13.00 1.75	\$1,301.25	835	1,089	1.19	74	88%	Swaley OS and TOS. Includes removal of a cross-road culvert.

Totals and Averages:

All:	86.00 hours	\$7,274.75	2,855 ft	5,753 yd ³	\$1.27/yd ³	67 yd ³ /hr	85%	Averaged using totals.
Excluding R-4 (Type 1):	74.5 hours	\$6,329.75	2,655 ft	5,264 yd ³	\$1.20/yd	71 yd ³ /hr	83%	

Footnotes

¹ The Type 2 outslope is too steep for a bulldozer to do efficiently alone. On steep slopes the berm along the lower edge is the problem (1 - 2 yd³ per linear yard of road). We tried different methods of berm removal to try to expediate the outsloping. The bulldozer can simply push it over the edge, completing 300 feet per hour, but this can put fill in inappropriate places and it leaves a line of smashed vegetation on the outside edge of the road. The excavator can pull the berm up and place it on the outsloping at a rate of 100 feet per hour. Additional bulldozer time may be required to smooth it out. The excavator can also flatten the berm with a sideways sweeping motion of the bucket, with only minimal sidecast, and no additional bulldozer time, at a rate of 200 feet per hour.

TABLE 13
COSTS of TOTAL OUTSLOPE ROADS¹
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Volume yd ³	Push Distance Feet	Unit Cost ³ \$/yd ³	Production Rate yd ³ /hr	Percent Bulldozer	Remarks
R-1 (1.50 - 2.50)	D-8 A Exc	7.25 12.00	\$1,552.50	100 ft	421	100 ft	\$3.69	22	38%	Includes FOS time. Steep push with limited working space due to stumps and trees.
R-2 (5.00 - 6.25)	D-8 A Exc	6.25 6.00	1,012.50	125	348	300 ft	2.91	28	51%	TOS with IBD left intact and bermed up.
R-2 (12.00 - 12.50)	D-8 A Exc	0.50 1.50	157.50	50	145	200 ft	1.09	73	25%	
R-3 (18.25 - 19.00)	D-8 A	7.50	675.00	75	589	150	1.15	79	100%	Grade staked.
R-3 (21.10 - 24.00)	D-8 A D-8 S	14.00 13.75	2,699.375	290	2,334	600	1.16	84	100%	Grade staked. Includes FOS time. Does not include moving push slot berms (~133 yd ³) to fill site (see R-4 on Table).
R-5 (38.50 - 39.50)	D-8 A D-8 S Exc	0.75 4.75 2.75	646.625	100	406	125	1.59	49	67%	Exc time spent working around stumps.

TABLE 13
COSTS of TOTAL OUTSLOPE ROADS¹ (CON'T)
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Volume yd ³	Push Distance Feet	Unit Cost ₃ \$/yd ³	Production Rate yd ³ /hr	Percent Bulldozer	Remarks
R-6 #1 (53.25 - 55.50)	D-8 A Exc	14.75 2.00	\$1,477.50	225	860	150	\$1.72	51	88%	Exc time on stumps OER. If ₃ excluded = \$1.54/yd ³
R-6 #2 (66.10 - 68.00)	D-8 A D-8 S Exc	2.50 1.75 4.75	718.625	190	924	250	.77	103	47%	Rx-6 overlaps onto R-6 TOS #2; time was difficult to separate. If combined, unit cost is \$1.94/yd ³ , production rate is 41 yd ³ /hr.
R-8 (76.00 - 78.50)	D-8 A D-7 Exc	8.50 7.00 1.00	\$1,389.50	250	1,535	125	\$.91	93	94%	
R-11 (86.50 - 91.50)	D-8 A D-8 S D-7 Exc DT's	13.50 6.75 7.25 30.00 107.00	8,453.26	500	2,722 1,224 ft (Trucked 2,322 yd ³) 500 ft (Pushed 400 yd ³)		3.11	17	17%	End hauled. Includes FOS time. Fill sites located at ST 95.00 - 98.00 and ST 107.00 - 108.00. There was usually one more truck than could be efficiently used. Cost includes \$346.13 of man/hour and \$16.48 of standby on dump trucks. Averaged using totals.
Totals and Averages:										
All:		283.75 hours	\$18,782.385	1,905 ft	10,284 yd ³	516 ft	\$1.83/yd ³	36 yd ³ /hr	41%	
Excluding R-11: (endhauled)		119.25 hours	\$10,329.125	1,405 ft	7,562 yd ³	300 ft	\$1.37/yd ³	63 yd ³ /hr	75%	Averaged using totals.

¹Times and costs include shaping the fill site (FOS) only when indicated under remarks.

TABLE 14 ^{not}
COSTS of MISCELLANEOUS OUTSLOPED ROADS (Volumes_A calculated)
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Road Width Feet	Unit ₁ Cost \$/LF	Production Rate (LF/hr)	Percent Bulldozer	Remarks
R-2 (10.00 - 12.00)	D-8 A Exc	1.00 0.25	\$108.75	200 ft	30 ft	\$.54	160	80%	Very slight OS
R-3 (13.00 - 18.25)	D-8 A Exc	10.75 10.25	1,736.25	525	~35 ft	3.31	25	51%	Includes 2 XRD's for gullies, fill outslope and deck edge.
R-5 (37.00 - 38.50)	D-8 S	5.75	451.375	150	~30 ft	3.01	26	100%	BOS for potential CBF. 0 1/2 R pushed ~175 feet. Removal of toe of CBF included in Rx-4.
R-5 (46.00 - 48.00)	D-8 S Exc	3.25 3.50	517.625	200	Deck to 32 ft	2.59	53	48%	Swaley OS. Includes 2 XRD's and a deck.
R-8 (79.25 - 80.25)	D-8 A D-7 Exc	1.75 0.25 0.75	351.125	100	20 ft	3.51 (\$2.33 if culvert removed excluded)	36	73%	Swaley OS. Includes removal of a cross-road culvert that was accidentally buried deeper by fill from R-8 TOS (1 1/2 hours with D-7). Grades into RB of Rx-8: time may be inaccurate.
<u>Totals and Averages:</u>		37.50 hours	\$3,165.125	1,175 ft	32 ft	\$ 2.69/LF	31 LF/HR	61%	Averaged using totals.

