REDWOOD NATIONAL PARK REHABILITATION STUDY

(Test Area 1 and 2)

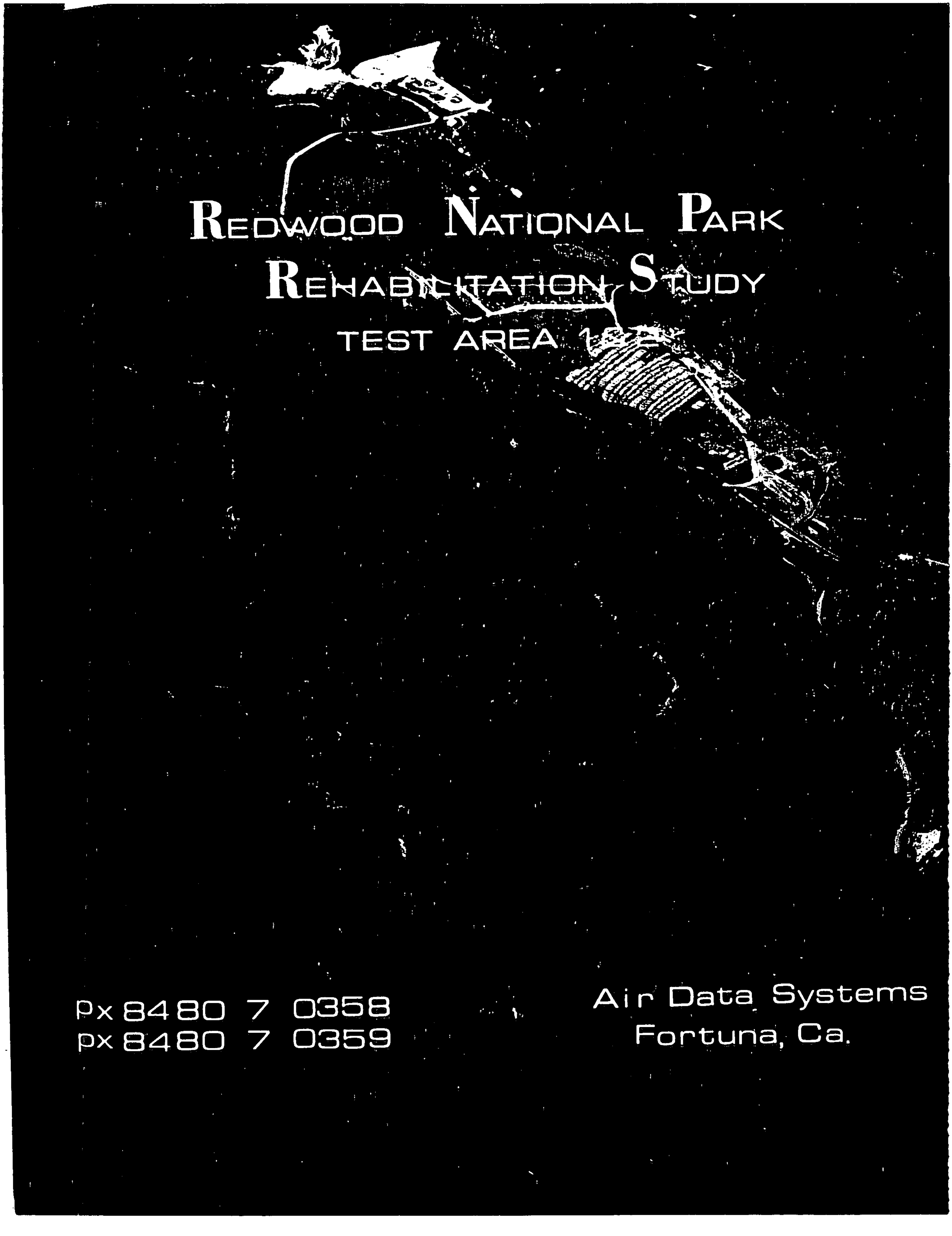
REHABILITATION METHODS AND COST ANALYSIS

by

Jack Naylor
Program Director
Photogrammetrist

Dennis Giovannetti
Geologist

November 1977



Redwood National Park Rehabilitation Study

TEST AREA 1&2

px 8480 7 0358
px 8480 7 0359

Air Data Systems
Fortuna, Ca.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

(All plates located in back pocket.)

ACKNOWLEDGEMENTS

We are grateful to Ms. Joyce Schmitz for her technical assistance in the writing of this report. Thanks are extended to Mr. Rudy Gillard for his support of the project. Conversations with Dr. Dick Janda and Mike Nolan of the U. S. Geological Survey were very helpful. Thanks also to Steve Veirs for several constructive discussions.

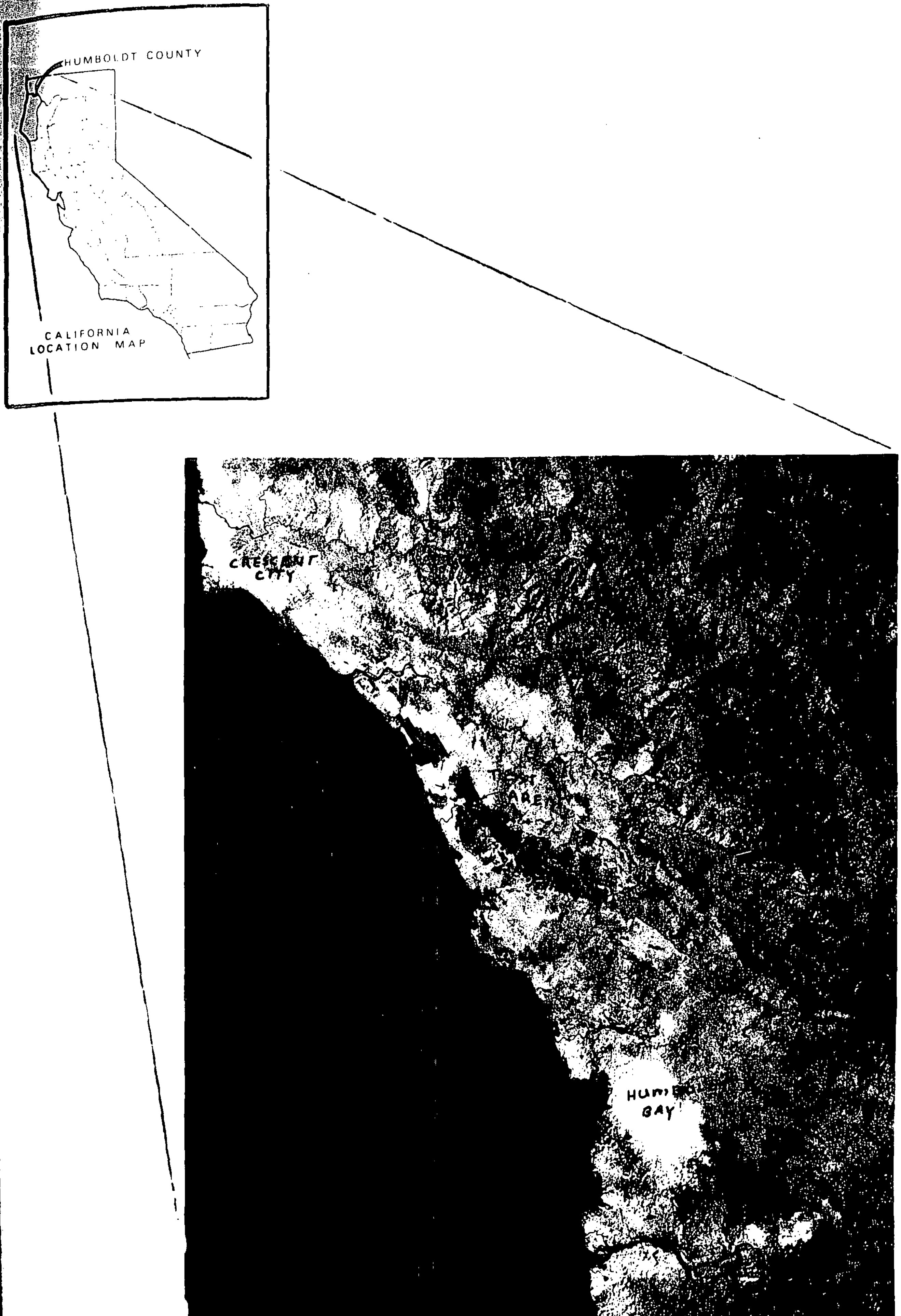
INTRODUCTION

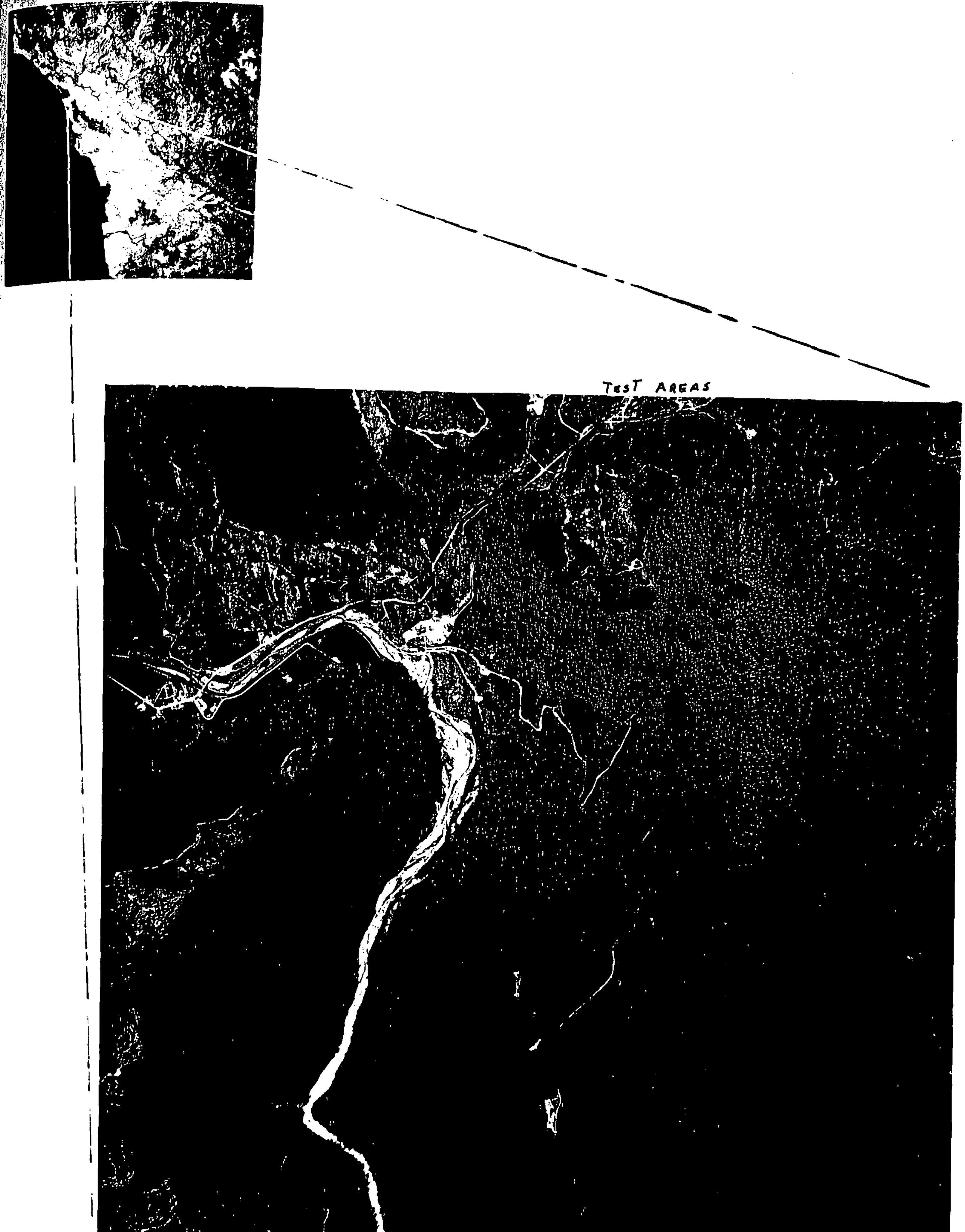
The purpose of this study was to apply rehabilitation measures to a 50 acre and a 180 acre test site (10-15 year old cutover timber lands). The techniques used are discussed and analyses are given for the two test areas for 1977 prices and terrain conditions, and also for 1977 prices and conditions as they existed in 1966. A stability analysis, based on geologic studies, is given for both test areas.

The two test areas are located in Redwood National Park (S23, T11 N, R1E, Humboldt Meridian, Figures 1 and 2). Test area 1 is primarily a northeast facing slope bounded on the east by Little Lost Man Creek. It was logged in 1965. Test area 2 has variable topography and is bordered on the north and west by an asphaltic road. It was logged between 1962 and 1965.

Labor intensive and tractor methods were used in different aspects of rehabilitating haul roads, landings, skid trails and stabilization of slope failures. Labor involved erosion control, minor excavation, stream bank armoring, grass seeding, tree planting, and culvert removal.

Photogrammetry was used in three aspects of the study: 1) to aid in locating problem areas and to help direct geologic investigations, 2) in job layout and organization,


HUMBOLDT COUNTY
CALIFORNIA
LOCATION MAP
CRESCENT
CITY


TEST AREAS

and 3) to illustrate the historical development of progressive erosion and area revegetation. Stereo pairs of 1962, 1966, 1970 and 1976 aerial photography as well as rectified enlargements at a scale of 1:2400 were used in the study.

Geologic studies were conducted for two reasons. The first and primary purpose was to construct geologic maps (outcrop and slope map - Plate 3) to be used in a slope stability analysis of the two test areas. Specific locations which are determined to be hazardous, or geologically unstable could then be checked against actual mass movements which were mapped in the field and plotted on the outcrop map. It was hoped that there would be a correlation between mapped mass movement locations and areas predicted to have a high hazard potential; if so, the credibility of geologic studies as predictive and preventative tools in reclamation work would be further substantiated. Studies by Blanc and Cleveland (1968), Gray (1970), Baily (1971), Cleveland (1971), Burnett (1972), Kojan and others (1972), Maberry (1972), Williams (1972), Dooley (1973), Nilsen (1973), Swanson (1975), and Huffman (1977) have previously shown the value of geologic investigations in areas where poor slope stability is a factor.

The second purpose of the study was to initiate a data base (rock-type, composition, distribution, and stability under various geologic dispositions) which could be enlarged with additional studies and effectively utilized in future stability studies in this region.

Appendix A lists several terms and their meanings, as they have been used in this report. All rehabilitation costs are itemized in Appendix B. Appendix C contains color prints of several specific ground conditions before and after rehabilitation work. S-# is used to symbolize work station locations. W-# is used to identify individual drainage courses.

METHODS

Photogrammetry

The complete coverage available of Humboldt County by high quality aerial photography allowed for an analytical and historical study of test areas 1 and 2. Photo coverage source, scale, and format used in photogrammetric work is given in Figure 3. Working photographic maps were enlarged to a scale of 1:2400. This scale was used because it gave good resolution and a manageable format size.

Photographic coverage of Redwood National Park (1976) was enlarged, scaled, and rectified (corrected for aerial camera angle). This photograph was used as a field guide and later as a base to plot physical rehabilitation stations (Plate 1) and aid in cost analysis calculations.

One photograph (Humboldt County coverage, 1966) covering test areas 1 and 2 was also enlarged and rectified. This photo was used in a study of the long term terrain evolution of the test areas along with 1962, 1966, 1970 and 1976 stereo coverage. It was also used in the development of a cost analysis using present day costs and terrain conditions as they existed in 1966 (conditions shown in Plate 2).

Plate 1 and Plate 3 document some 1976 and 1977 information along with a pictorial representation of the area for future reference.

Photographic Coverage

Source	Scale	Format
Humboldt County 1962	1:12,000	9" X 9"
Humboldt County 1966	1:12,000	9" X 9"
Humboldt County 1970	1:12,000	9" X 9"
Redwood National Park 1976	1:12,000	9" X 9"

Figure 3. Photographic coverage, source, scale, and format used in this study.

Geology

Initial field investigations were conducted on September 11 and 12. The area was revisited on October 26 to observe new test area locations made accessible by brushing. Field data are plotted on a combined geologic outcrop and slope map (Plate 3). Outcrop data from field investigations includes rock-type, distribution, attitude (strike and dip of bedding), and observed mass movements. Slope contours were drawn to designate areas of 0-10, 10-20, and greater than 20 degrees of topographic slope. A 1:24,000 scale U. S. Geological Survey topographic map enlarged to 1:2400 was used as a base in constructing the outcrop and slope map.

The outcrop and slope data in Plate 3 were used to make subjective judgments of the "hazard potential" of test area terrain. This topic is discussed in a later section of this report. These judgments are subjective because only three objective variables (rock type, rock attitude, and hillside slope) and one subjective variable (geologist's understanding of the competency of individual rock types within the area) are used in determining the hazard potential (slope instability) of an area. Many other variables actually effect slope stability, i.e., direction of slope, amount and frequency of precipitation, human agencies, and elements of seismic activity. Judgments on slope stability were influenced by observations of actual mass movements (effects geologist's opinion of rock competency), although the four variables previously mentioned were primarily relied on in making stability judgments. By attempting to keep knowledge of actual slope movements separate from slope stability predictions a comparison between predicted "high hazard potential sites" and actual slope failures could be made.

Four rock samples were studied with the petrographic microscope to determine the presence of clays, type of matrix cement, and mineral constituents and their degree of alteration. This information combined with hand sample observations aided in rock competency judgments.

Clay analyses were run on two samples by x-ray diffraction techniques. Analyses were done using U. S. Geoologic Survey techniques and equipment (in a test program designed to set up a standard x-ray procedure and train a technician in sample preparation and equipment operation).[2]

---

[1]Word to be found in Appendix A, Terms.

[2]All geologic data (map and analyses) gathered in this study has subsequently been turned over to Dick Janda of the U. S. Geological Survey.

Physical Rehabilitation
(Test Area 1)

Labor intensive methods were used in test area 1. Efforts were directed at reestablishing drainage nets, and gully, slope, and stream side erosion control.

Erosion control on gullies and slope failures, areas (S-1, S-2, S-3, S-7) located on Plate 1 and Plate 2 was accomplished in two steps: 1) check dams of various sizes were installed in gullies (dissecting slide masses and skid trails); gullies were also filled with brush bundles and 2) 1-3 foot redwood stakes were driven into slump masses (with slopes greater than 20-25 degrees) to give support to alder and willow waddles.

Check dams were spaced at distances judged appropriate to keeping surface runoff at safe velocity levels. These distances were interpretations based on gully width, depth, slope and resultant water velocity potential. A water runoff velocity of 1.2-3.0 ft/sec was considered sufficient to initiate significant soil erosion (Kittredge, 1973; using a soil composition ranging from loamy sand - 15% clay to loam - 65% clay).

All first order streams (draining to the northeast) in this area have been crossed by Humboldt bridges[1] during haul road construction. These bridges consist of logs placed in the drainage and covered with road material. Intensified erosion has partially undermined these bridges with upslope erosion tending to bury them. Because of this, and the natural rotting of the wood, these crossings are susceptible to cave-ins, making them dangerous to work around (test area 1, where W-2, W-4 and W-5 cross the major haul road; Plates 1 and 2).

Reestablishment of a natural drainage net through the haul road was done at one location (S-6). At this location a plugged culvert had caused redirection of a drainage channel which resulted in water back-up behind the haul road. Water eventually drained in a dispersed manner across the road, depositing silt and sand as it flowed. The plugged culvert was removed, and a trench dug in its place which reestablished the natural drainage through the road. A temporary increase in sediment transport is expected until trench walls stabilize themselves. The detrimental effects of a temporary increase in sediment transport are considered minimal when compared with possible road failure caused by 1) increased water saturation of above road soil and 2) further overloading of the road by sedimentation. Originally a sediment trap was to be installed, but this was found to be impossible because of down slope slash accumulation which obscured the slope drainage course.

Stream work was done at location S-4. Problems which existed were 1) water saturation and erosion of the toe of S-3 slump on the cutbank side (southwest) of the stream, 2) a large woody blockage inhibiting the natural water course, sharply diverting downstream flow into the northeast stream bank and 3) buildup of debris and gravel bar which had the

the potential of blocking fish access to upstream spawning beds.

Corrective measures consisted of: 1) Removal of woody blockage from gravel bar area and digging a channel through the bar. This reduced flow directed at the northeast bank and minimized channel blockage which could have led to fishery problems. 2) Armoring of the southwest streambank. Redwood slats (2" x 2' x 4') and large stream boulders were used to deflect water from the toe of slump S-3. This was done in an attempt to slow down erosion of the toe until planted willows and alders had time to grow. 3) Jetty construction. Four jetties were built from available stream boulders. They are designed to deflect stream force away from the southwest stream bank, and to promote erosion and redistribution of the gravel bar. Jetties will require monitoring and periodic maintenance.

Douglas fir trees will be planted (January, 1978) on haul roads, landings, other compacted areas, and mass movement sites (tree density of approximately 1 tree/yd). Grasses (¼ annual rye, ¼ annual brome, and ½ perennial fescue) were planted and fertilizer (16-20-0, i.e., 16% Total Nitrogen - 20% available Phosphoric Acid - 0% soluble Potash) distributed on all areas where ground reclamation work was done.

(Test Area 2)

Mechanical and labor intensive methods were used in test area 2. A D-4 Caterpillar track-tractor equipped with a 6 foot blade and 6-way ram was used in machine work. This tractor was not equipped with rippers, so ripping[1] was done with a tilted blade. Tractor work was directed at 1) destroying or weakening road integrity[1] and 2) reestablishing the natural drainage net.

Two methods were used in destroying road integrity: 1) pulling the road[1] and 2) putting the road[1] to bed. For this study, decisions on whether a section of road was pulled or put to bed were entirely experimental. Each method was used under similar conditions (where possible) with the idea that cost and efficiency data could be generated and evaluated.

In one area (S-13 to S-16) several road sections were pulled. Approximately 1/3 of the haul road and its embankment had been planted with Monterey pine trees. These were removed and the entire road area was ripped and regraded to about a 2% downslope. Pulling the road was done as a erosion control/ rehabilitation measure. This allowed for the development of cost figures, and created conditions which can be used to evaluate the effectiveness of the technique.

Reestablishing the natural drainage net across haul roads was done whether a road was pulled or put to bed. This was accomplished by construction of crossroad ditches.[1] In this way channelized upslope runoff, which had become part of a roadside gully system or a crossroad dendritic drainage network, was redirected across the road to its prior downslope channel. Plugged culvert removal was done by the tractor. Crossroad ditches were dug to replace the culvert and direct water across the road.

Labor intensive activities involved support for tractor work and implementation of erosion control measures. Because of the thick vegetation some initial clearing with chain saws and machete was necessary before tractor work could begin. Water bars and cross ditches, ripped by the tractor, were completed by shovel and pick(to decrease erosion). Culverts dug up by the tractor were cut into sections and carried out by hand.

Erosion control work consisted of putting check dams in hillside gullies, and upslope from water bars, and re-vegetation with trees and grass. Check dam locations were picked in response to water velocity and channel characteristics as discussed for test area 1. Douglas fir trees will be planted (January, 1978) on haul roads, landings, other compacted areas, and mass movement sites (tree density of approximately 1 tree/yd^2). Grasses (¼ annual rye, ¼ annual brome, and ½ perennial fescue) were planted and fertilizer (16-20-0, i.e., 16% total Nitrogen - 20% available Phosphoric Acid - 0% soluble Potash) distributed on all areas where ground reclamation work was done.

PHYSICAL DEVELOPMENT OF THE LAND

The availability of aerial photography of the test areas from 1962 to the present gives the opportunity to review a 15 year sequence of environmental changes.

The original stands of virgin redwoods were logged from 1962 to 1965. The area was logged by the clear-cutting method with land management techniques not in keeping with today's standards. Douglas fir and spruce trees were aerial seeded. This has resulted in a large, single-year class of young trees. Monterey pine trees were experimentally planted in several locations. The natural regeneration of redwood trees has been good. A few redwood seedlings are in evidence, especially on the moister slopes and swales.

Humboldt County 1962 Photography: This photography illustrates the classic cover of old-growth redwood forest masking the topography of the land. The 1962 coverage shows the initial start of the logging show (Figure 4).

Humboldt County 1966 Photography: This photography (Figure 5 and Plate 2) shows that, in test area 1, the steepness and lack of prominent ridges between drainage nets required an extensive development of skid trails. These ran parallel or slightly oblique to hill contours and extensively dissected first order and intermittant streams courses. The skid trails on the upper slope of test area 1 connected with the major haul roads of test area 2 at S-1 and S-13. The skid trails on the lower slope connected to the single haul road

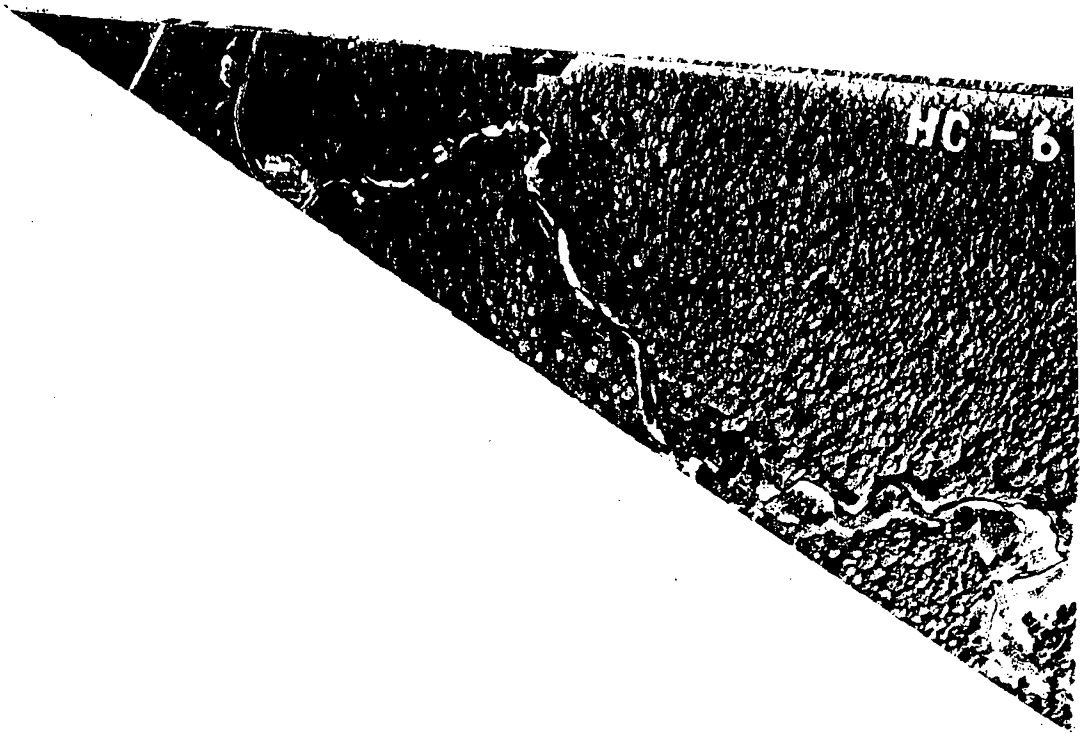
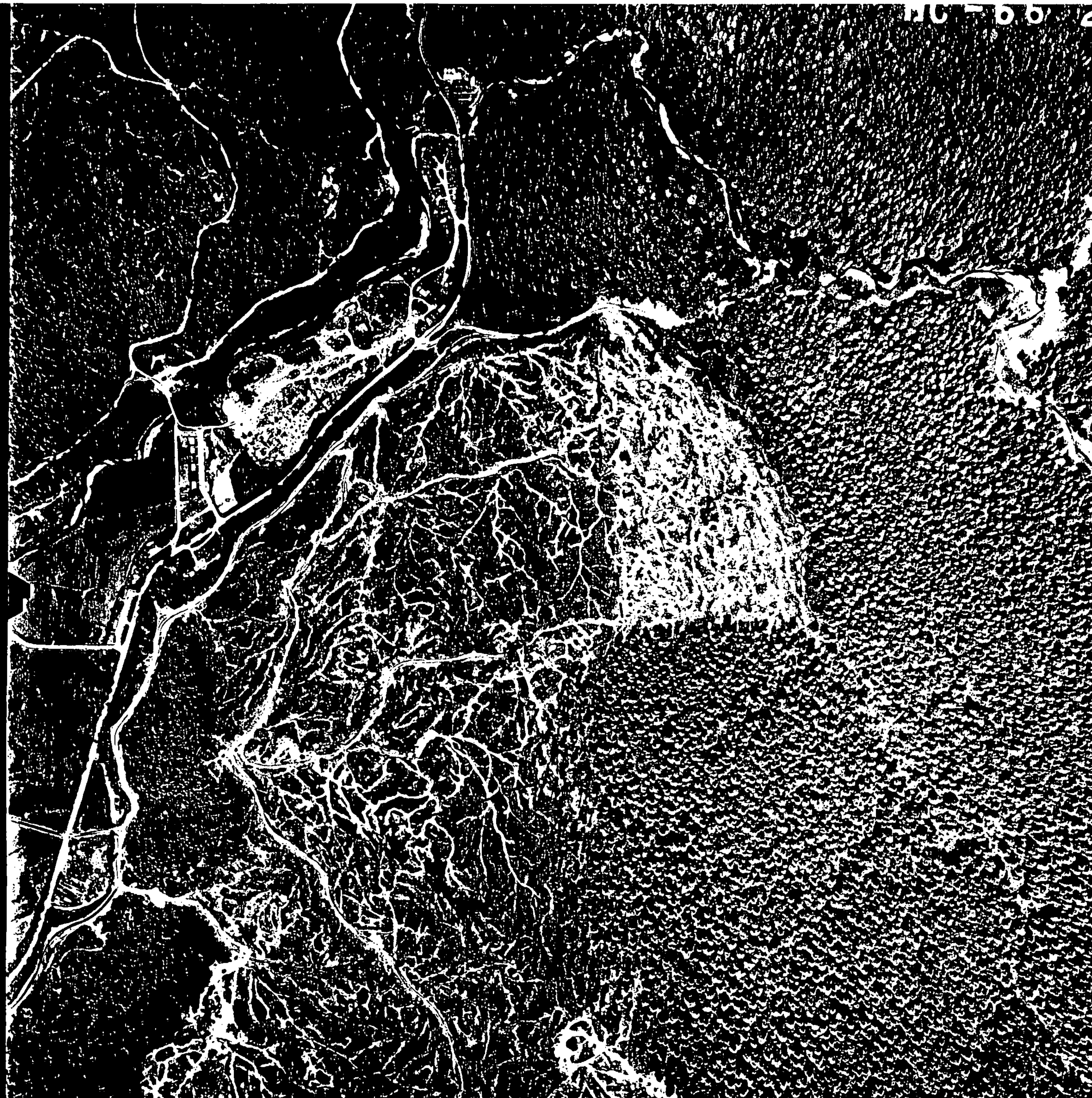
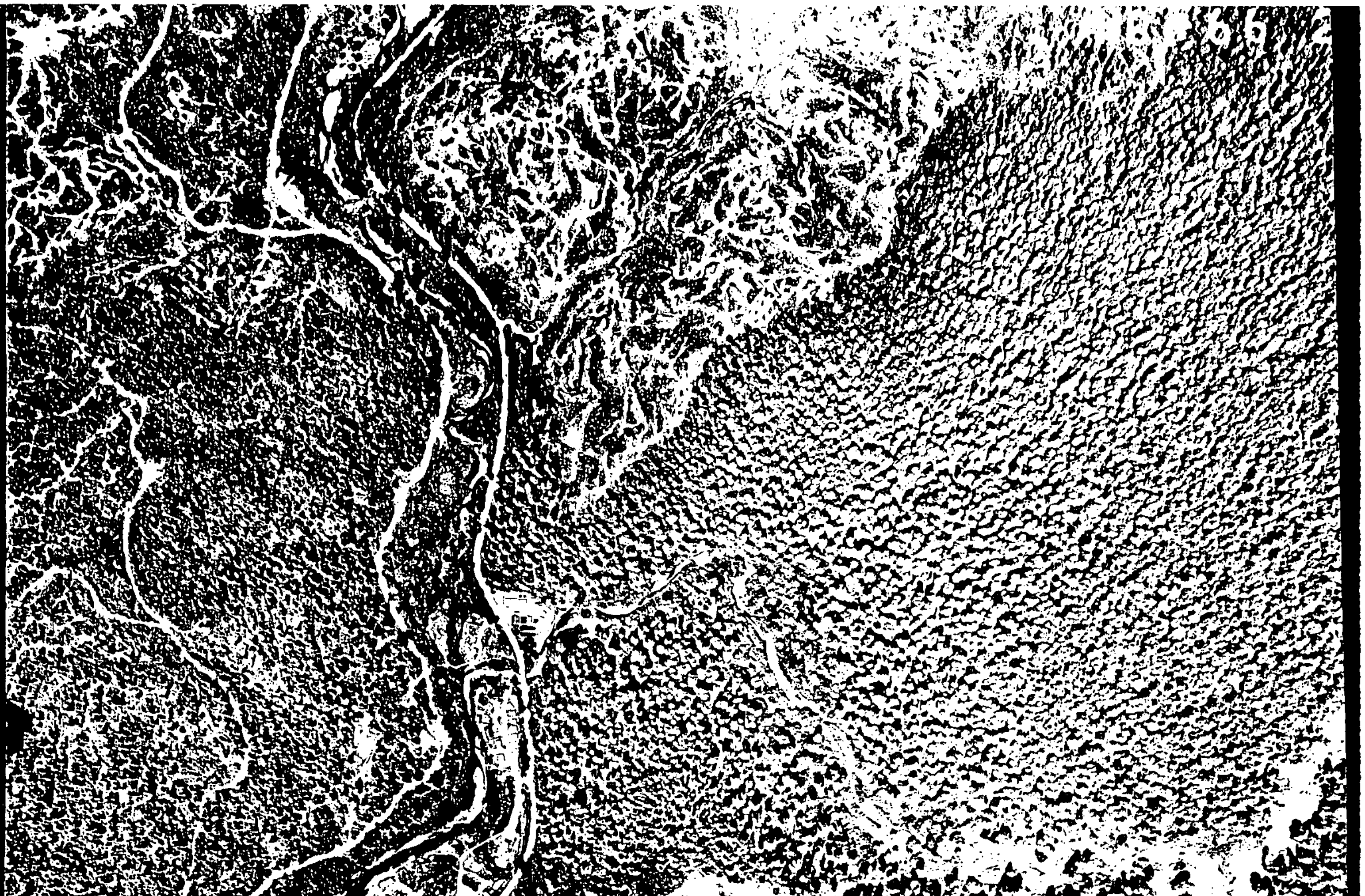
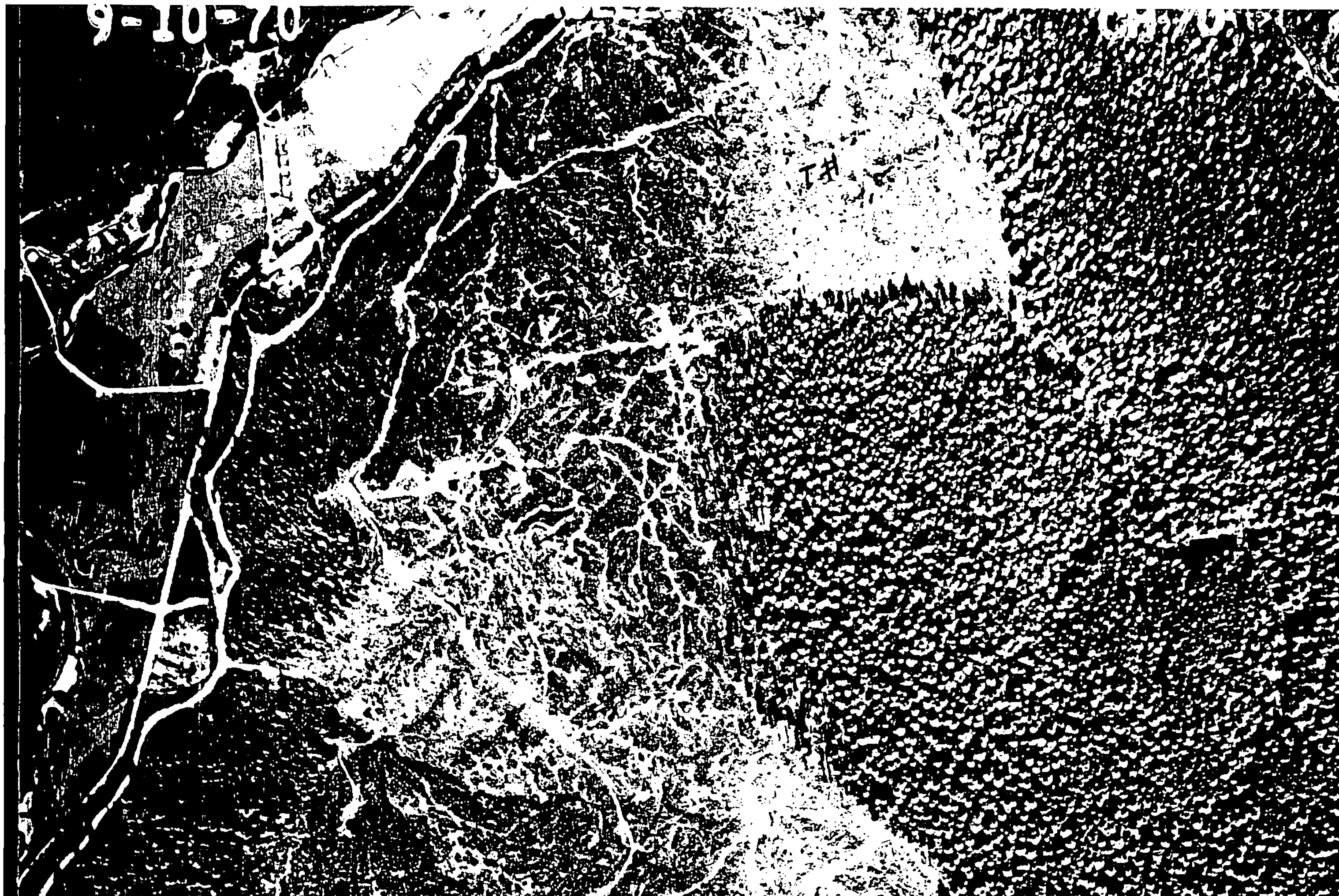