Footnotes:

¹R-2 has an exceptionally low unit cost; it was only very slightly outsloped. All others on this table involve swaley outsloping. Excluding R-2, the

TABLE 15
COSTS of MISCELLANEOUS ROAD TREATMENTS
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Unit Cost	Remarks
R-2 (8.50 - 10.00)	D-8 A	4.50	\$405.00	150 ft.	\$2.70/LF	Shaping ~1,918 yd ³ of fill from Rx-1 and Rx-2.
R-4 (26.00 - 29.00)	D-8 A D-8 S	2.25 2.50	398.75	300	1.33/LF	Final shaping of fill from R-3 TOS and Rx-4. Additional time was spent shaping fill during excavations.
R-8 (74.00 - 76.00)	Exc	2.25	168.75	200	.84/LF	Building berm for IBD using fill stockpiled from Rx-7 (cascade).
R-9 (80.75 - 82.50)	D-8 A D-7	2.00 5.75	631.375	175	3.60/LF	Final shaping of fill from Rx-8, Sx-8 A, Rx-9, Sx-9 A and R-10 (glacier). Time may be inaccurate due to working on crossings simultaneously.
R-10 "Glacier" (83.00 - 85.00)	D-8 R D-8 A/S D-7 Exc	4.00 9.00 2.50 0.50	1,483.75	200	7.42/LF	Removal of road and humboldt crossing (constructed to gain access to rehabilitation site).
R-12 & R-13 (93.00 - 108.00)	D-8 A	3.00	270.00	250 (+)	--	Re-open 250 feet of IBD, construct drainage ditch and 2 cross-road drains. Remainder of road between these stations is untreated or is a fill site.
<u>Totals and Averages:</u>		38.25 hours	\$3,357.625	1,275 (+)	\$2.63/LF	

TABLE 16
costs of LANDING EDGE OUTSLOPING
83-2

Site Number	Equipment	Hours	Site Cost	Length Feet	Unit Cost \$/LF	Remarks
R-4 ¹ (27.00 - 29.50)	Exc	6.75	\$506.25	350 ²	\$1.45	Cat D-8 S spent some time here also, but time was hard to separate from FOS.
R-5 ¹ (39.50 - 41.00)	D-8 S Exc	4.00 1.50	426.50	150	2.84	Exc. time spent working around stumps
R-9 ¹ (80.75 - 81.75)	D-8 A	3.00	270.00	100	2.70	Time may overlap with adjacent crossings and FOS.
R-11 (85.00 - 86.50)	D-8 A	1.50	135.00	150	.90	Landing was shaped to drain. (very slight OS).

Totals and Averages: 16.75 hours \$1,337.75 750 feet \$1.78/LF

¹Edges of landings had potential to fall into stream channels. Edges were pulled back and fill stored on stable portions of the landing. Times do not include FOS.

²Length around edge of landing longer than mid-road station distance.

Miscellaneous Heavy Equipment Costs

Miscellaneous heavy equipment costs for Unit 83-2 total \$10,425.535 (Table 17). One secondary treatment is included on this table. The remainder cannot be categorized as primary or secondary costs, but are truly miscellaneous.

The secondary treatment included here is moving straw with the heavy equipment from stockpiled locations onto finished slopes. This cost is \$856.75. Additional small blocks of time (less than 15 minutes each) was spent moving straw throughout the heavy equipment phase; this was included in the cost of the individual worksites.

Travel, between and to and from worksites, accounted for the largest portion of the miscellaneous costs: \$4,861.875. This includes \$1,162.50 of excavator cost to gain access to skid trail crossings. The remainder is accumulated time (in half hour blocks) spent traveling on the haul road between worksites and fuel trucks. Some worksites were inaccessible to trucks because of partial excavations during the end hauling phase.

Paid down time for all pieces of equipment totals \$1,059.50. This covers breakdowns repaired in less than a half hour.

Miscellaneous costs of \$2,386.00 includes discussions, being unavoidably stuck, helping others get unstuck, fueling while on the slope and construction of a couple of water bars. Discussions with equipment operators regarding desired end product and equipment approach cost \$1,005.75. Time spent unavoidably stuck in various precarious locations, accounts for \$933.00. Of this, 83 percent was incurred while working on the R-10 "Glacier." Helping others get unstuck accounts for \$334.75. Fueling the excavator on the slope cost \$56.25.

Miscellaneous water barring also cost \$56.25.

Brushing roads for dump truck access and straw stockpiles totals \$839.25.

Moving salvagable culverts to temporary storage points cost \$422.16. The culverts were periodically hauled away by the park's 2 ton boom truck. Cost of boom truck operation is not included in the project.

TABLE 17
83-2 MISCELLANEOUS HEAVY EQUIPMENT COSTS

Category	Equipment	Hours	Cost	Site Cost
Moving Straw	Bulldozers (3)	6 1/4	\$556.75	\$856.75
(Secondary Treatment)	Excavator	4	300.00	
Travel ¹	Bulldozers (3)	24 1/2	2,180.625	4,861.875
(between, and to	Excavator	35 1/4	2,643.75	
and from work-	Loader	1/2	37.50	
sites) ¹				
Paid Down Time	Bulldozers (2)	9 1/2	853.25	1,059.50
(accum. 1/2 hour	Excavator	2 3/4	206.25	
periods)				
Miscellaneous Time	Bulldozers	19 1/4	1,898.50	2,386.00
paid in full ²	Excavator	6 1/2	487.50	
Brushing	Bulldozers (3)	8 1/4	783.00	839.25
(for dump trucks)	Loader	3/4	56.25	
Moving Culverts	Bulldozers (2)	3	247.00	422.16
	Excavator	1/2	37.50	
	Loader	1/2	37.50	
	Dump truck	3	100.16	
				<u>\$10,425.535</u>

¹Slope travel time totaled 15 1/2 hours; the remaining time is accumulated 1/2 hours for travel from worksite to fuel truck due to the impassability of the road to vehicle travel. (See report text for further explanation)

²Time includes discussions (42 percent), unavoidably stuck in the mud (39 percent), helping others get unstuck (14 percent), fueling while on the slope (2 percent), and construction of a couple of waterbars (2 percent).