Figure 4: Humboldt County 1962 Stereo Coverage [no.1-2]

Figure 5: Humboldt County 1966 Stereo Coverage [no.1-3]






9-10-70

of test area 1. This haul road was constructed just above Little Lost Man Creek. A landing and loading area was placed in a precarious position above the creek (S-3 to S-4), the stream's natural meander was directed at the slope below the landing. In the stereo pair (Humboldt County 1966) this condition is readily seen. Landing construction added more weight to and steepened the slope, resulting in an increased potential for slope failure and an acceleration in the natural erosional process. Stations and drainages W-1, S-2, W-3, W-4, S-3, and S-7 are visible, showing the early conditions which eventually led to slope failures in areas (S-2, S-3, S-7). Location S-2 and drainage W-1 in test area 1 are lightly outlined on the stereo pair. This heavy dissecting of a drainage course by skid trails creates a situation where early rehabilitation work might have lowered the total erosion which has effected this station to date. A situation such as this, i.e., steep slope, shale rock type, and dissected drainage course, should be given high priority in rehabilitation scheduling. This collecting of water and the subsequent erosion eventually let to the failure in area S-2. This occurred sometime after 1970. Drainage W-4, just above S-6 and S-7 (gully and culvert removal sites), illustrates the chain of events which can occur when a drainage course becomes filled with slash and sediment. The shallow drainage of W-4 above S-7, which quickly filled after logging, eventually led to high water overflow into the small drainage area (W-3). This caused the erosion and failure in area S-7 with subsequent plugging of the culvert at S-6 and the resultant road failure. Sometime after 1970 a large stump slumped into the S-7 failure area from its north bank further diverting the flow. This created a gully from S-7 to the old landing S-8. In test area 2 the major haul roads were constructed parallel or slightly oblique to major slope contours. Skid trails were developed along the ridges. Minor skid trails branch off these, and lead down into the adjacent drainages. Large amounts of slash are noticeable both in the logged area and in the drainages. A large skid trail from S-18 down the steep slope to area S-20 has begun to erode with a large amount of material sloughing off into the haul road. An example of drainage net runoff becoming part of a roadside gully system is seen in test area 2 (S-16 to S-17). The culvert (channeling W-3) had become plugged. This caused W-3, W-4, and some intermittant streams to run parallel to the road (creating a gully), and drain into W-5.

Humboldt County 1970 Photography: This photography (Figure 6) shows areas where vegetation had quickly reestablished itself (in most cases the degree of revegetation is directly related to the extent of soil compaction). Areas of future failures in both test areas can be seen (test area 1, S-2, S-3, S-7; test area 2, S-12, S-21).

rk 1976 Photography: This

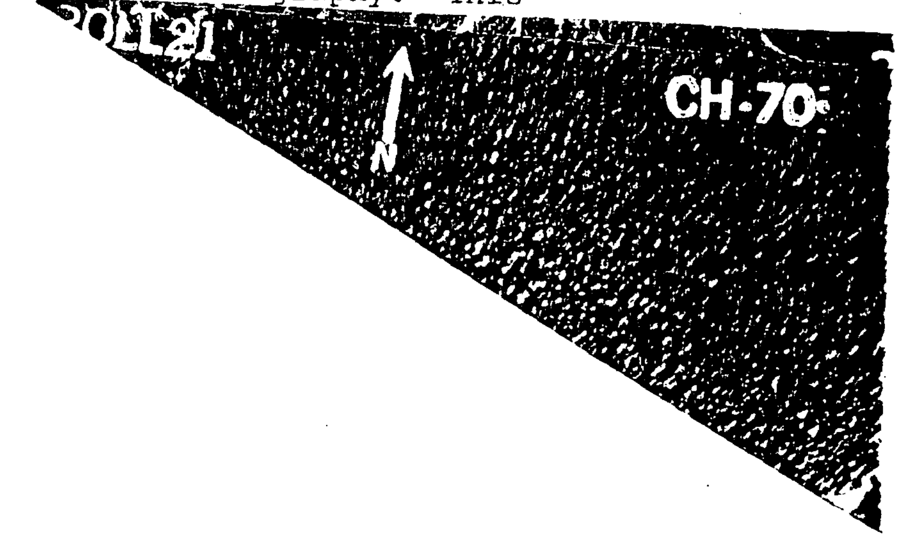
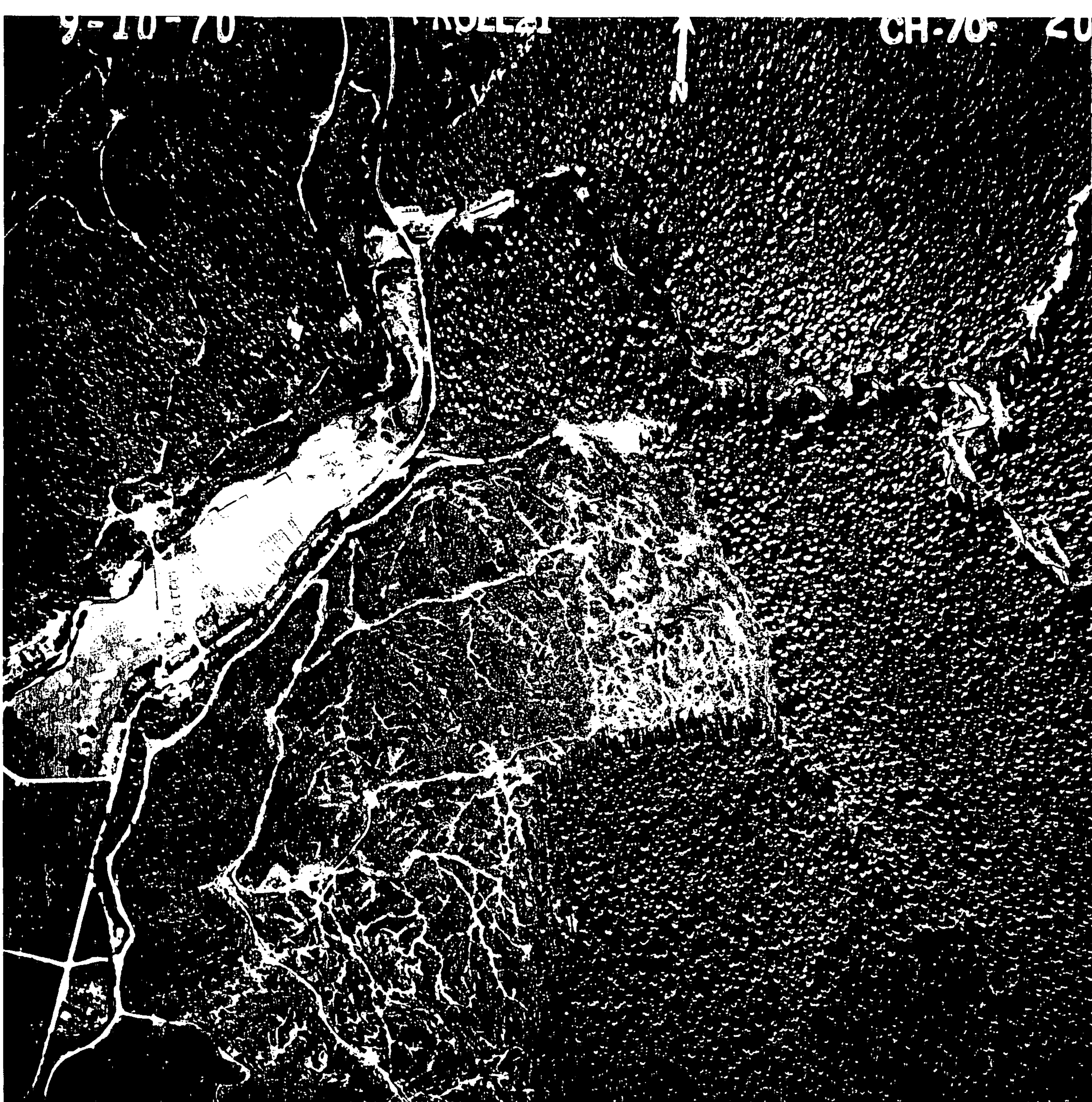
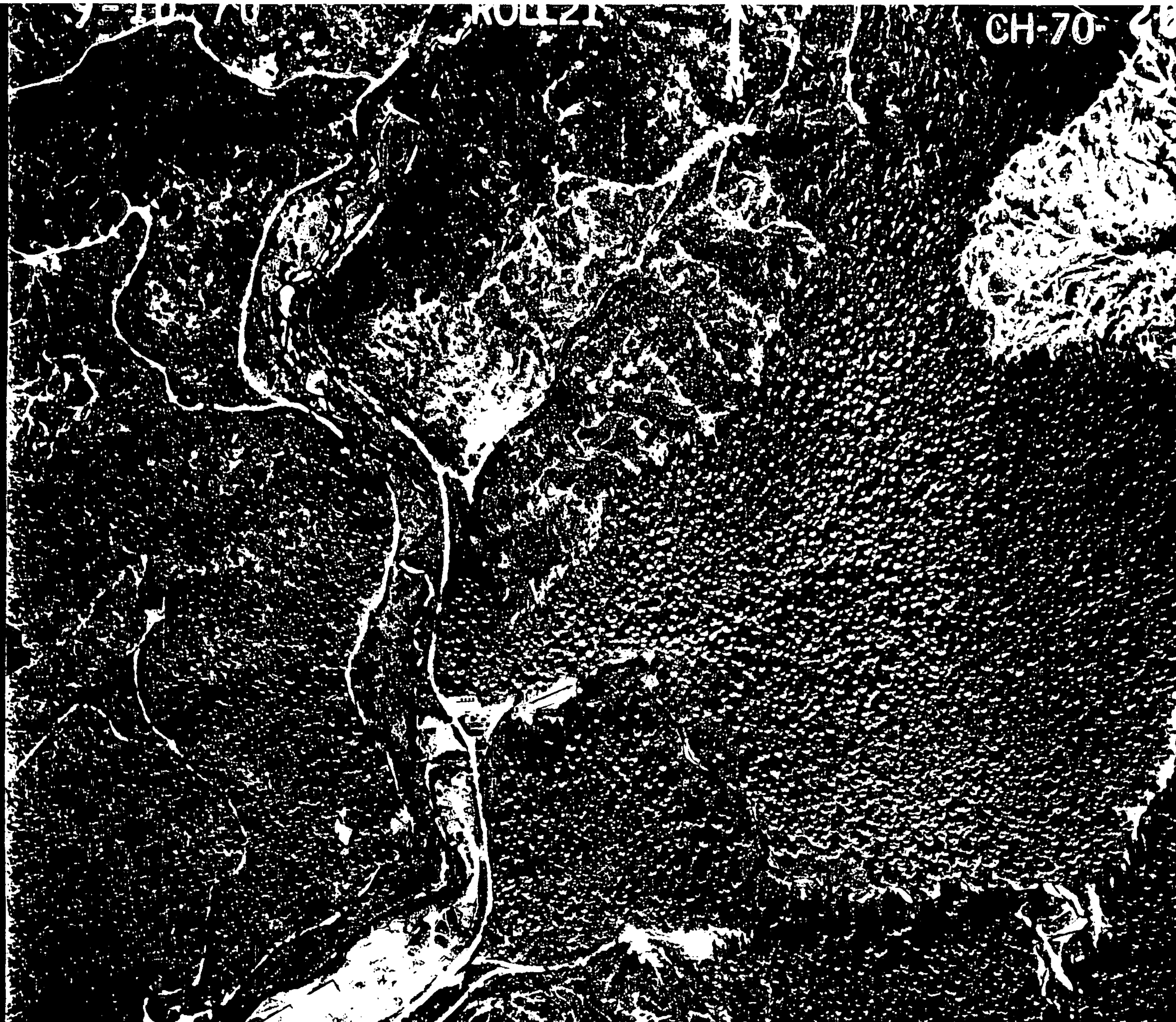


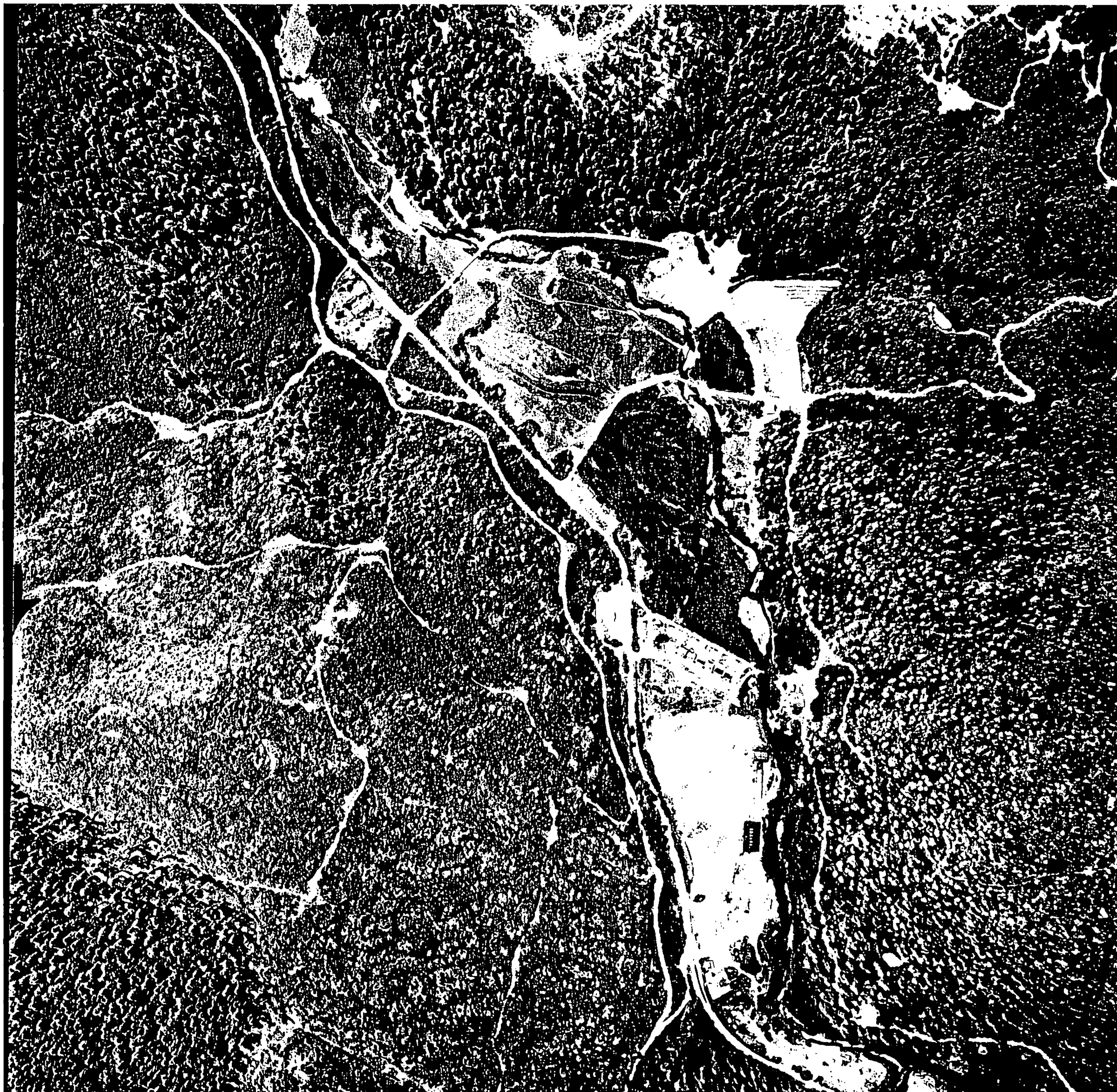
Figure 6: Humboldt County 1970 Stereo Coverage [no. 1-3]

Figure 7: RNP 1976 Stereo Coverage [no. 1-2]


9-10-70
N
CH-70


9-10-70
ROLL21
CH-70-


P 76 1:10000
6-24
8 A



Redwood National Park 1976 Photography: This photography (Figure 7 and Plate 1) illustrates areas where natural rehabilitation has been successful, and areas, due to compaction or failure, that have not been successful. Erosion of soil and rock, slope failure, and soil compaction inhibit the reestablishment of ground cover while lowering water and stream environment quality. These problems must be addressed in any successful rehabilitation program.