Evaluation of Heavy Equipment Techniques and Costs

Overall the heavy equipment and techniques used to perform the erosion control rehabilitation work on Unit 83-2 worked well. We learned more about the limitations and advantages of different pieces of equipment, and experimented with some new techniques (new to us, anyway). The costs are not excessive, considering the extremely steep, unstable slopes that were treated, and the large size of several stream excavations. For the most part, the prescriptions are holding together well, but time will tell on this matter. As of early January, a slope failure (also involving some fill) has occurred below Rx-3, and a portion of the left stream bank of Rx-5 has dropped several feet (although little sediment has reached the creek). Some downcutting is occurring at the upper end of Rx-5, where the herringbone arrangement of organics were placed too far apart. Rx-11, which was only partially excavated has downcut 2 to 3 feet, but appears to have stabilized. To date, other areas have experienced little or no erosion.

Regarding

re-construction of roads, we learned that the bulldozer must be equipped with a winch. A minimum of \$770.00 would have been saved, just in time spent stuck in the R-10 "Glacier". The winch would have facilitated bringing logs to the "Glacier" for construction of the corduroy road; this should be kept in mind for stream crossing reconstruction on the 1840 road! Also a bulldozer equipped with a winch generally has a lower hourly rate than one with rippers.

We found ripping goes a little quicker if on the first pass, usually the slowest, the rippers are only about two thirds of the way down. Subsequent passes (with 1 tooth between previous furrows) decompact the area sufficiently. The ripping should be done all at once, and that dozer replaced by one with a winch.

The extra weight of the rippers makes pushing slower, and outsliping on steep slopes precarious.

Haul road crossings (excluding those end-hauled) proceeded efficiently. Preliminary excavation (up to 75 percent of the total volume) using a CAT D-8 H reduced excavator time and lowered our average costs from previous years. The excavator was used mainly to define the thalweg and place armor. Use of a large bulldozer should be maximized on crossings. Those excavations done almost exclusively by the bulldozers were the cheapest per cubic yard. However, local ground conditions, natural channel configuration and stump location may require more excavator time.

Rock armor placement was costly, as usual. The bucket clamp on the excavator facilitates this process. The clamp was also extremely useful in dealing with organics.

The skid trail crossings on Unit 83-2 were all small ($<150 \text{ yd}^3$), making solo excavations by the excavator not only possible but very efficient. Here the bucket clamp was necessary for removing and/or placing organics in the channel (Refer to L. Johnson's "Summary of Erosion Control Work, Unit 83-5, W-Line and K & K Slope"). It is recommended that skid trail access routes be brushed before the excavator travels them (this can be done by the laborers, the bulldozer (fast), or the excavator (slow!)), and that if the excavator has to travel or work on steep ground, it be equipped with track guards (to prevent the tracks from coming off the rollers).

Organics must be placed with spacing similar to check dams. They should be angled down towards the center of the channel, in a herringbone arrangement. If not carefully placed, they may cause additional channel erosion.

This year end-hauling was cheaper than ever before (per yd^3). Several things helped: short haul distances, having room for two trucks at or very near the loading spot, using a large track mounted loader (able to load a truck in less than two minutes), and having plenty of pull outs or passing spots on the way to the fill sites. The end-hauled crossings were costly in terms of total cost, but this is due to the large volumes of fill in the channels. If they had not been totally excavated, they would have needed rock armor, or other channel protection. Costs could have been 10-15 percent less than what we spent, but should the flow ever escape the rocked thalweg (likely in areas where there is deposition of sediment from eroding skid trail crossings above), there would be high potential for large amounts of erosion in the excavation.

When end-hauling a total outslope, loading is done most efficiently by the excavator, as long as it can reach all the necessary fill. If a dozer is needed to push fill up to the excavator, it may be quicker to use a loader, and have the bulldozer push the fill all the way up to the loader.

For any end-hauling, the number of trucks needed will depend on the excavation rate as well as the haul distance. On short hauls, time to back in and load may be the limiting factor.

Most of the outsliping was done by the bulldozers this year, as suggested by Ed Wosika. - This worked very well, except around stumps and straw stockpiles. Excavator assistance proved cost effective in these spots. The excavator was also used to remove the lower berm along areas of "Type 2" outsliping. This was the most cost effective alternative to pushing this material off the edge of the road (where it could enter a stream channel) (this is also discussed under "Costs of Outsliping with Known Volume"). The bulldozer with the angle blade did most of the outsliping. Initially this CAT

did virtually all the outsliping (even around stumps). It proved to be more cost effective to have him leave areas around stumps and straw piles, because in order to take advantage of the angling blade in these locations, he would have to stop and re-position the blade several times. A hydraulic operated angle blade would be superior in these locations (but these are limited to smaller bulldozers). If the site is set up so that outsliping can proceed for several hundred feet, always moving the dirt the same direction, the angle blade works well. It reduces the amount of maneuvering (quartering) to complete the outslope. However, our road reaches were too short, or interrupted too frequently by stumps or bales, to allow best use of the angling blade.

The amount of long pushes versus working in restricted spaces must be carefully weighed in the choice of a bulldozer. We had many long pushes, and not too many places where close quarters made coordination a problem, and so things worked fairly well with 2 large bulldozers. In tight quarters, we found that the D-8 size bulldozer was a little large to work in coordination with the excavator. However, where push distances were over 100 feet, the D-8 was very effective. Two large bulldozers, working as a relay team, are essential for pushes over about 200 feet. Using this method, the cost per cubic yard is competitive with end-hauling for distances up to perhaps 600 feet. It is more efficient if the push route is not ripped until pushing is completed: the fill scoots along the hard surface.

For watershed rehabilitation work, especially when working in flowing streams or on wet slopes the widest tracks available should be used whenever cost permits (28" is the widest for CAT D-8, without going to the special low ground pressure machines, which are only available in D-7 and smaller sizes).

When working on wet ground a considerable amount of time can be spent not only being stuck but avoiding getting stuck. With wide tracks, the bulldozer can operate as if it is dry; it is nearly impossible to get stuck. It is also a safeguard against rained-out stand-by costs. Of all the different things we tried this year, wide tracks were the best.

For cost estimating, in areas where a long push is required, bulldozer time must reflect the expanded volume of fill. This is taken into account on the nomograms for total outsloping, but we neglected it in our cost estimates for stream excavations. When there is a large volume to be moved a long distance, the error involved can be considerable.

LABOR INTENSIVE PHASE

LABOR INTENSIVE APPLICATION

Labor intensive work was completed by Redwood National Park laborers (38 percent), Redwoods United, Inc. employees (35 percent), and YCC crews (27 percent), Table 18. Redwoods United was used primarily for straw mulch application and brushing the M-3-1 haul road crossings. The YCC crews were used entirely for straw mulch distribution and application. Redwood National Park laborers did a variety of tasks, though again the main treatment work was straw mulch distribution and application, and brushing haul road stream crossings. Other labor intensive treatments included minor channel armoring (during straw application work), installing culverts on the M-3-1 to open and maintain the road (using Redwood National Parks backhoe), moving excess straw bales to W-Line rehabilitation site, and travel between Orick and the site.

LABOR INTENSIVE COSTS

The distribution and application of straw mulch was the single largest cost (46 percent) of the labor intensive phase (Table 19). The total straw mulch cost was \$9,550.53. In addition to labor costs to distribute and apply the straw (\$5,301.28), this includes the purchase and delivery cost for 1,150 bales (\$3,392.50), and the use of heavy equipment for distribution (\$856.75). The area mulched totals 16.35 acres, with a unit cost of \$584.13 per acre or \$8.30 per bale.

The second highest labor intensive cost was the category of travel time (\$3,327.40, 28 percent). Travel time between Orick and M-3-1 haul road averaged 2 1/2 hours round trip daily (25 percent of a 10-hour work day) for Redwood National Park laborers, and Redwoods United employees. Travel time for YCC was 50 percent of their 8-hour work day, leaving only 4 hours of on-

site work time (which includes walking in to a worksite, setting up, getting organized, and finally doing work with breaks and a lunch); very inefficient!

Brushing haul road stream crossings on the M-3-1 was the next highest labor intensive phase, costing \$2,629.50. Brushing stream channel crossings was completed on 14 crossings during the month of March to help facilitate photo point documentation and volume surveys.

There were two miscellaneous labor intensive tasks, totaling \$336.22. The first task was the installation of a culvert on the M-3-1 glacier earthflow using Redwood National Parks backhoe. This occurred prior to the ripper bulldozer opening the M-3-1 for rehabilitation work. The other task was transporting excess straw bales (150 - 200) from the M-3-1 and M-3 stockpiles to the W-Line rehabilitation site in September.

EVALUATION OF LABOR INTENSIVE WORK

The main labor intensive treatment on the M-3-1 unit was the application of straw mulch on treated haul roads and stream crossings. As of September 1st only 425 bales of straw had been spread using Redwood National Park laborers (135 person hours) and YCC crews (144 person hours). At this time, the basin received over 4 inches of precipitation over a 3-day period. There remained 725 bales of straw to be spread, which were now saturated with water and incredibly heavy to move. Even so, Redwood National Park laborers (135 person hours) and Redwoods United employees (255 person hours) were able to spread 41 percent more bales taking only 28 percent more time compared to the efficiency (or inefficiency) of the YCC crew (with Redwood National Park laborers) prior to September 1st. However, the quality of work must also be compared. Work completed after the rains was patchier: the straw was so wet that it clumped together making it more difficult (or impossible) to spread evenly. It also took less

time to spread because in some cases the bales were simply broken open and the pancake clumps tossed out in a random fashion. Therefore, in many locations the straw application is 4 - 8 inches thick. Approximately 50 bales were wasted because they were too heavy to move and/or the baling wires had broken before they could be placed for spreading.

The straw bales were stockpiled in pre-calculated quantities at flagged locations for later distribution by the heavy equipment. This method did not work as well on this unit as it did on Unit 82-1. The main problem was getting the bales from the stockpile and distributing them with a dozer onto an outloped road section. After the rain, it was virtually impossible for the equipment to distribute the straw, because of the muddy conditions and saturated bales. When the laborers came along, they spread what they could wherever the saturated bales ended up. Another problem was the location of the initial stockpile deliveries. Some stockpiles were placed too close to the outboard edge of the road, where the equipment had a difficult time getting behind the straw bales. And in another case the straw was accidentally placed off the edge of the road requiring the excavator to retrieve the bales. Next year we plan to utilize the technique used on Unit 83-7, where the excavator places bales above the cutbank every 20 - 30 feet along the road. This reduces the number of times the straw is handled before it finally gets spread, reducing the cost and insuring proper straw application rates.

Travel time by the YCC crews consumed up to 50 percent of their 8-hour work day. YCC crews should be required to work a 10-hour day if they are to be used on future rehabilitation labor intensive projects. There is a gross inefficiency by not having them out there working the same hours as the in-house and Redwoods United laborers.

All in all, we were pleased with this year's labor intensive work performed and its cost effectiveness, given the poor conditions that occurred. We would like to thank all the laborers who worked on our site for a job well done, and especially, Lou Tirado, for doing an excellent job of organizing the work load between rehabilitation units.