GEOLOGY

Regional Setting

An understanding of the regional geologic setting is necessary if predictions and data extrapolations are to be extended to inaccessible areas. Once the subject area is positioned within a regional geologic framework, much more geologic information is available from basic geologic concepts and published literature. A brief discussion of the regional geology will be given below. For a more thorough discussion the reader is referred to papers by Blake and others (1967), Irwin (1964), and Bailey and others (1964).

Test areas 1 and 2 are located within the Coast Range Province as defined by Blake and others (1967) and shown in Figure 8. This province is composed of a variety of rock types which correspond to a variety of geologic environments and modes of origin. Franciscan Group rocks dominate in the Coast Range Province and consist predominantly of grey sandstone (often referred to as greywacke), shale, volcanic rocks, and chert (Blake and others, 1967). Less abundant rock types consist of Cenozoic[1] marine and non-marine sedimentary rocks.

The tectonic style[1] associated with this province has played a significant role in determining rock distribution and metamorphism[1] (where present). Coast Range Province and Klamath Province rocks have been juxtaposed by large

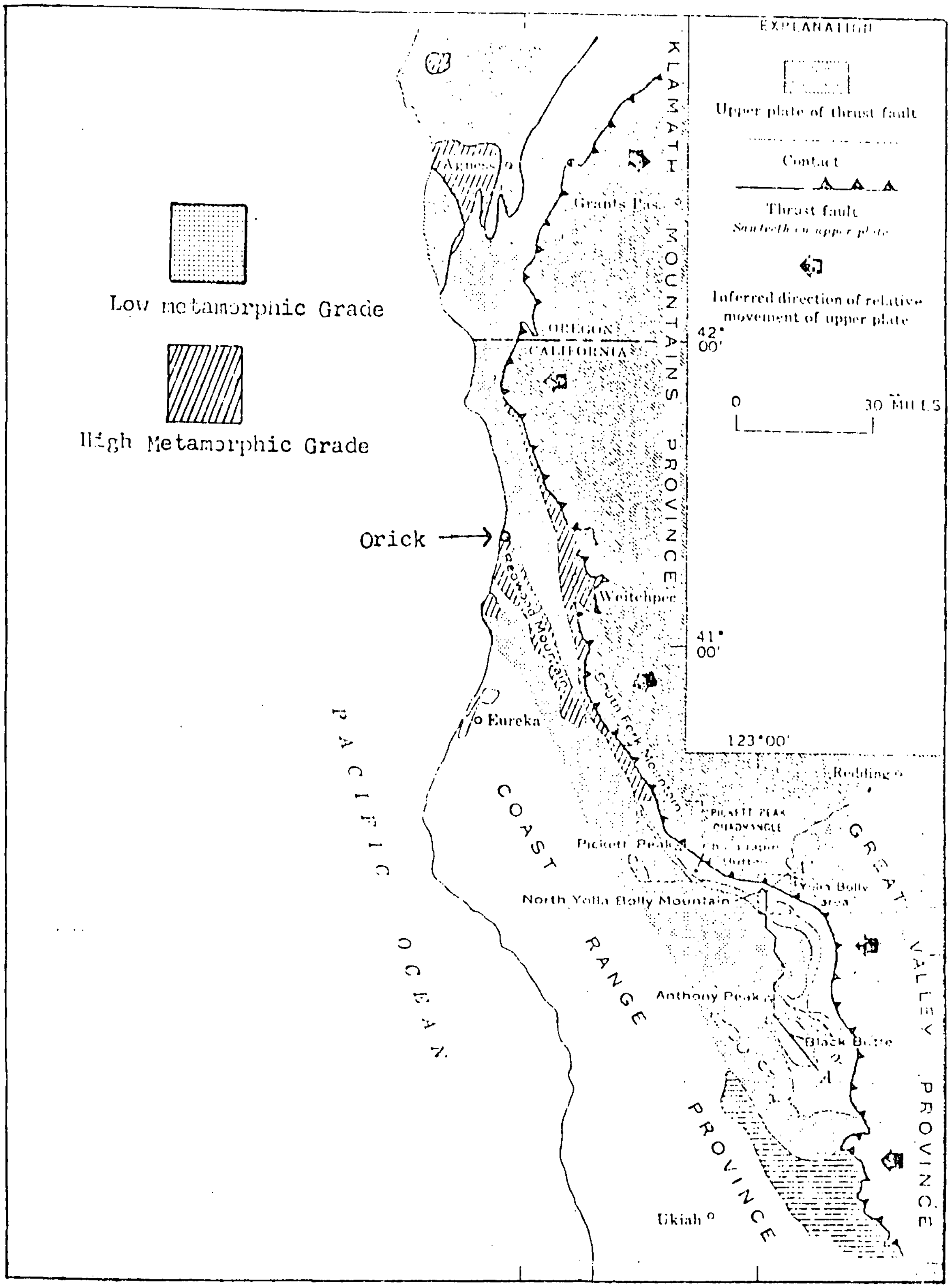


Figure 8. Map showing location of geologic provinces and trends in the degree of rock metamorphism (modified after Blake and others, 1967).

scale thrust faulting (Figure 8). A predictable succession of general rock characteristics is associated with this faulting. Approaching the fault from the west an increase in metamorphic grade occurs, with rock types going from unmetamorphosed (or slightly metamorphosed) grey sandstone and shale, to highly metamorphosed quartz mica schist[1]. Rock mineralogies change in response to the eastward increase in metamorphism. Rock competency characteristics are often controlled by rock mineralogy (schistose and micaceous rocks generally are less competent than only slightly metamorphosed sandstone). Incompetent rocks should be, and are, found proximal to the fault.

Locally (Redwood Creek, Orick, and surrounding areas), the same general pattern exists. This is complicated slightly by the presence of high grade metamorphic rocks in the Redwood Mountain area (Figure 8). This region (metamorphic outlier[1]) is composed of rock types which typically are found near the Klamath/Coast Range Province boundary thrust fault. This outlier is of particular interest since land, currently being negotiated to be incorporated into Redwood National Park, is located within its boundaries. Particular problems (slumping and landsliding) associated with the lack of rock competency can be expected to occur in this area. Studies by Nolan and others (1976) support this conclusion.

Geology (Test Area 1 and 2)

Plate 3 is a compilation of outcrop and slope data. Circular pattern (rock type) designations are not meant to identify actual aerial extent of each observation, but to illustrate a point observation, and probable occurrance of this rock type beyond the observation point. Shale map patterns, alternating with other rock type patterns, indicate interbedded shale.

Geologic rock units mapped in test areas 1 and 2 include rocks of the Franciscan Group and an Unnamed unit (possibly Gold Bluffs Formation). Bedding attitudes may be meaningless in reconstructing the structural geology of the area because of the chaotic and disturbed nature of the Franciscan Group. These rock attitudes, regardless of the fact that they may be in a detached block, are sufficient to aid in slope stability studies. No stratigraphic sequence could be developed because of the lack of outcrops combined with an uncertain structural geology.

Franciscan Group Rocks: Test area 1 and 2 bedrock geology is dominated by Franciscan Group sandstones, shale, and conglomerate. These rocks are considered to be Late Jurassic and Cretaceous in age (Irwin, 1964).

Sandstones range from grey to brown; are texturally immature; and are primarily composed of feldspar, quartz, chert, muscovite, biotite, and mafic volcanic and shale rock fragments. Cements are either silica or clay minerals.

X-ray diffraction analyses of the clay fraction indicates the presence of chlorite, mica (illite), minor kaolinite, and possible mixed-layer clays.

Brown sandstones tend to have a more chloritic matrix (cement), and more volcanic rock fragments than grey sandstones. Weathering (chemical breakdown) of these components is responsible for the less competent nature of the brown sandstones. Rusty, iron-rich waters can often be seen in proximity to these sandstone outcrops (test area 2, near S-20). The release of iron from the rock probably indicates the breakdown of clay cements and volcanic rock fragments. Outcrops of claystone (brown and incompetent) were seen in some areas of high water saturation. This rock type was mapped as brown sandstone (assumed to be highly weathered) although it may represent a weathered finer-grained rock type.

Grey sandstones are highly competent. They are cemented by silica with quartz, chert, feldspars, chlorite, and muscovite being the main minerals. Small amounts of the metamorphic mineral phrenite are present along with minor carbonate.

Massive and highly fissile black and brown shale is found as chips weathering out of hillsides, as massive beds (3-4 feet thick), and as one foot interbeds in grey and brown sandstone outcrops. Some shales are moderately competent (although tend to split along preferred planes) and generally black, while others are incompetent (making soft clay outcrops) and generally brown in color. Some outcrops mapped as brown sandstone (assumed to be highly weathered) may, in fact, be highly weathered massive shales.

Brown and grey colored conglomerate occurs in a couple of locations. The sandy matrix between pebbles is mineralogically the same as the brown and grey sandstones described above. Clasts consist of chert, shale, and volcanic rock fragments. Pebbles are well-rounded and are up to 3 cm. in length. The rock has a clay and silica cement and is highly competent.

Unnamed Unit: One small outcrop of light brown, thin-bedded, micaceous siltstone occurs on a haul road near S-6 (test area2). Field relations indicate that this rock type sits unconformably[1] on Franciscan Group shale. Because of this, it has tentatively been assigned to the Tertiary Period. Rocks of the Gold Bluffs Formation (Tertiary[1]) occur to the north and west. Siltstone at S-6 may belong to this formation, although rocks of the Gold Bluffs Formation (which have been observed) are coarser in grain size and less indurated.

Mass Movements: Five soil and debris slumps and one rock fall are mapped in test areas 1 and 2. Slumps are restricted to the soil zone and uppermost fractured bedrock. Large quantities of debris (stumps and other large and small slash) are mixed in with soil in the slump mass.

These failures are between 100 and 300 feet long and in all but S-3 (test area 1) probably restricted to the upper 8 feet of soil. The slump at station S-3 (test area 1) is located at the site of a prior log landing. The landing is failing now due to water saturation and stresses set up by stream bank erosion (Little Lost Man Creek). Shale bedrock is mapped around the landing and may have been instrumental in the initial failure. The whole landing area is about 2 feet lower than the adjoining haul road segments which indicates settling, possibly in response to bottom material being removed by springs, or movement (slightly rotational?) of the whole landing downslope. Piecemeal slumping is responsible for the more recent mass wasting. Abundant tension cracks on the slump side of the landing indicate this recent activity. Multiple rock types in the landing material (observable in the slump headwall below the landing) and its morphology (as seen in Humboldt County, 1966 photography), indicate that it was constructed partially of fill, or at the location of a prior landslide.

The one rock fall mapped occurs in brown sandstone adjacent to the asphaltic haul road (near the northwestern boundary of test area 2). This location is a near vertical rock face, created during haul road construction.

Stability Analysis

Assessments of slope stabilities for this study are made assuming that failures are rock-related, and failure planes will penetrate the bedrock. Soil creep and slumps are dependent on soil competency characteristics, which may, or may not, be related to the immediate underlying bedrock. Potential hazards from soil failures are expected to exist on slopes steeper than 9 degrees if the area is put in a stress situation. Stress may result from human agencies, i.e., drainage net diversion and oversteepening of slopes in haul road construction; or, natural stress set-up by active drainages. The potential for bedrock failure should be evaluated (bedrock failures may be very extensive and damaging), even if soil failure is observed and given a higher priority in rehabilitation efforts.

The stability analysis for test area 1 and 2 is based on knowledge of ground slope, bedrock type, attitude of bedding (strike and dip), and rock competency characteristics. As shown in Plate 3, the majority of this area has slopes of at least 10-20 degrees, with much of the area having greater than 20 degree slopes. These slopes would generally be considered failure prone in Franciscan Group terrain, and lead to giving an area a "high hazard potential" rating. Studies by Nilsen and Brabb (1975) done in the San Francisco Bay Area have determined that slopes greater than 9 degrees

(Franciscan Group terrain) are susceptible to mass movements.

Post Logging (1966): The below assessment of slope stability is derived from geologic conditions excluding knowledge of mass movements. The statements given can be considered applicable to a stability study on test areas 1 and 2 with conditions as they existed in 1966 (in 1966 more data would have been available because of better access due to unvegetated haul roads and trails).

Rock competency varies widely throughout the study areas. Grey sandstone is always very indurated and unlikely to fail even on steep slopes. Areas where they crop out would be considered stable. Brown sandstones (depending on their degree of weathering) present possible instability problems. On steep slopes (greater than 20 degrees) a moderate to high hazard potential would exist. In high water saturated areas the more weathered rock would produce a thick, clay-rich soil zone, with a possible potential for failure if stressed. Weathered shale would be considered highly unstable on slopes greater than 10 degrees (also may add to soil instability). Slopes (greater than 10 degrees) with downslope-dipping unweathered shale cropping out, or interbedded shale with brown sandstone, would be considered highly unstable.

Using these stability guidelines the following areas would have been considered to have a high hazard potential: 1) The entire southwest slope adjacent to Little Lost Man

Creek, and 2) the northwestern and western sides of test area 2, except where grey sandstone occurs.

These areas would then be evaluated in terms of other factors such as; skid trail orientation and density, disturbed drainage nets, revegetation problems, and instabilities caused by haul road construction. A priority system could then be set-up to deal with areas determined to be potentially unstable bacause of the nature of their geology, and modifications by man.

Post Logging (1977) and Evaluation of 1966 Conclusions: The following analysis is based on conclusions drawn from outcrop data and observations of mass movements mapped during this study. In essence, it combines conclusions that were stated earlier (conclusions which probably would have been arrived at in a 1966 stability analysis) with actual failure conditions.

Grey sandstone, and grey and brown conglomerate are not considered a problem rock type unless associated with badly weathered shale, and located on very steep slopes. Brown sandstone has the potential for failing (slopes greater than 20 degrees), but probably will maintain its integrity unless stressed by prolonged water saturation and major slope modification by man. Shale (near slope modifications by man) may become highly unstable on greater than 20 degree slopes, and it is felt that in water-saturated conditions 10 degree slopes would be sufficient. Both shale and brown sandstone upon weathering may add to slope instability (clay addition to soil may decrease soil competency under certain conditions). Unnamed siltstone was not observed enough to determine its stability characteristics.

Stability predictions based on rock and slope parameters (1966 analysis) are generally correct. Shale and brown sandstone are associated with 3 of 5 mapped slumps (locations S-2, S-3 in test area 1; S-12 in test area 2). Stability problems bordering Little Lost Man Creek are related to shale bedrock, water saturation, and natural erosion of the creek. Haul road construction overstressed the slope, and stimulated an already sensitive condition.

REHABILITATION COST ANALYSIS

Test Area 1, 1977

The cost of this rehabilitation study is divided into labor and material costs, and consulting and photogrammetric fees. Cost of work done is itemized in Appendix B.

Labor was used in erosion control, stream side work, and revegetation. The cost is given for total man hours. Materials consist of photographic supplies, equipment and tools, tree seedlings, and grass seed and fertilizer.

	ITEMIZED COSTS	TOTAL COSTS
LABOR COSTS:		
Man Hours Expended = 312		
Cost Per Hour = $9.50		
		$2,964.00
MATERIAL COSTS:		
Photogrammetric Supplies	$465.00	
Equipment and Tools	200.00	
Trees	300.00	
Grass Seed and Fertilizer	60.00	1,025.00
CONSULTING AND PHOTOGRAMMETRIC FEES:		
Photogrammetric Consultant Fee	160.00	
Geologic Consultant Fee	210.00	
Technical Consulting	110.00	
Technical Assistance	80.00	
		560.00
	TOTAL COST	$4,549.00

Test Area 1 = 50 Acres
Cost Per Acre = $92.00

The cost per square yard for stabilization of slope failure (S-1, S-2, S-3 and S-7) was $.82 (total sq. yds. = 2,330 man hrs. = 201, rate/hr. = $9.50).

The cost for stream side work (S-4) was $712.00 (man hrs. = 75, rate/hr. = $9.50).

The cost for the planting of trees and the distribution of grass seed and fertilizer was $335.00 (man hrs. = 35, rate/hr. = $9.50).

REHABILITATION COST ANALYSIS

Test Area 2, 1977

The cost of rehabilitating this study area was divided into tractor, labor, and material costs, and consultant and photogrammetric fees. Cost of work done is itemized in Appendix B.

Labor was subdivided in Appendix B into Preliminary Labor (brushing and trail construction), Direct Labor, and Planting (which includes the planting of trees and grass, fertilizer, and straw distribution). Preliminary Labor was not included in Labor Costs of Work Units on Page 33.

The daily walk between the vehicles and work areas was added to whatever type of work was being done during that particular day. The walking accounted for 5-10% of the working day. The tractor was driven in and out of the area each work day for maintenance and fueling. This accounted for 7-15% of its work day.

Costs on Page 32A

COSTS OF TEST AREA 2, 1977

	ITEMIZED COSTS	TOTAL COSTS
TRACTOR COSTS:		
Hours Expended = 28		
Cost Per Hour = $30		$ 840.00
LABOR COSTS:		
Man Hours Expended = 377		
Cost Per Hour = $9.50		
		3,587.00
MATERIAL COSTS:		
Photogrammetric Supplies	$465.00	
Equipment and Tools	250.00	
Trees	400.00	
Grass Seed and Fertilizer	60.00	
		1,175.00
CONSULTING AND PHOTOGRAMMETRIC FEES:		
Photogrammetric Consultant Fee	480.00	
Geologic Consultant Fee	750.00	
Technical Consulting	150.00	
Technical Assistance	80.00	
		1,460.00
	TOTAL COST	$7,062.00

Cost Per Acre = $39.00

Several work areas are grouped together as work units and cost per mile is computed and listed below. All roads are assumed to have a 50' width. Unit costs are listed for total road work, upper pulled road, upper bedded road, lower pulled road, lower bedded road. The reason for this cost breakdown is to generate cost per mile figures for different road types and different rehabilitation methods.

The upper portion of the haul road (S-2 to S-4) is considered a section which has retained its integrity. It would most closely represent actual costs for recently constructed haul roads.

The lower portions of the haul road have less structural integrity and could represent minor haul roads or major skid trails.

Units	Type of Work	Length	Cost	Cost Per Mile
Total Road Work	Tractor	3225'=.61 mile	$ 494.00	$ 809.00
	Labor	"	910.00	1492.00
	Planting	"	450.00	737.00
			TOTAL COST	$3040.00
Upper Pulled Road	Tractor	275'=.05 mile	145.00	2900.00
	Labor	"	190.00	3800.00
	Planting	"	76.00	1520.00
			TOTAL COST	$8220.00
Upper Bedded Road	Tractor	150'=.03 mile	30.00	1000.00
	Labor	"	38.00	1266.00
	Planting	"	19.00	633.00
			TOTAL COST	$2899.00
Lower Pulled Road	Tractor	750'=.14 mile	180.00	1285.00
	Labor	"	304.00	2171.00
	Planting	"	104.50	746.00
			TOTAL COST	$4202.00
Lower Bedded Road	Tractor	2050'=.39 mile	138.00	350.00
	Labor	"	342.00	855.00
	Planting	"	228.00	570.00
			TOTAL COST	$1775.00

REHABILITATION COST ANALYSIS
1966

The analysis given in this section represents a retrospective study of rehabilitation cost for conditions as they appeared to exist in 1966 in these test areas.

Costs are based on data generated in the test area 2, 1977 cost analysis. Rehabilitation recommendations were made to correct ground conditions as they appeared to have existed in 1966 (Plate 2). Recommendations were made with the aid of Humboldt County (1966) photography.

Corrective measures would be directed at nullifying the effects of haul roads and skid trails on drainage nets and normal runoff patterns.

(Test Area 1)

Rehabilitation work in test area 1 would involve:

1) Destroying the integrity of the haul road above Little Lost Man Creek.
2) Removal of two Humboldt bridges and one culvert.
3) Skid trail erosion control.
4) Stream side work.

The condition of the main haul road (Plate 2) was assumed similar to the present upper haul road in test area 2, 1977 (S-2 to S-4; see Appendix B for cost itemization). The two major skid trails on the upper slope (Plate 2) were assumed similar to the present lower haul road in test area 2, 1977 (S-13 to S-16; see Appendix B for cost itemization).

RECOMMENDATIONS AND COST ESTIMATES	COST
Main Haul Road 2600' = .49 mile @ $8220/mile	$ 4027.00
Removal of Humboldt Bridges	
Tractor time = 15 hrs. @ $30/hr.	450.00
Labor = 40 hrs. @ $9.50/hr.	380.00
Two Major Skid Trails	
3000' = .57 mile @ $1775/mile	1011.00
Grass Seeding and Fertilizing of All Skid Trails (Cost derived from updating estimates from Jackson (1971)) 16,000' x 40' = 653,400 sq. ft./43,560 = 15.0 acres	
$40/acre x 15	600.00
Erosion Control in S-2 (1977 failure area) where excessive skid trails dissect drainage course	
600' of skid trail = .11 mile @ $1775/mile	195.00
Removal of Slash and Debris from W-2, W-4, and W-5. Drainage course by tractor wenching and hand labor Tractor time estimates (personal communication with Charles McDaniels, Operating Engineer, and Joe Romanini, Professional Logger.) Tractor time = 30 hrs. @ $30/hr.	900.00
Labor = 120 hrs. @ $9.50/hr.	1140.00
SUBTOTAL	$ 8703.00

Cost Per Acre = $174.00

Tree planting could be done by aerial seeding or hand planting of seedlings to varying densities.

Landing S-3 consists of an estimated 15,000 cu. yds. of soil, rock and slash. Possible solution to this problem area would be the physical removal of 1/3 to 1/2 of the total mass. Using a 5 yd. front-end loader and a 10 yd. dump truck, it will require a minimum of 42 hrs. to remove 5000 cu. yds. 42 hrs. @ $65/hr. = (minimum)	$ 2730.00
Streamside work similar to work done in the 1977 test area 1 (S-4) would be done in two locations to remove slash and debris and exert some control on Little Lost Man Creek using jetties to ease the erosion and already stressed streamside slopes. (E.L. Nobel (1970) has shown debris basins to trap sediments moving in the drainage courses to be a very effective & economical type of erosion control. These would be placed at locations where monitoring and maintenance for a 2 to 5 yr. period would be possible.)	$ 1200.00
SUBTOTAL	$ 3930.00
(This total does not include tree planting) TOTAL	$12,380.00

Test Area 1 = 50 Acres; Cost Per Acre = $247.00

(Test Area 2)

There is approximately 8,000' of haul road in test area 2. This road in 1966 is assumed to have similar characteristics to the 1977 upper road (S-2 to S-4; see Appendix B for cost itemization). The haul road would be both put to bed and pulled.

Upper areas or near ridge sections of the road would be put to bed. This method would be used on upper roads because:

1) Costs are approximately 40% less per mile to put a road to bed than to pull a road.

2) Surface runoff and subsurface water movement is less (lower erosion potential).

This would allow for less extensive erosion control methods. Revegetation and the long term destruction of the road integrity would be adequately accomplished by ripping, planting, and the natural growth and expansion of the planted trees.

The lower sections of the haul road, where higher runoff and subsurface water movements are a factor, would be pulled.

Erosion control on the skid trails could use either labor intensive or mechanized methods, depending on the time requirements and the scope of the rehabilitation program.

Debris and slash removal from three drainages (W-2, W-3, and W-5) would require mechanized and labor intensive work.

RECOMMENDATIONS AND COST ESTIMATES

Station or Area	Length or Area	Type of Work	Cost or Cost/mile	COST Cost
S-1 to S-9 Upper Road	3200'=.61 mile	Road to Bed	$ 2899.00	$ 1769.00
S-9 to S-22 Lower Road	4800'=.91 mile	Pull Road	$ 8220.00	7480.00
Erosion Control on Skid Trails	25 acres	Grass Seeding Fertilizing	$40/acre	1000.00
W-2, W-3, and W-5	2500'	Tractor removal of debris and slash	35 hrs.@ $30/hr.	1050.00
		Labor intensive removal of debris & slash	150 hrs.@ $9.50/hr.	1415.00
			TOTAL	$12,714.00

Cost Per Acre = $70.63

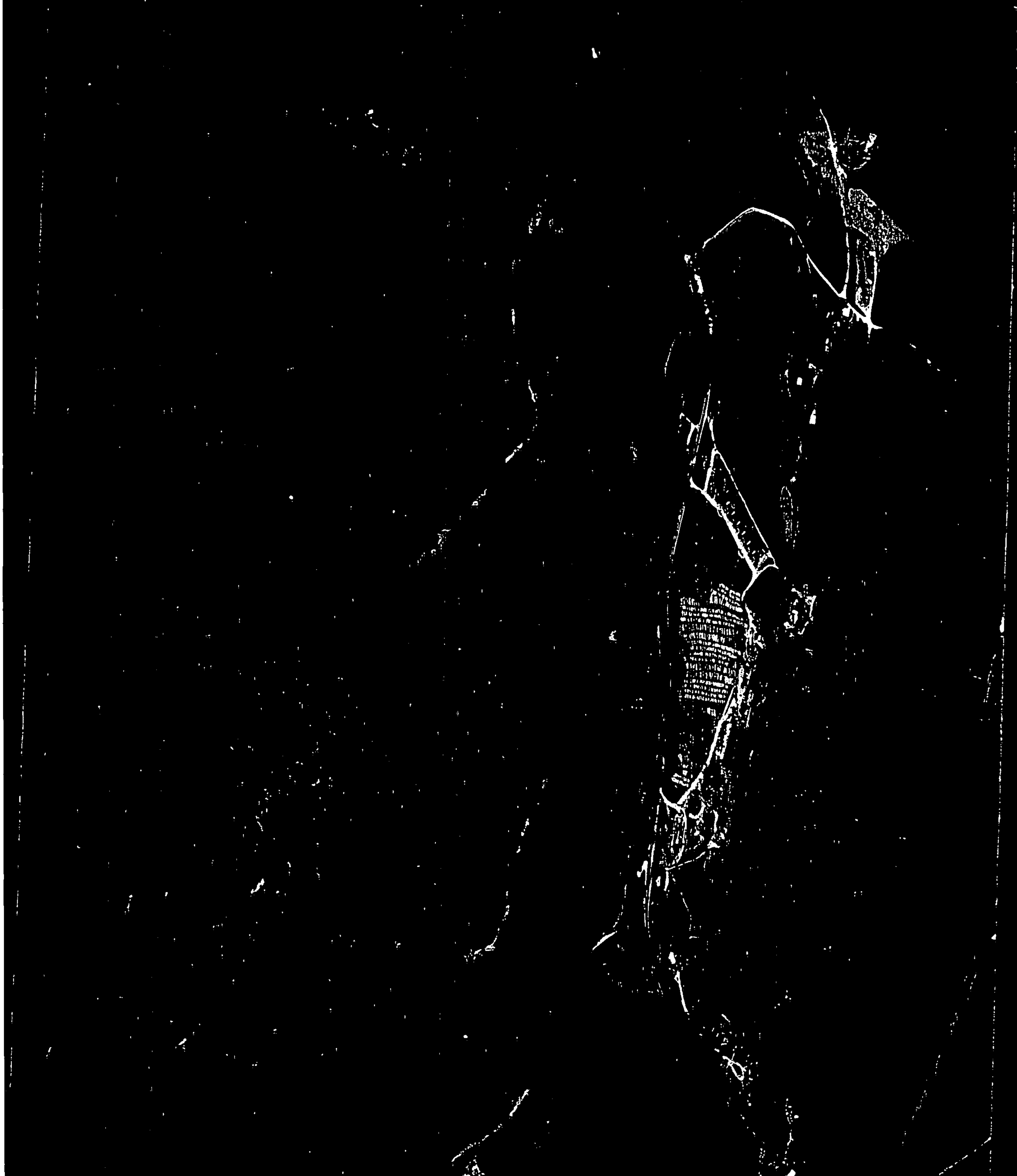
Additional Work Recommended (total costs uncertain):

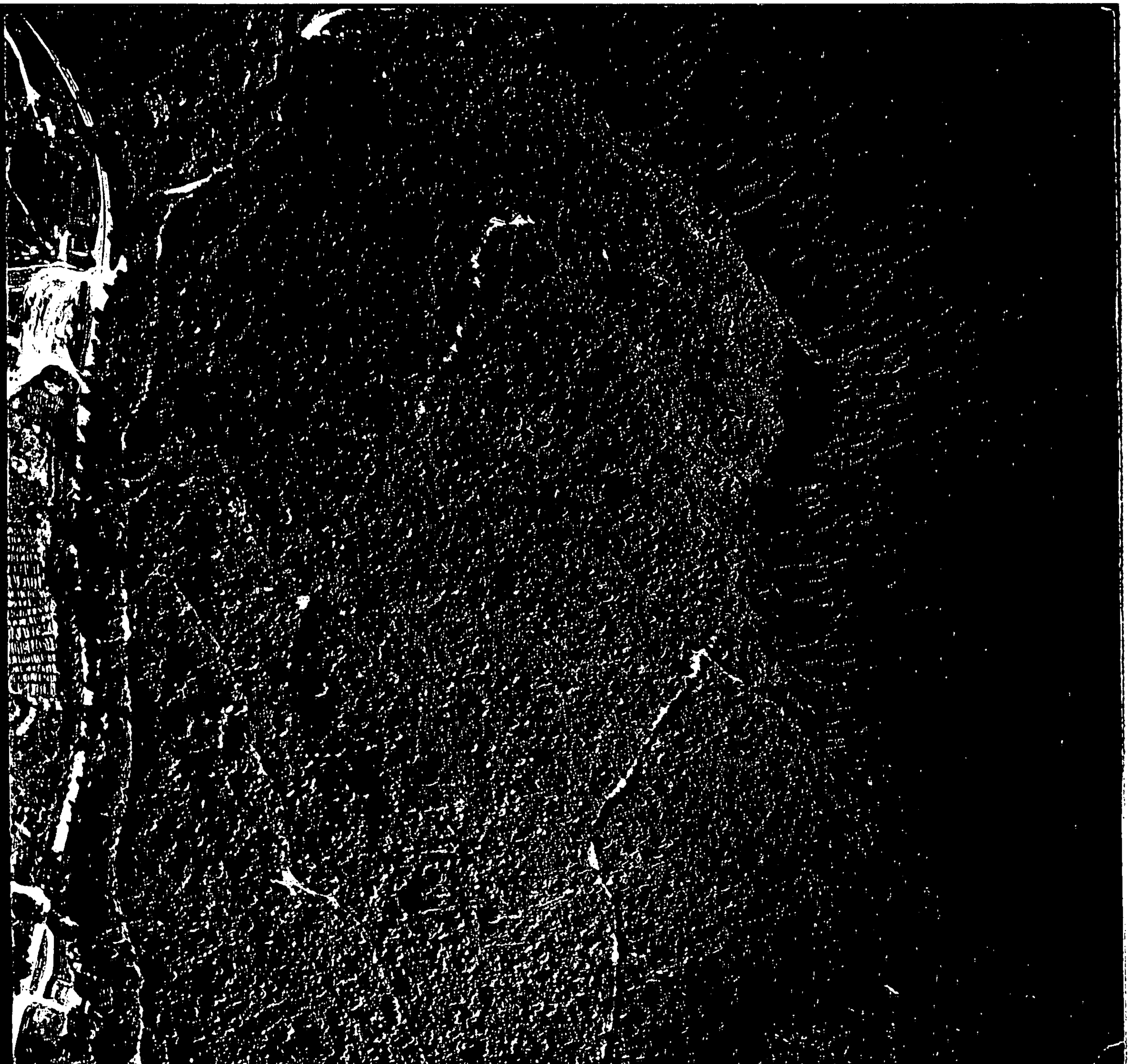
1) Further erosion control using mechanized or labor intensive methods to apply mulch and seed mixtures to disturbed or high erosion potential areas would be recommended.

2) Construction of Silt Boxes in drainage courses would be recommended. These would be placed at locations where monitoring and maintenance for a 2 to 5 year period would be possible (Nobel(1971)).

Reforestation can be done either by aerial seeding or by hand planting of seedlings.

Figure 9: 1977 B&W Obliques
[no. 1-3]





CONCLUSION

No major mass movements occurred in test areas 1 and 2 since logging in 1962 (except the landing at S-3). The test areas experienced abundant soil slumping and gullying following logging. Revegetation has since obscured all slumps, except those which have had recent movement (mapped mass movements). Quick revegetation is probably responsible (along with generally stable rock types; except shale) for the apparent slope stability (except for the slope associated with the haul road adjacent to Little Lost Man Creek, test area 1).

Photogrammetric studies of 1966 photography were able to identify problems which aided in causing mapped slope failures. These failures might have been avoided if the proper rehabilitation measures would have been applied.

Rehabilitation measures in test area 2 were more effective than in test area 1. This is because both mechanized and labor intensive methods were used. Haul roads (constructed with heavy equipment) require similar equipment to disaggregate the compacted surface, and allow vegetation and normal stream patterns to return. The haul road in area 1 was not disaggregated because only labor intensive methods were available, and these were not adequate to do the job.

Mechanical rehabilitation methods can address:

1) Destruction of haul roads and skid trail as needed.

2) Reestablishment of drainage nets, and the removal of materials from drainage course.

3) Mechanical applications of mulch, seed, fertilized mixtures to areas of high erosion potential.

Labor intensive rehabilitation methods can address:

1) Erosion control in gullies, slope failures, drainage nets, and skid trails.

2) Stream-side work including minor stream course re-directing. This can be done where a stream is mining through sand and gravel beds rather than in a bedrock channel.

3) Grass seeding and the planting of trees.

4) Labor associated with tractor work.

5) Construction and maintenance of silt boxes in drainage course.

BIBLIOGRAPHY

Bailey, E.H., Irwin, W.P., Jones, D.L., 1964. Franciscan and Related Rocks, and Their Significance in the Geology of Western California: California Division of Mines and Geology Bulletin 183, 175p.

Bailey, R.G., 1971. Landslide Hazards Related to Land-Use planning in Teton Nat'l Forest, Northwest Wyoming: U.S. Dept. Agriculture, Forest Service, Intermountain Region, Ogden, Utah, 131p.

Blake, M.C., Jr., Irwin, W.P., Coleman, R.G., 1967. Upside-Down Metamorphic Zonation, Blueschist Facies, Along a Regional Thrust in California and Oregon, IN Geological Survey Research 1967: U.S. Geol. Survey Prof. Paper 575-C, p. C1-C9.