TABLE 18
LABOR INTENSIVE COSTS
83-2

	Work Types	Type of Laborers	Person Hours	Cost	Total Cost	Quantity	Total Person Hours	Rate: Quantity/ Hour, etc.	Total Unit Cost	Percent of Total Cost &	Percent of Total Hours
SECONDARY TREATMENT	Straw Distribution	RNP YCC	82 1/2 112	\$741.38 375.20	\$1,116.58	1,150 Bales	194 1/2	6 Bales/ person hour	\$.97/ Bale	10%	10%
	Straw Application	RNP RUI YCC	270 255 144	2,353.35 1,348.95 482.40	4,184.70	1,150 Bales	669	1.7 Bales/ person hour	3.64/ Bale	36%	35%
	TOTAL SECONDARY TREATMENTS			= \$5,301.28		863 1/2 Person Hours				46%	45%
	Brushing	RNP RUI	142 1/2 247 1/2	1,320.22 1,309.28	2,629.50	14 haul road crossings	390	28 person hours crossing	188.00/ crossing	23%	21%
	Travel	RNP RUI YCC	177 1/2 167 1/2 256	1,583.73 886.07 857.60	3,327.40	--	601	--			28%
MISCELLANEOUS	Miscellaneous ¹	RNP	37 1/2	336.22	336.22	--	37 1/2	--		3%	2%
	TOTAL MISCELLANEOUS TREATMENT			= \$6,293.12		1,028 1/2 Person Hours				54%	55%
	GRAND TOTAL LABOR INTENSIVE COST				<u>\$11,594.40</u>		RNP 710 person hours RUI 670 person hours = 1,892 person hours YCC 512 person hours				

¹ See Report Text.

TABLE 19
STRAW MULCH COSTS
83-2

I. Purchase and delivery cost for 1,150 bales @ \$2.95/bale:		\$3,392.50
(Ordered 1,400 bales @ \$2.98/bale)		(4,155.00)
II. Heavy equipment straw distribution cost: ¹		
A. Moving straw using D-8 bulldozers, and excavator;	\$856.75	856.75
III. Labor Intensive Costs:		
A. Distribution (using dump trucks, boom trucks, all labor costs);	1,116.58	
B. Application (RNP, RUI, YCC);	4,184.70	\$5,301.28
	TOTAL COST =	\$9,550.53

UNIT COSTS: Total Bales Used 1,150 \$8.30/bale
 Total Mulched Disturbed Acres 16.35 \$584/acre
 Application rate was 4,925 lbs/acre

¹Also included in Table 17, Miscellaneous Heavy Equipment Costs

VEGETATION SUMMARY REPORT
WATERSHED REHABILITATION UNIT 83-2
M-3-1 ROAD AND SLOPE

APRIL 1984

Bonnie C. Griffith

Introduction

Site Description

Rehabilitation Unit 83-2 (M-3-1 Road and Slope), approximately 25 miles south-east of Orick, is located on the west side of Redwood Creek basin within the upper reaches of the Bridge Creek drainage (see map 1). The unit of 470 acres has a northwest aspect with an elevation range of 1500 to 2610 feet and a slope of 15 to 110 percent. Weather conditions range from cool, rainy winters with a mean annual precipitation of 70 to 100 inches and a mean annual temperature of 53° F. Heavy equipment phase, under the supervision of Terry Spreiter, Site Geologist, and Louise Johnson, Physical Science Technician, was done below 2300 feet from July 6 to September 11, 1983. A total of 1.9 miles of haul road was ripped and outsloped and 11 haul road stream crossings and 28 skid trail crossings were excavated by bulldozers (CAT D8H 46A) and an excavator (John Deere 690B), resulting in 16.61 acres of rehabilitated area. A total of 37,979 yd³ of material was excavated from the site. This included 16,019 yd³ from haul roads, 19,025 yd³ from road crossings, and 2,935 yd³ from skid trail crossings. Straw mulch was applied at approximately 5,000 lb/A. See map 2 for area left unstrawed.

Prior to logging, the Bridge Creek drainage supported on old-growth redwood forest and its associates. These included Douglas-fir, Pseudotsuga menziesii; Western hemlock, Tsuga heterophylla; Tanbark-Oak, Lithocarpus densiflora; Madrone, Acer macrophyllum; Wax myrtle, Mycra californica; California rose-bay, Rhododendron macrophyllum; California huckleberry, Vaccinium ovatum; salal, Gautheria shallon and Yerba de Selva, Whipplea modesta. In moist areas the vegetation composed of red alder, Alnus oregona; Western coltsfoot, Petasites palmatus; horetail, Equisetum; Chain fern, Woodwardia frimbriata; and deer fern, Blechnum Spicant.

Logging of Rehabilitation Unit 83-2 began in 1964 with the construction of the M-3-1 Road. Of the 345 acres harvested the following three years, 286 acres were tractor yarded on the hillslopes above the road, and 58 acres were cable yarded below the road. A total of 424 acres (90 percent of the site) was logged with the final two cable units (75 acres) and a tractor yarded section (4 acres) in 1975 and 1976. Only two old growth areas (46 acres) remain in drainages 4 and 7 (see map 2).

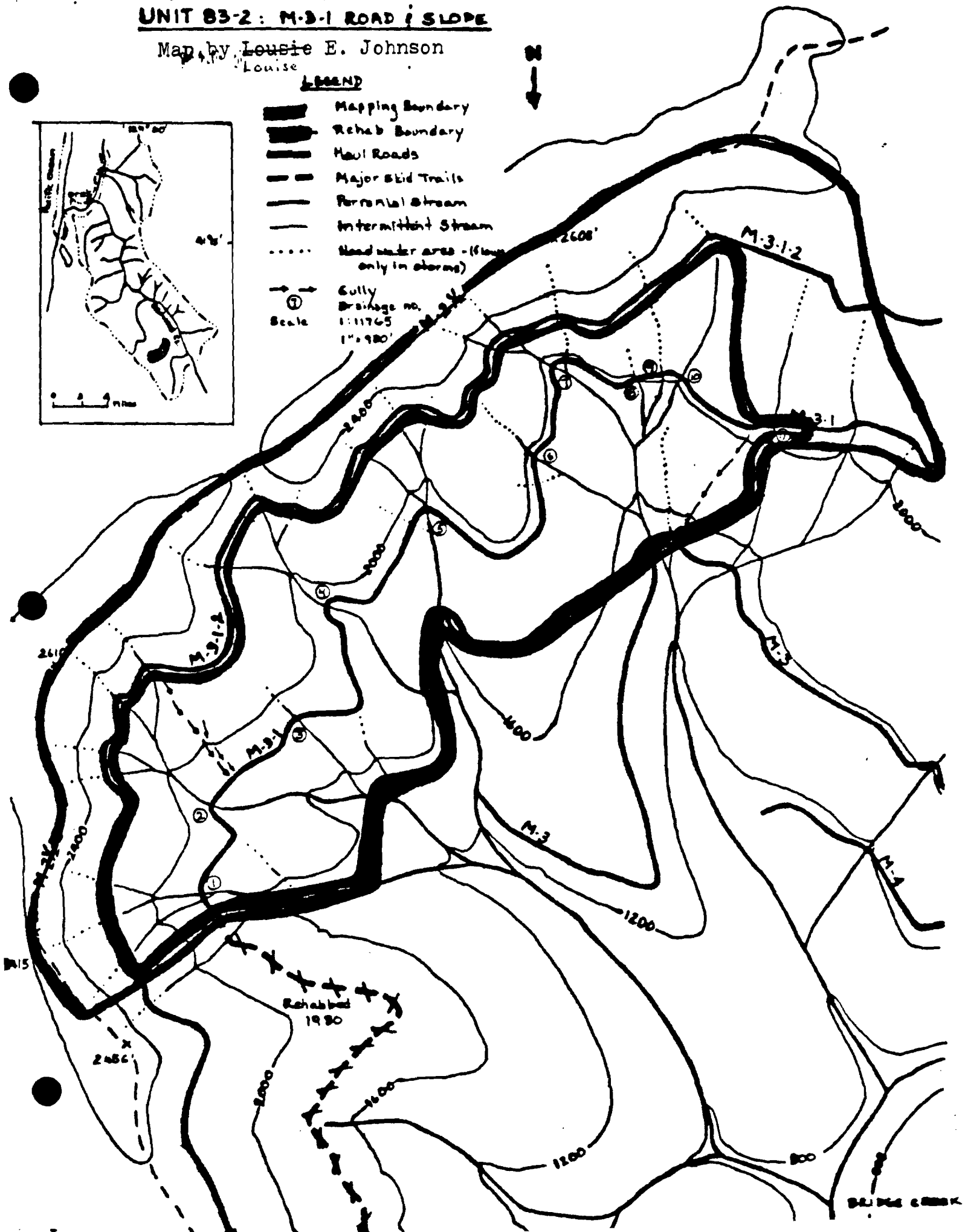
Post-logging vegetation includes predominately second-growth Douglas-fir and to a lesser extent second-growth and resprouting redwood, Tanbark-Oak, madrone, and wax myrtle. The two dominate shrub species are coyote brush, Baccharis pilularis var. Consanguinea and Blue brush, Ceanothus thyrsiflorus. In the drainages and along the in- and out-board road edges, red alder is dominant. Other species associated with these wet areas include horetail, Western coltsfoot, and chain fern. On the road surface there are 'weedy' species: Cirsium sp., Sonchus sp., Hypericum sp., Taraxacum sp., Gnaphalium japonicum, and Epilobium paniculatum.

Map 1. Site Location
UNIT 83-2: M-3-1 ROAD & SLOPE

Map by Louise E. Johnson
 Louise

LEGEND

-  Mapping Boundary
-  Rehab Boundary
-  Haul Roads
-  Major Stid Trails
-  Perennial Stream
-  Intermittent Stream
-  Headwater area - (flow only in storms)
-  Gully
-  Drainage no.
-  Scale 1:11765
1" = 980'



The dominate soil series of Bridge Creek drainage are Coppercreek, Devils creek, Ahpah, and Lacks. The following are brief soil descriptions of each series.

Coppercreek

Coppercreek soils are formed in colluvium and residium derived from schist. These soils are well drained, deep to very deep with medium runoff. They have dark loam A horizons and yellowish-brown to brown gravelly clay loam B and C horizons. Coppercreek soils classified as a fine loamy, mixed, isomesic Typic Humitropepts. They occur on hillslopes with 15 to 70 percent slopes. Old growth vegetation associated with these soils are redwood, Western Hemlock, Tanbark-Oak, Douglas-fir, California rose-bay, and sword fern.

Devils creek

Devils creek soils are formed in colluvium derived from schist. These soils are very deep, moderately well to somewhat poorly drained with medium runoff. They have dark brown loam A horizons, yellowish-brown to brown gravelly clay loam B horizons, and gray, mottled gravelly loam Cg horizon. Devils creek soils are classified as a fine-loamy, mixed, isomesic Typic Humitropepts. They occur in hillslopes hollows, along streams, and on lobate landslides or land flow colluvium deposits. Slopes are 30 to 70 percent. Old growth vegetation associated with these soils includes redwood, Western hemlock, Tanbark-Oak, salal, sword fern and redwood sorrel. Typical cutovers have dense stands of red alder with an understory of coltsfoot and sword fern.

Ahpah

Ahpah soils are formed from residium weathered from schist. These soils are well drained, deep to moderately deep with medium runoff. They have brown gravelly loam A horizons and yellowish-brown gravelly clay loam B and C horizons. Ahpah soils are classified as fine-loamy, mixed, isomesic Typic Humitropepts. They occur along ridgelines and upper hillslopes with slopes of 15 to 50 percent. Vegetation associated with this type includes Douglas-fir, Tanbark-Oak, Madrone, redwood salal, and California rose-bay.

Lacks

Lacks soils are formed in residium and colluvium weathered from schist. These soils are well drained moderately deep with medium runoff. They have brown gravelly loam A horizons and light yellowish-brown very gravelly clay loam B and C horizons. Lacks soils are classified as loamy-skeletal, mixed, isomesic Typic Humitropepts. They occur on convex hillslopes in highly dissected terrain with slopes of 30 to 75 percent. Vegetation associated with this soil includes Douglas-fir, redwood, Tanbark-Oak, Madrone, and huckleberry.

Table 1. Vegetation Treatments - Rehabilitation Unit 83-2.