Blanc, R.P., and Cleveland, G.B., 1968, Natural Slope Stability as Related to Geology, San Clemente Area, Orange and San Diego Counties, California: Calif. Division of Mines and Geology Special Report 98, 19p.

Borcherdt, R.D., ed., 1975. Studies for Seismic Zonation of the San Francisco Bay Region: Geological Survey Prof. Paper 941-A, 102p.

Burnett, J.L., 1972. Geologic and Slope Stability Maps of the Hayward Hills, California: Hayward, California Planning Dept., Hayward Hills Study Area, scale 1:24,000.

Cleveland, G.B., 1971. Regional Landslide Prediction: California Division of Mines and Geology Open-File Release 72-23, 33p.

Dooley, R.L., 1973, Geology and Land Use Considerations in the Vicinity of The Green Valley Fault, Solano County, Calif: Calif. Univ. Davis, unpub. M.S. Theses, 47p.

Gray, D.H., 1971. Effects of Forest Clear-Cutting on the Stability of Natural Slopes: Association of Engineering Geologists Bulletin, v. 8, nos. 1 and 2, p. 45-66.

Huffman, M.E., 1977. Geology for Timber Harvest Planning, North Coastal California: Calif. Geology, September 1977, pp. 195-211.

Irwin, W.P., 1964. Late Mesozoic Orogenesis in the Ultramafic Belts of Northwestern California and Southwestern Oregon, IN Geological Survey Research 1964: U.S. Geol. Survey Prof. Paper 501-C, p. C1-C9.

Bibliography (continued)

Jackson, R.E., Stoneman, N. N., 1971. A Post Logging Practice for Redwood Forest: J. Forestry 71(2), p. 90-92.

Kojan, E., Faggin, G.T., III, and Rice, R.M., 1972. Prediction and Analysis of Debris Slide Incidence by Photogrammetry, Santa Ynez - San Rafael Mountains, California: Int'l Geol. Congress, 24th, sec. 13, p. 124-131.

Maberry, J. O., 1972a. Map Showing Landslide Deposits and Areas of Potential Landsliding in the Parker Quadrangle, Arapahoe and Douglas Counties, Colorado: U.S. Geol. Survey, Misc. Geol. Inv. Map I-770-E, scale 1:24,000.

Nilsen, T.H., 1973a. Current Slope Stability Studies by the U.S. Geological Survey in the San Francisco Region: Landslide, The Slope Stability Review, v.1, no.1, p. 2-10.

Nobel, E.L., and Lundee, L.J., 1970. Analysis of Rehabilitation Treatment Alternatives for Sediment Control, IN: a Symposium--Forest Land Uses and the Stream Environment, 1971, Continuing Education Publications, Oregon State Univ. Press, Corvallis, p. 86-96.

Nolan, K.M., Harden, D.R., Colman, S.M., 1976. Erosional Landform Map of the Redwood Creek Drainage Basin, Humboldt County, Calif: U.S. Geol. Survey Water-Resources Investigation 76-42 Open-File Report, scale 1:62,500.

Swanson, F.J., 1975. Impact of Clear-Cutting and Road Construction on Soil Erosion by Landslides in the Western Cascade Range, Oregon: Geology, July 1975, p. 393-396.

Williams, D. L., 1972. Map Showing Landslides and Areas of Potential Landsliding in the Salina Quadrangle, Utah: U.S. Geol. Survey Mosc. Geol. Inv. Map I-591-L, scale 1:250,000.

APPENDIX A

Terms

Cenozoic -- an era of geologic time about 70 million years ago.

Cross Road Ditch--the construction of an open ditch through the road material to connect a drainage course interrupted by the road structure.

Humboldt Bridge --local term used to describe the once-used method of bridging drainages. Several logs are layed in parallel with the stream course. Low summer flow can drain between the logs. Soil and road materials are then placed on top of the logs. Trouble begins when rainy season increases the stream flow.

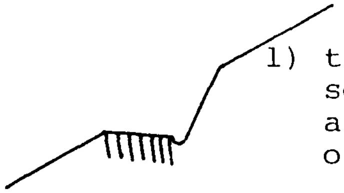
Human Agencies -- man is a geologic agent. Some of our activities create unwanted events or vastly accelerate natural processes. We erode the soil, cause landslides, alter surface and subsurface water flows, and effect natural processes in many ways. (Michael Huffman (1977))

Indurated -- a compact rock hardened by the action of pressure, cementation, and especially heat.

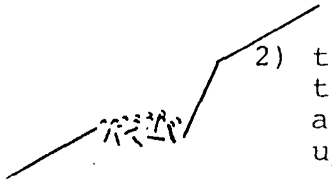
Metamorphic Outlier--an isolated rock or group of metamorphic rocks which is peculiar to the surrounding geology.

Metamorphism -- the mineralogical and structural adjustments of solid rocks to physical and chemical conditions which have been imposed at depth below the surface zones of weathering and cementation.

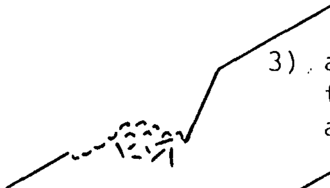
Pull a Road -- a method used to destroy the integrity of a road and allow even downhill drainage. The idealized sequence is as follows:



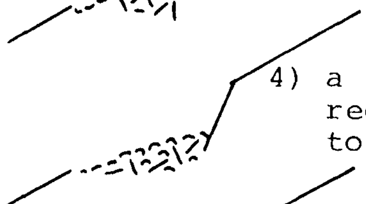
1) the haul road originally is sloped so that runoff water can be channelized along the roadside cut bank to culvert or bridge areas.



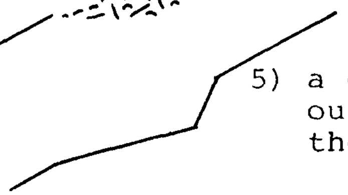
2) the haul road is ripped by a tracked tractor equipped with rippers--in effect a heavy plough or spike used to plough up the entire road to its base.



3) a mechanical backhoe or trencher pulls the road edge (embankment side) up and back into the ripped (ploughed)area.



4) a tracked tractor equipped with a blade redistributes and mixes the materials to a basic downslope grade.



5) a grader would put an even and continuous downhill sloping grade (≥2%) along the entire section of work.

Put a Road to Bed--a less extensive method used to reduce a road's integrity by a series of rips across the road (to gain access to mineral soil below the road base and aid in weathering), water bars, and cross road ditches.

Rip -- a ploughing or deep cutting through the road material to its base. Done by attaching ripper(s) to the back of a tractor or by tilting the blade so that one edge concentrates the cutting action.

Road Integrity -- the structural completeness and strength of a road. The haul road structure in this area consists of a minimum of 1.5' to 2' of angular grey sandstone quarry rock with 0.5' to 1' of rounded stream pebbles on the surface. The roads have been highly compacted by the great tonnage of equipment & logs rolled over them. By destroying the "integrity" of this unit of compacted material, the disruption of surface and near-surface water movement can be alleviated.

Schist -- a strongly foliated crystalline rock formed by dynamic metamorphism. It can be readily split into thin flakes and slabs.

Tectonic Style -- a particular style of rock deformation.

Tertiary Period --the first period of the Cenozoic era. Thought to have a time span of between 5 million and 3 to 2 million years ago.

Through Road or Through Cut Road--a section of road cut through a hill, usually to keep grade. This results in cut banks on both sides of the road. This makes rehabilitation difficult. A section of haul road in test area 2 (S-10 to S-11) is a through road. This troughing of a hillside is very disruptive to the natural drainage (both surface and subsurface).

Unconformity -- a substantial break in the geologic record where one rock unit is overlain by another that is not next in chronological succession.

APPENDIX B

Test Area 1, 1977

Station	Type of Work	Labor Time (hr.)	Planting Time (hr.)
S-1	Gully erosion control	14	2
S-2	Slope failure erosion control	64	12
S-3	Slope failure erosion control	55	9
S-4	Stream side work	71	4
S-5	Revegetation only		2
S-6	Culvert removal (50')	25	
S-7	Slope failure erosion control	41	4
S-8	Revegetation only		2
S-9	Reestablishment of drainage net, disrupted by Humboldt bridge. An attempt was made to cause erosional forces to work through the mass. Success is doubtful.	7	
	SUB-TOTAL	277	35
	TOTAL HOURS	312	
	(@ $9.50/hr. labor rate)		
	TOTAL COST	$2,964.00	

Total area of slope failures (slumps):

S-1	1 yd x 30 yds	=	30 yd^2
S-2	16 yd x 100 yds	=	1600 yd^2
S-3	20 yd x 20 yds	=	400 yd^2
S-7	10 yd x 30 yds	=	300 yd^2
			2300 yd^2

Cost for stabilization of slope failures (slumps):
201 hrs. @ $9.50/hr. labor rate = $1910
Cost per sq. yd. = $.82

Hourly Wage Rate:

Wage Per Hour	$5.00
Compensation, Insurance and Fringe Benefits	1.50/hr
Payroll Taxes	.50 per hr.
Nonproductive time -10%	.70/hr
Profits - 23%	1.80/hr
Hourly Wage Rate	$9.50

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
S-7	Bed Road	1.5		6	3
S-8	Rip	1			4
S-9	Culvert Removal	.33		4	
S-9 to S-10	Bed Road	2	40	13	6

A large crossroad ditch was constructed at S-9a to establish a drainage course through this section of road.

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
S-10	Crossroad Ditch & Rips	1	1	2	2
S-10 to S-11	Water Bar	.33	20	8	1

It was not possible to thoroughly put this section of road to bed as it is a through cut road. The break and collection of the normal hillside drainage along this section has over-stressed the area below S-11 and caused failure S-12. The established water bar was bypassed and the water shunted through a heavily vegetated area. The water load has been lowered by 1) the upper water bar near S-10 landing, 2the established water bar taking the road runoff, and 3) the new water bar taking the hillside runoff to a heavily vegetated area.

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
S-12	Planting				2

This failure is in a meta-stable condition. By directing excessive runoff away from the area and reestablishing vegetation, stability will be increased.

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
S-13	Rips	.33			1.5
S-13 to S-14	Pull Road	4	20	24	9

This section of haul road was planted with Monterey pine which were up to 1 1/2 feet in diameter. These were layed over and pushed off the embankment. Care was taken to push as little dirt as possible over the embankment. The area was then ripped (ploughed) and re-graded. Same was done to S-15.

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
S-15	Pull Road	4	10	16	5
S-16 to S-17	Bed Road	1.5	12	12	12
S-18	Rip	.33	10		2
S-19	Culvert Removal	.5	30	2	1
S-20	Bed Road	1	20	2	2

This section of haul road is located along the base of a ridge. It is a through cut road at its end section. The collection and channeling of water from the one established water bar caused slope failure S-21. Water load has been lowered by: 1) The upper water bar, 2) a lower water bar shunting water across the road into a

Station	Type of Work	Tractor Time (hr.)	Preliminary Labor (hr.)	Direct Labor (hr.)	Planting Time (hr.)
	roadside area that doesn't drain into the S-21 area, and 3) the established water bar near the bottom draining the bottom area only.				
S-21	Plant				2
S-22	Plant				1
	TOTALS	27.13	171	131	71

TRACTOR COSTS:

Hours Expended = 28
Cost Per Hour = $30
Total Cost = $840

LABOR COSTS:

Man Hours Expended = 377
Cost Per Hour = $9.50
Total Cost = $3587.00

HOURLY WAGE RATE:

	Per Hour
Wage Per Hour	$5.00
Compensation, Insurance and Fringe Benefits	1.50
Payroll Taxes	.50
Non-productive Time 10%	.70
Profits 23%	1.80
Hourly Wage Rate	$9.50

UNIT COST STATIONS

Station	Type of Work	Dimensions	Tractor Time	Direct Labor	Planting
S-2	Bed Road	50' x 150'	1	4	2
S-3	Pull Road	50' x 150'	2.5	12	4
S-4	Pull Road	50' x 125'	2.33	7.5	4
S-4 to S-5	Bed Road	40' x 400'	.66	5	5
S-9 to S-10	Bed Road	40' x 850'	2.5	13	6
S-13 to S-14	Pull Road	75' x 500'	4	23	9
S-15	Pull Road	75' x 250'	2	8	3
S-16 to S-17	Bed Road	40' x 800'	1.5	18	12

Materials:

Photographic Supplies (construction of 1 report plate)

Diapositive	$ 15.00
U.S.G.S. Topo	35.00
Copy Camera	20.00
Rectified Enlargement	40.00
Print Back	20.00
Contact Prints	25.00
	$155.00

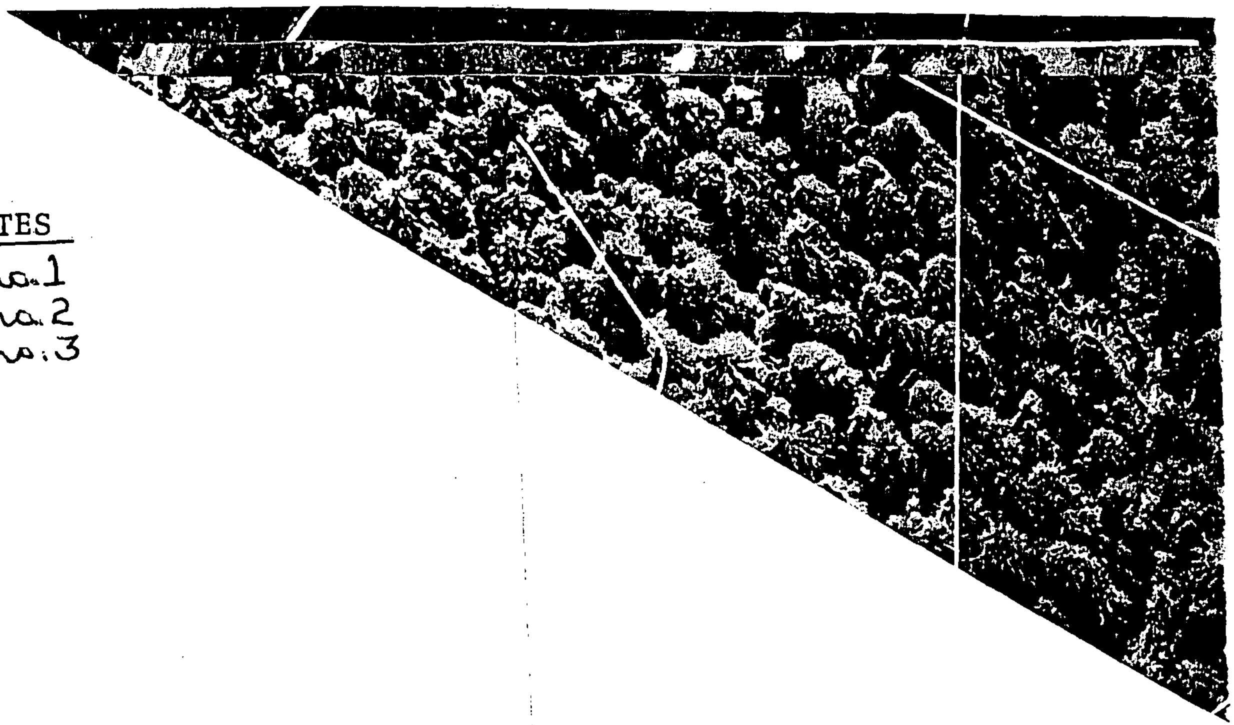
Report Plates (3)	$ 465.00
Equipment	200.00
Trees (4000 trees @ $100/1000 trees)	400.00
Grass Seed and Fertilizer	60.00
TOTAL COST	$1125.00

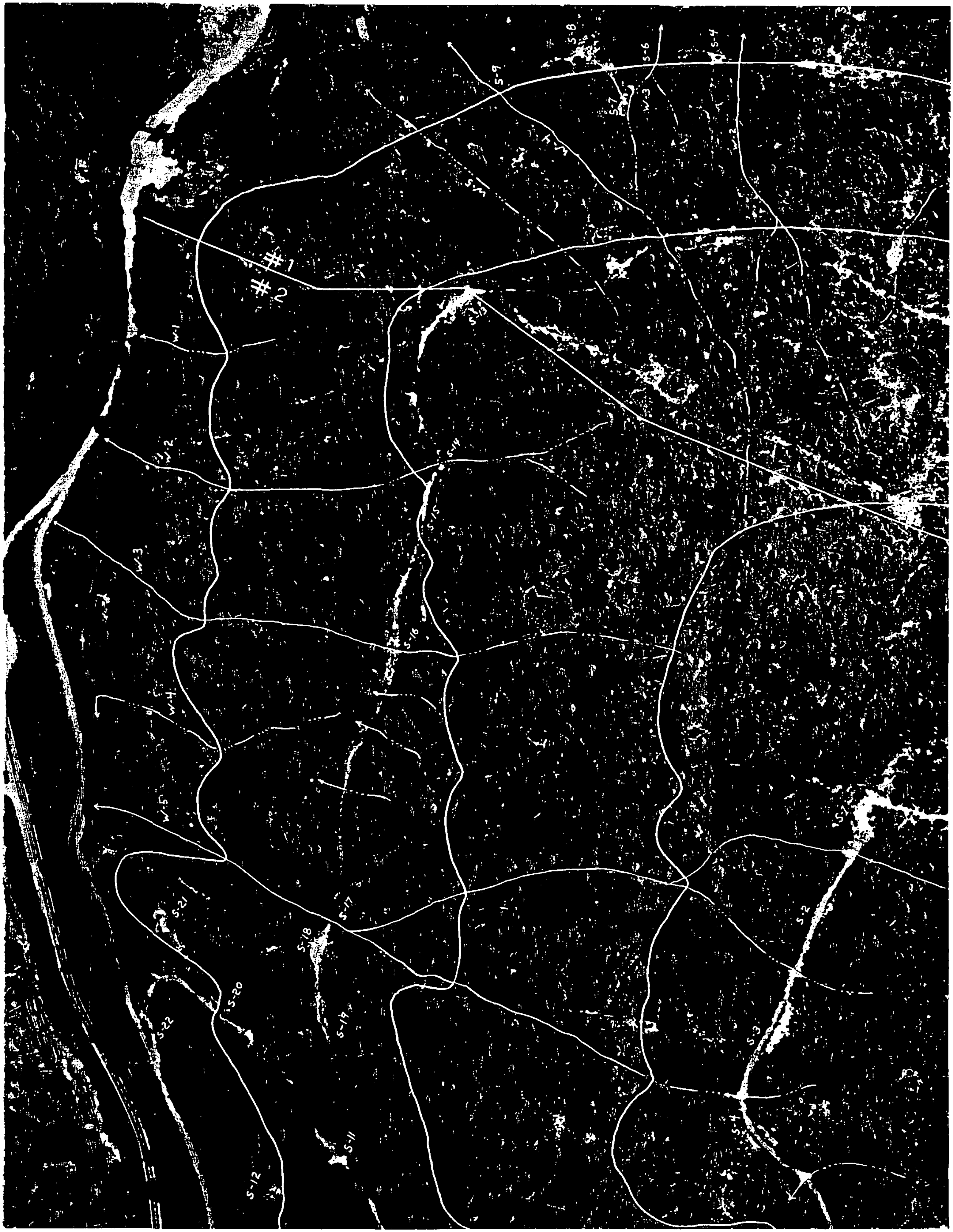
Photogrammetric and Consulting Fees:

Photogrammetric (terrain analysis)	$ 480.00
Geologic (field work, lab studies and report compilation)	750.00
Technical Consulting	150.00
Technical Assistance (darkroom and drafting)	80.00
TOTAL COST	$1460.00

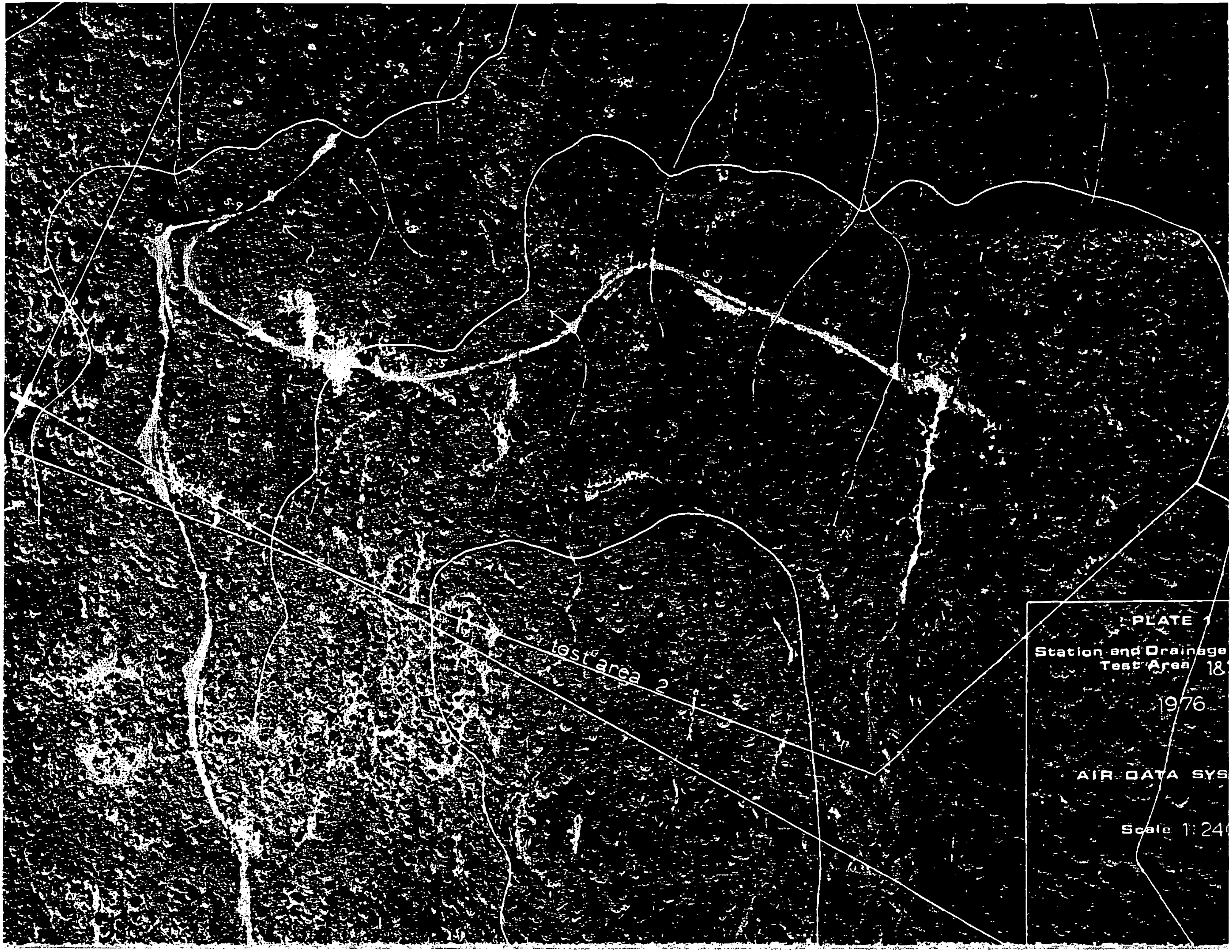
PLATES

no. 1
no. 2
no. 3




#1
#2
W-1
W-2
W-3
W-4
W-5
S-1
S-2
S-3
S-4
S-6
S-8
S-9
S-11
S-12
S-13
S-14
S-15
S-16
S-17
S-18
S-19
S-20
S-21
S-22


S-22
S-21
W-5
S-20
S-12
S-18
S-11
S-19
S-17
S-10
S-9a
S-9
S-8
S-4
S-3
S-6
S-2
S-5
S-1
S-7
test area 2


S-9a
S-9
S-8
S-6
S-5
S-4
S-3
S-2
S-1
test area 2
PLATE 1
Station and Drainage
Test Area 18
1976
AIR DATA SYS
Scale 1:24

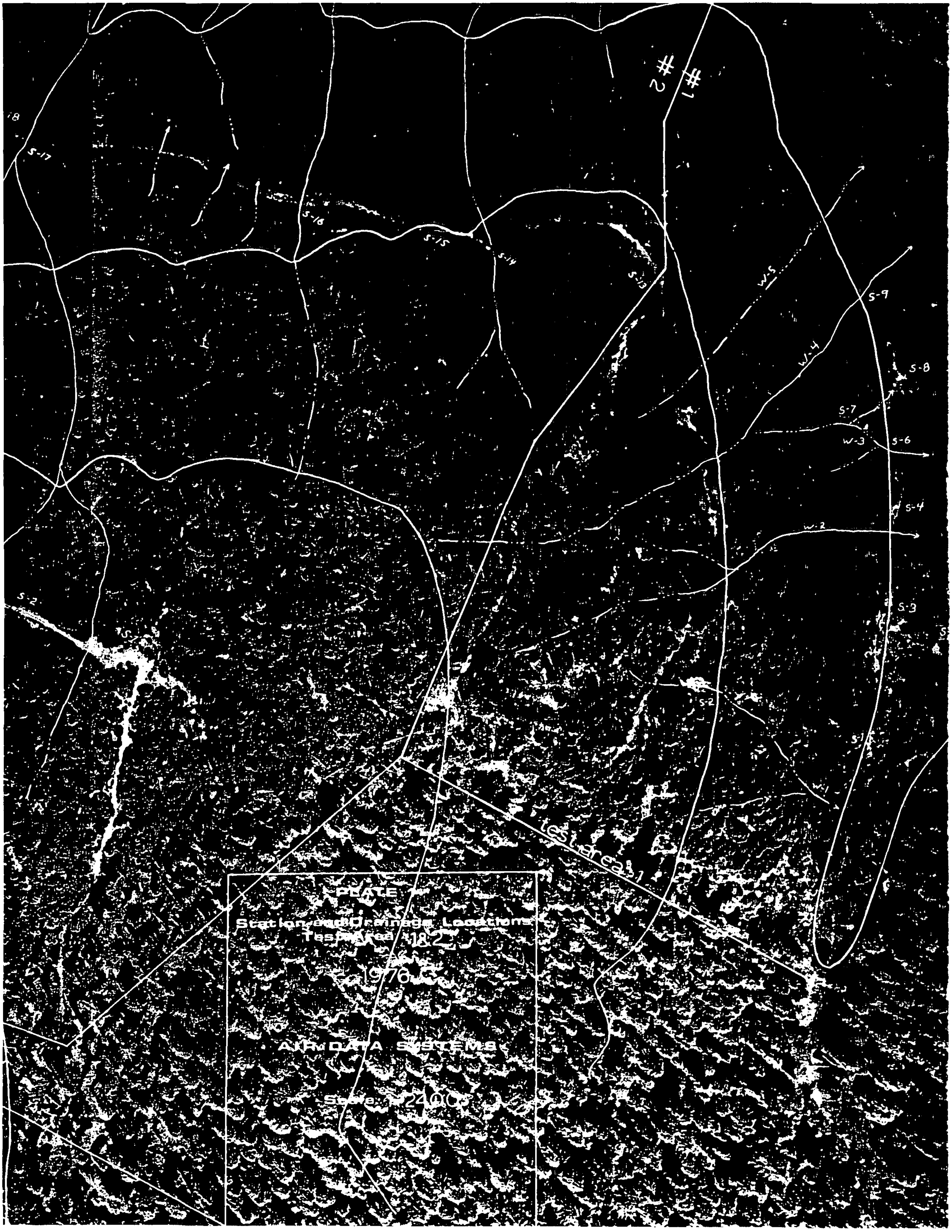
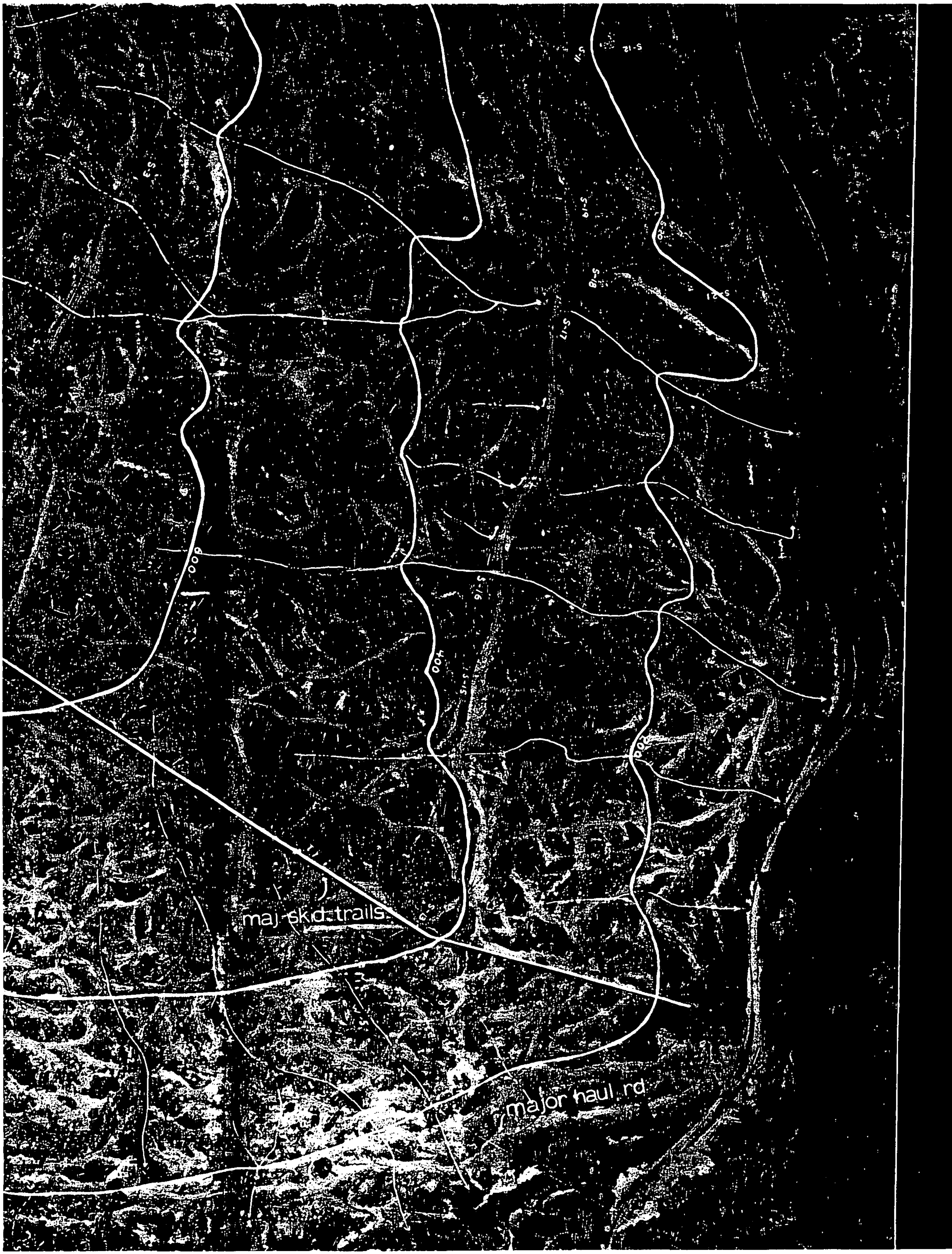


PLATE
Station and Drainage Locations
Test Area 1&2
1976
AIR DATA SYSTEMS
Scale 1:2400
test area 1
#1
#2
S-1
S-2
S-3
S-4
S-6
S-7
S-8
S-9
S-13
S-14
S-15
S-16
S-17
W-1
W-2
W-3
W-4
W-5