Date Planted	Worksites	Area (sq. ft.)	Spacing (feet)	Douglas-fir	Redwood	Alder
1-17-84	R-1	19,450	8			--
	Rx-1	6,770	4			140
	R-2	19,900	8			--
	L-1	24,300	8			--
	Rx-2A	9,450	8	900	1,356	--
	R-2	5,800	8			--
	Rx-2	12,375	4			395
	R-3	44,800	8			--
	Rx-3	3,080	4			20
	R-4	15,100	8			--
1-18-84	L-2	89,400	8			--
	R-4	35,800	8			--
	Rx-4	26,600	4	890	1,645	660
	R-5	53,400	8			330
1-19-84	Rx-5	33,915	4			1,225
	R-6	22,700	8			--
	L-3	34,800	8			--
	R-6	35,300	8	814	2,170	270
	Rx-6	8,840	4			--
	R-7	3,400	8			--
	Rx-7	20,190	4			540
1-23-84	R-8	16,500	8			--
	Rx-8	3,950	4			--
	L-4 (R-9)	21,900	8	714	1,340	--
	R-10	7,800	8			--
	Rx-10	1,860	No treatment			--
	*R-11 (includes Rx-11)	41,340	8			--
	R-12	34,700	8			12
Total		653,420		3,318	6,512	3,842

R - road reach

Rx - road crossing

L - landing

*Mass movement area not planted.

Revegetation Objectives

The main objective of planting with conifers and red alders is to accelerate the revegetation and the stabilization of rehabilitated logged slopes, haul roads, skid trails, and road and stream crossings.

There are several reasons why revegetation treatments are not prescribed for all ripped and/or outsloped areas. The ground may be too rocky for planting tools or too wet for the planting stock. On a steep slope, planting may result in unwanted ground disturbance. In these instances, it is better to rely on the surrounding vegetation to establish new plant growth. Vegetation treatments may not be prescribed when there is a sufficient seed source available to the rehabilitated area. During the first winter season, it may be more cost effective to defer revegetation treatment in a few areas when a definite possibility of mass movement exists.

Vegetation Treatments

Planting stock consisted of two-year, bareroot Douglas-fir (seed zone 092, elevation 2000 feet) grown and purchased from Arcata Lumber Company, Smith River, And Louisiana-Pacific Corporation, Big Lagoon Nursery, Crannell.

Planting was accomplished January 17, 18, 19, and 23, 1984, by Redwood National Park labor and Redwoods United, Inc. crews. Road reaches were planted with two redwood for every Douglas-fir at an average spacing of eight to ten feet. Three Douglas-fir were prescribed for every redwood at eight to ten feet spacings for the exposed landings occurring along the ridgelines. Road crossings received two alder for every redwood at four to five foot spacings. Road crossing (Rx-2A) was planted with two Douglas-fir for every redwood (Table 1). During the first two days of planting the straw and surface soil were frozen in the morning and throughout much of the day depending on the slope aspect. Work leaders were instructed to make sure trees were 'kicked in' properly to prevent frost heaving. The last two days of planting were warmer and the ground was soft to muddy on certain outsloped road sections. In February there was a light snow within the Redwood Creek basin, which covered the M-3-1 road and slope.(map 2).

Additional trees were planted on February 1, 1984, at five worksites: Rx-2 - 35 alder and 5 redwood both at 5 foot spacings; Rx-5 - 10 Douglas-fir at 15 foot spacings and 25 alder at 3 foot spacings; Rx-6 - 14 Douglas-fir at 10 foot spacings and 30 alder at 5 foot spacings; Rx-7 - 12 redwood and 30 alder both at 5 foot spacings; and R-12 - 12 alder planted in three groups of four at 1 foot spacings and 14 Douglas-fir at 10 foot spacings.

The cost for planting and planning the revegetation prescription for Unit 83-2 is summarized in Table 2. Table 3 is the cost analysis for planting stock.

Table 2. Rehabilitation Unit 83- 2. Revegetation Costs.

PLANTING

<u>Redwood National Park</u>	<u>Hours</u>	<u>Costs</u>
Biological Technician ¹	9	\$ 84.69
Transportation ²	12	163.18
Subtotal	21	247.87
In-house Labor ³	51	474.44
Transportation	24	286.32
Subtotal	75	\$ 760.76
<u>Redwoods United, Inc.</u>		
Personnel	243.5	\$1,332.24
Transportation	108.5	879.62
Overhead ⁴		398.14
Subtotal	352	2,610.00
Total	448	3,618.63
COST PER TREE		\$ 0.26

PLANNING AND REPORTS

<u>Biological Technician</u>		
General	57.5	\$ 547.40
Experimental Plots	10	94.10
Reports	10	94.10
Subtotal	77.5	735.60
TOTAL	525.5	\$4,354.23

¹Wages include 11 % for government benefits - term employees.

²Transportation includes 125 mi. x \$0.50 /mi. plus 4 days @ 62.50/day.

³Wages include 7% for government benefits - temporary employees.

⁴18 % Administrative charge on wages plus transportation.

Table 3. Planting Stock Costs

Planting Stock	# Planted	Purchase Cost/Tree	Subtotal	Transportation Cost/Tree	Subtotal	Total
Douglas-fir	3,318	\$0.120	\$ 398.16	\$0.020 ²	\$ 66.36	\$ 464.52
Redwood	6,518	0.149	971.18	0.012 ³	78.22	1,049.40
Alder	3,842	0.149+0.015 ¹	630.09	0.012 ³	46.10	676.19
Total	13,678		\$1,999.43		\$190.68	\$2,190.11
Overall Cost/Tree		\$0.146		\$0.013		\$ 0.16

¹Costs for inoculation.

²Costs include transport from Arcata Lumber Company, Smith River to Orick, California and to rehabilitation sites.

³Costs include transport from Louisiana-Pacific Nursery (Crannell) to Orick, California and to rehabilitation sites.

Test Plots

On February 1, 1984, survival plots were established at three sites with different exposures. The rows of all plots were marked by wooden stakes. Flagging was not used because in the past it has attracted the unwanted curiosity of the deer and elk. Landing 2 is a highly exposed and dry area occurring along the ridgeline. A random area was chosen, staked and conifers counted: 16 redwood and 41 Douglas-fir planted at an average 8 foot spacing. Landing 4, which is less exposed and dry, occurs below the ridgeline. An area was randomly selected, staked and 13 redwoods and 25 Douglas-fir were counted. Road reach 12 protected by second growth vegetation is a wetter site than landing 2 and landing 4. Only the survival of 25 Douglas-fir will be measured at this landing. Trees will be monitored at the end of summer (August 1984) and in the following Spring of 1985 (map 2).

Monitoring Recommendations

An area to be watched is the landslide at road reach 11. This mass movement, surrounded by seed bearing alder, was outslowed and no vegetation treatment was prescribed. It will be useful to observe the rate of alder regrowth and how effectively they are able to minimize the rate of movement.

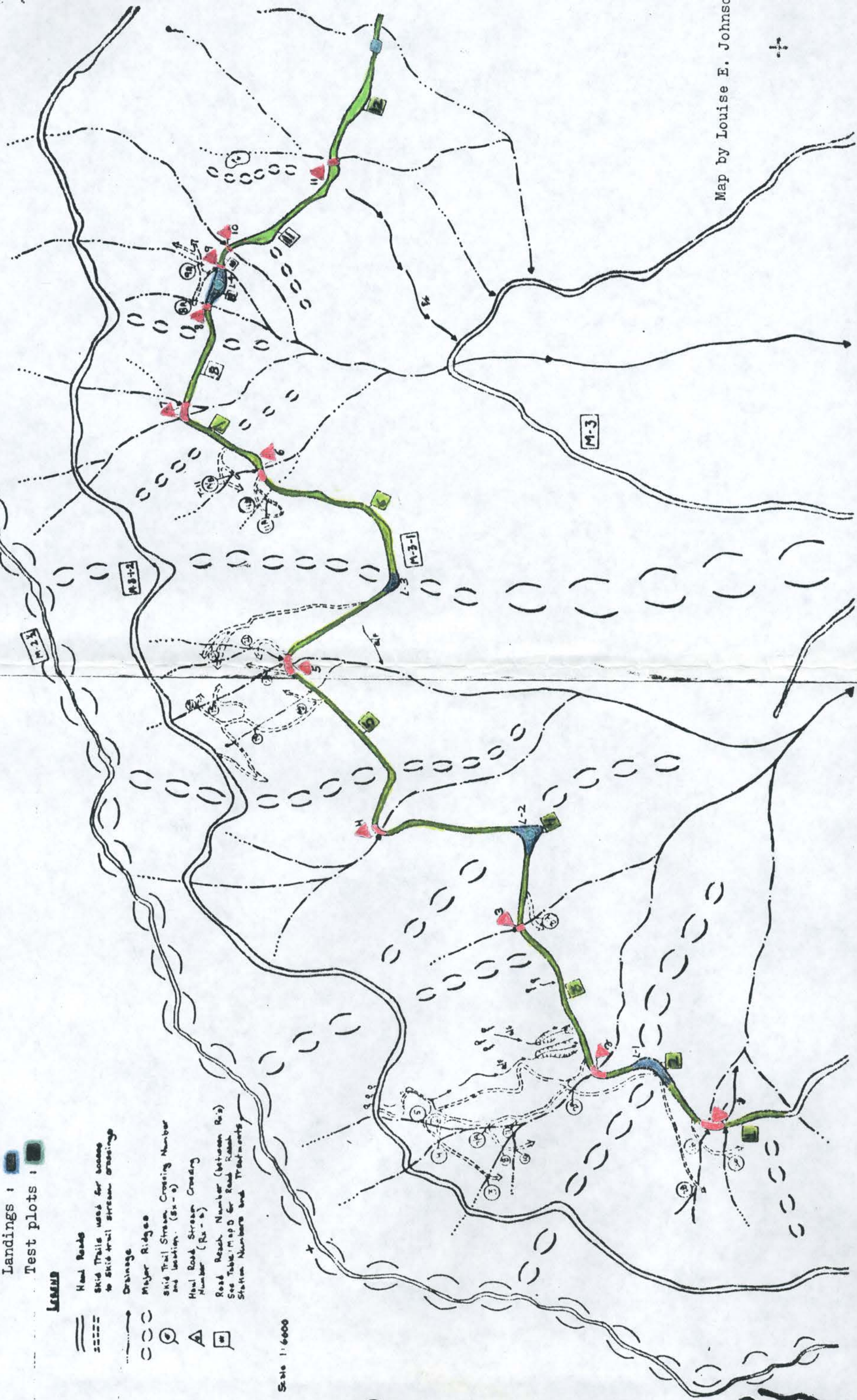
Map 2. Rehabilitation Unit 83-2. Worksite Locations.

- Road reach : 
 Road crossings : 
 Landings : 
 Test plots : 

Legend

-  Haul Roads
 Skid Trails used for access to skid trail stream crossings
 Drainage
 Major Ridges
 Skid Trail Stream Crossing Number and location. (Sx-a)
 Haul Road Stream Crossing Number (Rx-a)
 Road Reach Number (between Rx's)
 See Table: Map D for Road Reach Station Numbers and Treatments

Scale 1:6000



Map by Louise E. Johnson



Unit: 83-2 PP#8 Pre H.E.



Unit: 83-2 PP#8 Post H.E.



Unit: 83-2 PP#19 Pre H.E.



Unit: 83-2 PP#19 Post H.E.



Unit: 83-2 1-A 7/19/83 PP#20 RX-5



Unit: 83-2 1-B 8/8/83 PP#20 RX-5



Unit: 83-2 1-C 8/9/83 PP#20 RX-5



Unit: 83-2 1-D 10/4/83 PP#20 RX-5



Unit: 83-2 1-E 7/10/84 PP#20 L.T.



Unit: 83-2 2-A 7/12/83 PP#17 RX-4



Unit: 83-2 2-B 7/22/83 PP#17 RX-4



Unit: 83-2 2-C 7/27/83 PP#17 RX-4



Unit: 83-2 2-D 10/4/83 PP#17 RX-4



Unit: 83-2 2-E 7/10/84 PP#17 L.T.



Unit: 83-2 PP#70 Landslide, Pre H.E.



Unit: 83-2 PP#70 Landslide. 4/5/83



Unit: 83-2 PP#71 Landslide, headscarp.



Unit: 83-2 PP#75 Active Landslide toe.