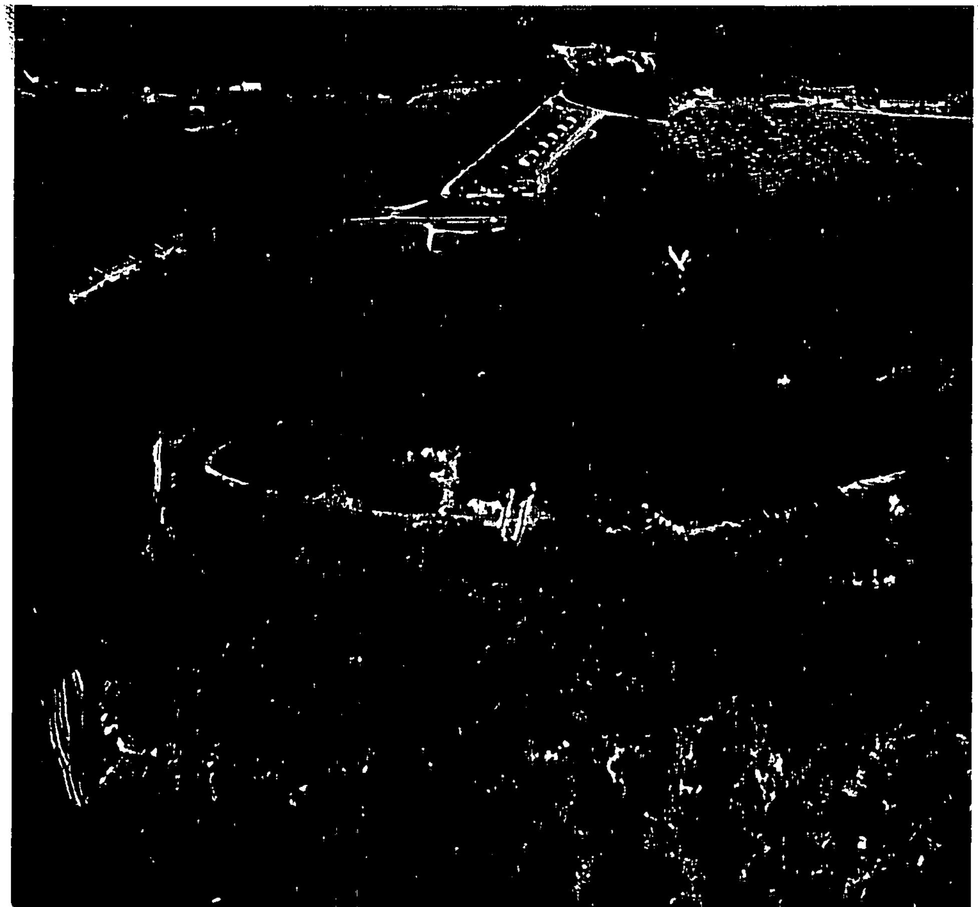

maj skid trails
major haul rd

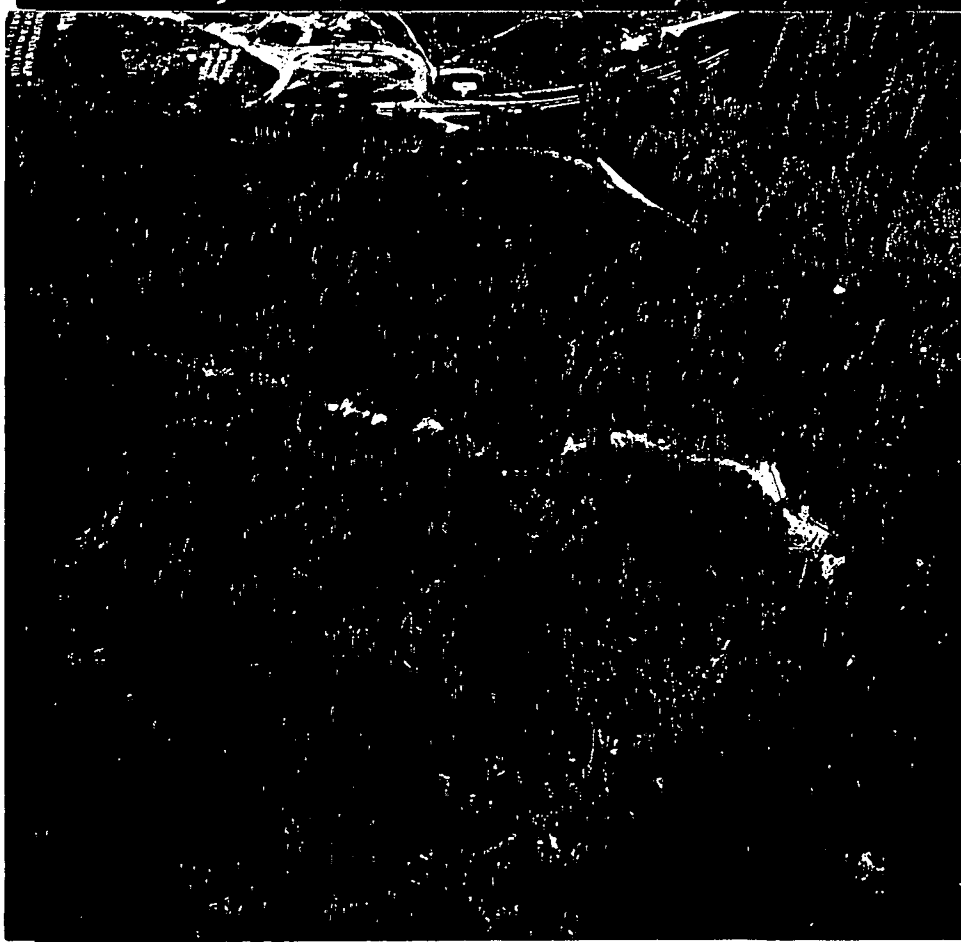

TEST AREA 2
800
S-2
S-3
S-4
S-5
S-6
S-10
S-11
S-12
S-17
S-18
S-19

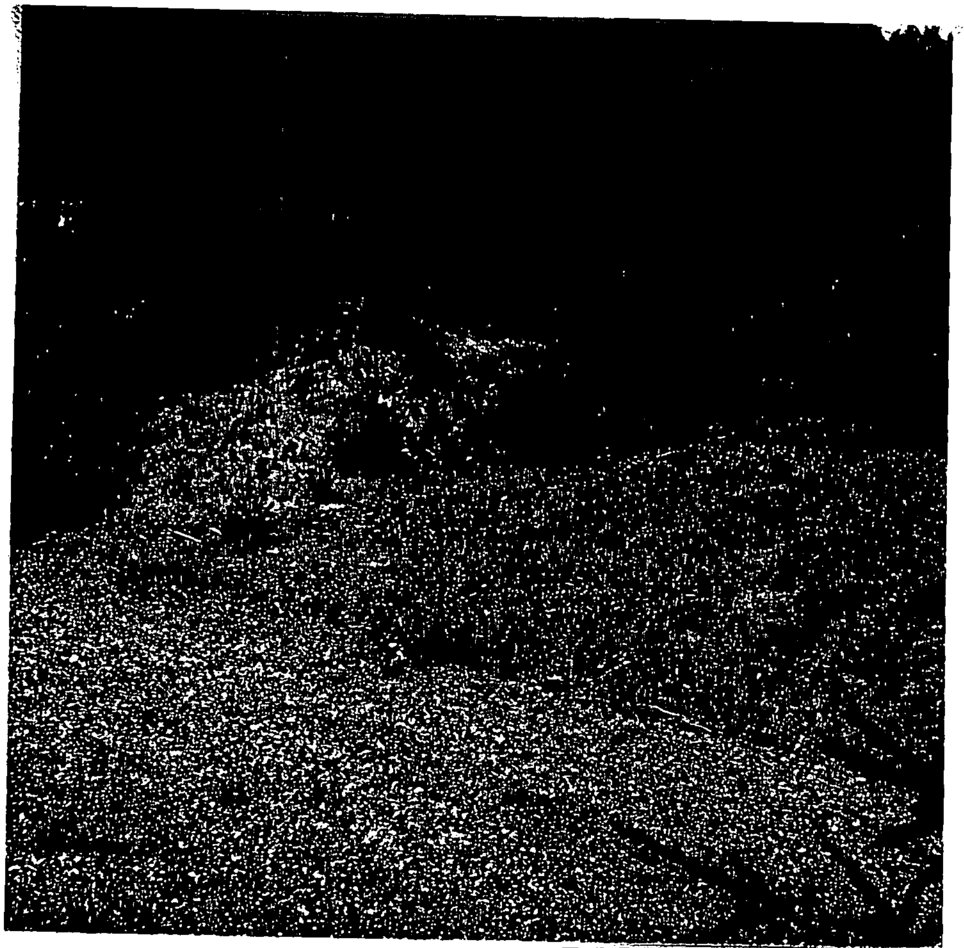

PLATE 2
Station and Drainage Loca
Test Area 1&2
1966
AIR DATA SYSTEMS
Scale 1:2400
TEST AREA 2
800
600
400

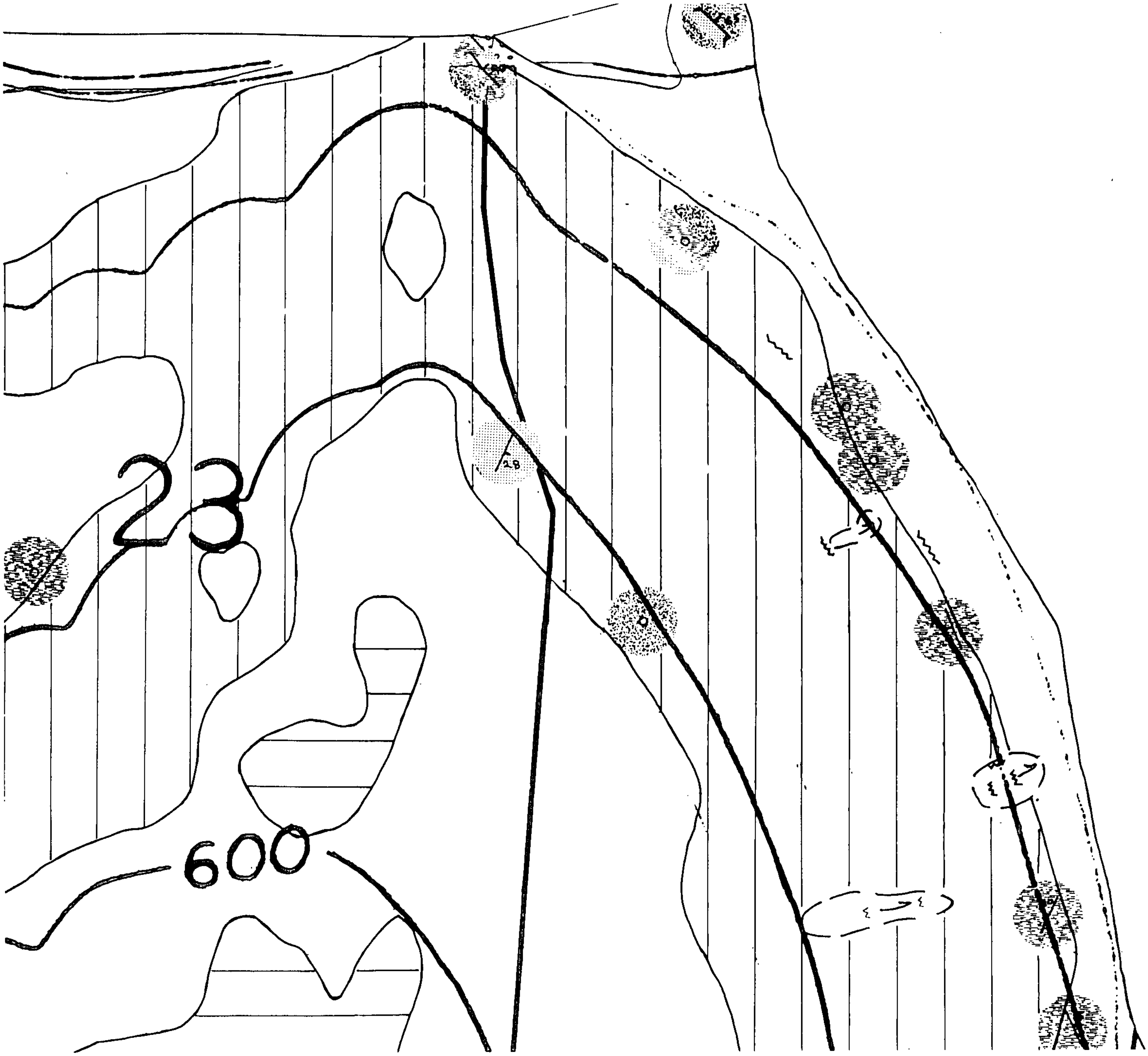

200
400
600
S-17
S-16
S-15
S-14
S-13
major haul rd
maj skid trails
TEST AREA
PLATE 2
Station and Drainage Locations
Test Area 1&2
1966
Scale 1:2400

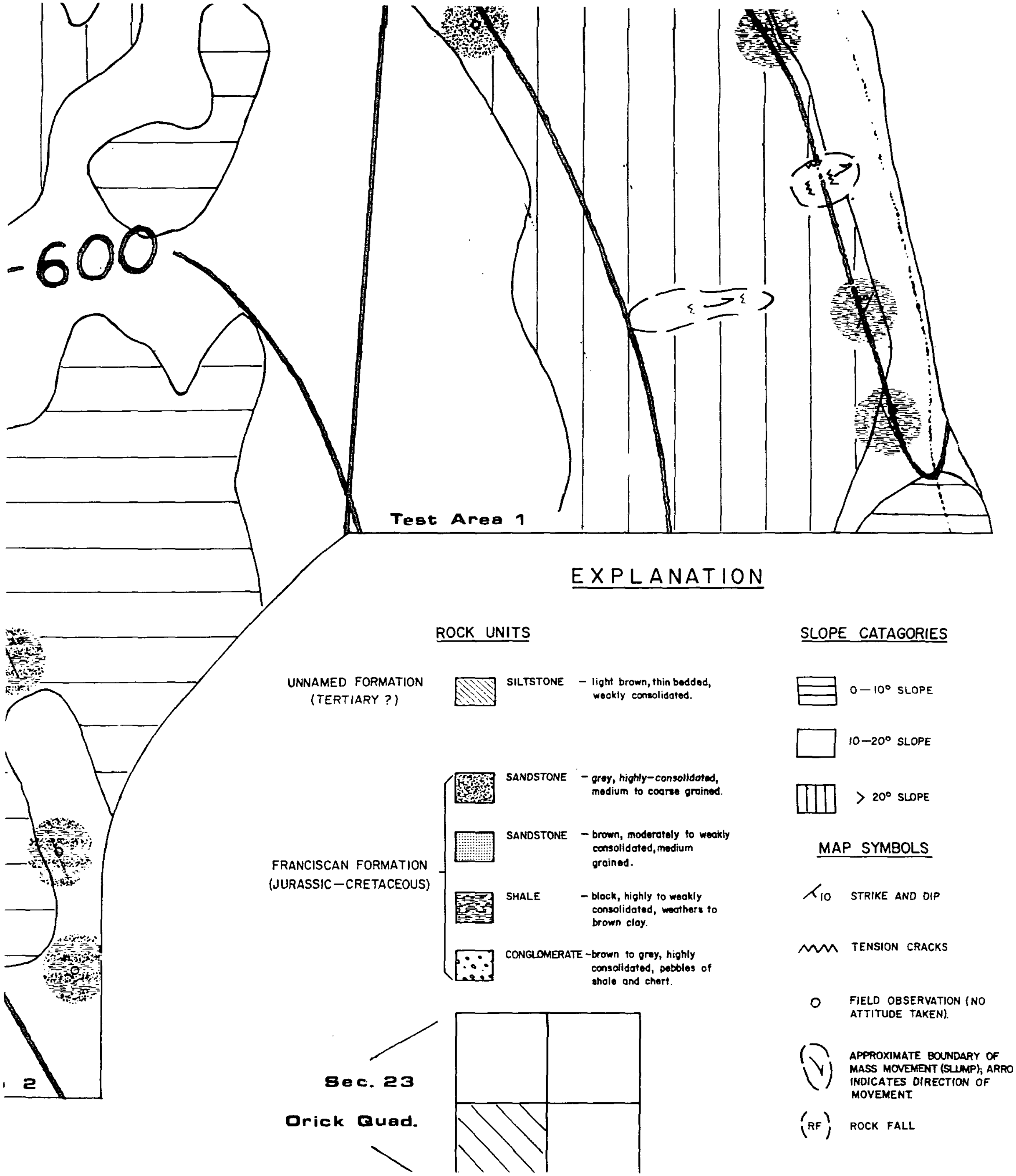
APPENDIX C: Color Prints
[no. 1-9]

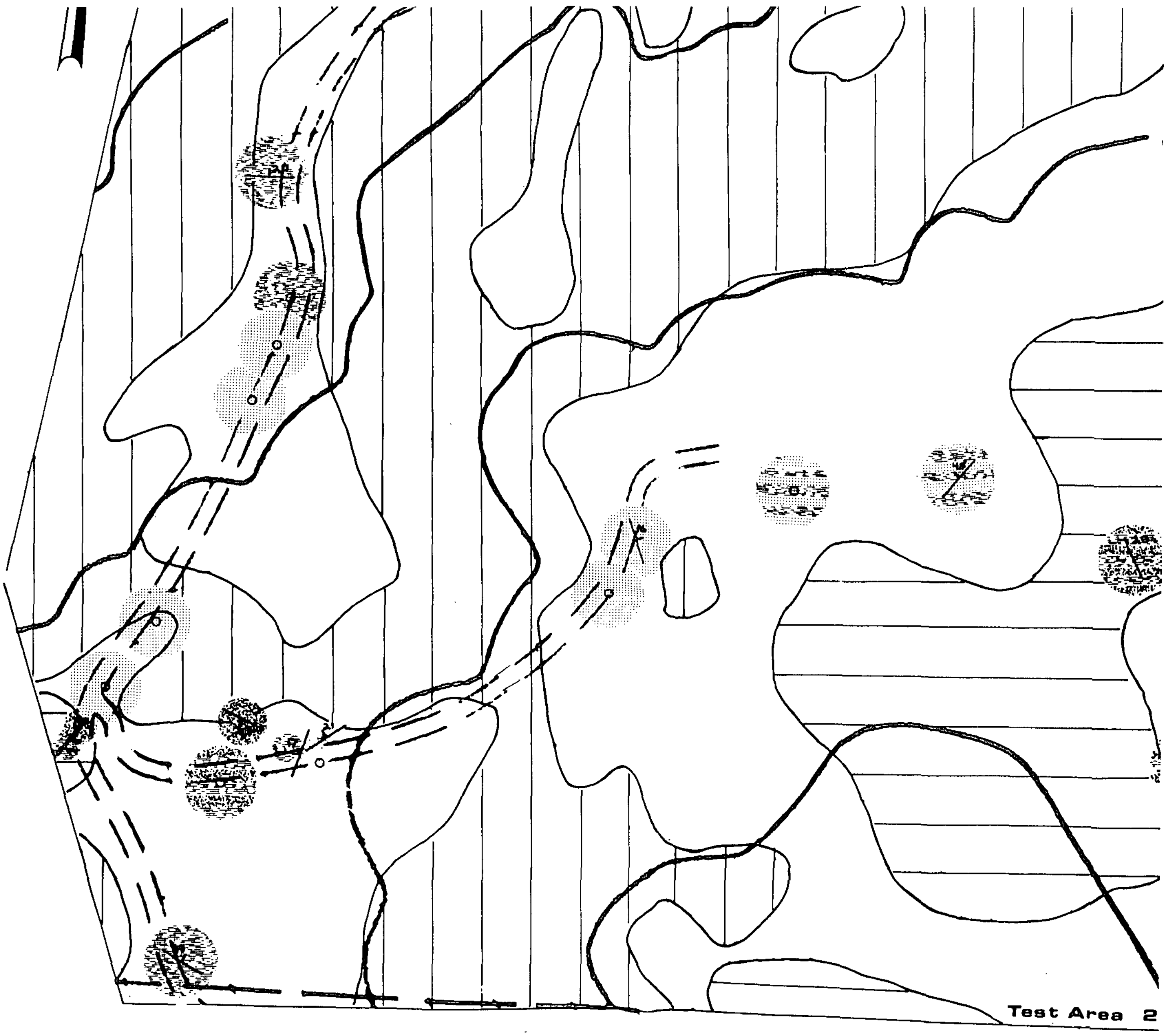








23
600
28


600
Test Area 1
2
EXPLANATION
ROCK UNITS
UNNAMED FORMATION (TERTIARY ?)
SILTSTONE – light brown, thin bedded, weakly consolidated.
FRANCISCAN FORMATION (JURASSIC–CRETACEOUS)
SANDSTONE – grey, highly–consolidated, medium to coarse grained.
SANDSTONE – brown, moderately to weakly consolidated, medium grained.
SHALE – black, highly to weakly consolidated, weathers to brown clay.
CONGLOMERATE – brown to grey, highly consolidated, pebbles of shale and chert.
SLOPE CATAGORIES
0—10° SLOPE
10—20° SLOPE
> 20° SLOPE
MAP SYMBOLS
10 STRIKE AND DIP
TENSION CRACKS
FIELD OBSERVATION (NO ATTITUDE TAKEN).
APPROXIMATE BOUNDARY OF MASS MOVEMENT (SLUMP); ARRO INDICATES DIRECTION OF MOVEMENT.
RF ROCK FALL
Sec. 23
Orick Quad.


Test Area 2

GEOLOGIC OUTCROP AND SLOPE MAP

RECLAMATION TESTS 1 AND 2

1977

BY DENNIS GIOVANNETTI

SCALE 1:2400