SUSITNA HYDROELECTRIC PROJECT

ACCESS PLANNING STUDY

JANUARY 1982

PREPARED BY:

R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

ALASKA POWER AUTHORITY

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SUSITNA HYDROELECTRIC PROJECT

TASK 2 - SURVEYS AND SITE FACILITIES

SUBTASK 2.10
ACCESS PLANNING STUDY

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INTRODUCTION

SUSITNA HYDROELECTRIC PROJECT
ACCESS PLANNING
REPORT

1 - INTRODUCTION

The Susitna Hydroelectric Project has, for many years, been considered a viable source of "clean" energy for Central Alaska. The project has been viewed as including one or more dams on the upper Susitna River. Extensive preliminary work has been done on the project by various government agencies. In an effort to expedite the project, the State of Alaska through the Alaska Power Authority, in late 1979, initiated the necessary feasibility studies and preparation of the necessary FERC (Federal Energy Regulatory Commission) license application. Access to the project is a part of those studies.

1.1 - The Study Area

The location of the project is approximately 120 air miles north of Anchorage (see Figure 1.1). The dams, as proposed, would be up stream from Talkeetna laying between the Parks Highway and the Denali Highway. This area is remote, with no existing access. The quantities of materials and supplies required for construction of the project and for the maintenance of the construction camps are of such a magnitude as to require major transportation facilities to serve the project site.

1.2 - Study Description

The Access Planning Study involved the selection of potential highway and railroad alignments that would serve the dam sites selected for detailed study. The process involved aerial reconnaissance of the potential corridors, definition of the parameters which control the horizontal and vertical alignment and the selection and analysis of alternative alignments which serve the needs of the entire project.

1.3 - Objectives And Scope of Study

The objectives of the Access Planning Study are as follows:

(a) To define an access route location or combination of route locations that will serve the supply needs of the hydroelectric project with a minimum of environmental impact.

(b) To determine a reasonable combination of transportation modes which will provide a cost effective system of supply.

(c) To define an access plan that will meet the overall scheduling requirements of the hydroelectric project.

The Scope of the Study includes the definition and analysis of routes within three general corridors. Corridor 1 is located on the north side of the Susitna River from the Parks Highway to the Watana site. Corridor 2 is on the south side of the Susitna River between the same general termini. Both corridors were required to serve both Devil Canyon and Watana Dam site. The third corridor connects the Watana Dam site with the Denali Highway to the north. Both road and railroad access are to be considered.

The study must examine the corridors and generate preliminary route locations and cost estimates. The cost estimates will include the costs of constructing the access, maintaining the facility and moving material over the route. The environmental impacts of the various alignments are to be addressed under Task 7, however a continuous flow of input from the environmental studies will be provided to aid in studying the alignments.

Engineering, Soils, Cost and Environmental information will be combined to develop alternate access plans that satisfy the stated objectives. This report will present those alternate plans.

1.4 - PLAN FORMULATION AND SELECTION PROCESS

There are a number of important factors to be considered in developing and analysing transportation facility plans. The locations of the dams, of course, dictate terminal points common to all access plans. The number and size of loads of material and supplies together with the volume of traffic to be generated by the construction camp population dictate the design parameters appropriate to the facility. The terrain, soils and environmental concerns control and limit the possible location for the facility. All of these factors will be considered.

(a) Planning Methodology

The planning process for transportation facilities of this magnitude is one of a series of iterations in which proposals are developed, tested, revised and tested again until a plan emerges that serves the desired function in a cost effective and environmentally sound manner. Following this pattern design parameters were developed, then potential alignments were selected that appeared to serve the project needs. A number of alternative alignments were identified for further consideration. During the process of evaluating the engineering considerations of the alternatives some were eliminated and some sections of others were revised so that all remaining sections conformed to the required design parameters. The information on the remaining sections was then given to the geological team and the environmental team for additional input. Consideration of this input has resulted in elimination of additional sections and changes in some of those remaining. The various available port facilities and transportation modal options were identified and then combined with the remaining possible alignments to form possible access plans. Each plan was then analyzed to determine how well the project objectives were satisfied. Any advantages or disadvantages were identified and the estimated costs for construction, maintenance and logistics were developed.

(b) Economic Analysis

Each access plan has four major cost factors associated with it. Each of the cost factors were considered and used in comparing the alternate access plans and determining the cost-effectiveness of the various plans.

- Construction cost estimates were prepared for each alternative. These estimates were very preliminary and valid only for comparison and determining the order of cost magnitude. More refined cost estimates are not possible or necessary at this stage of the work. Detailed cost estimates are not possible due to the lack of micro-scale data. The estimates prepared are, however, correct with regard to order of magnitude and, because of the assumptions, for comparison purposes.

- Maintenance cost estimates were developed for the various plans. These costs covered only maintenance on the facility constructed. Maintenance costs on existing facilities that may be atributable to the project would be difficult to identify and the difference between plans would be insignificant.

- Logistics costs as used herein are the costs associated with moving material, supplies and equipment to the site. Port costs, freight rates for various modes, and the transportation modal split combine to generate signficant cost variations when comparing access plans. Each plan was evaluated by estimating the transportation costs for major material items to be moved to the site.

- Schedule costs were discussed in terms of time delays that would result from selecting any of the alternate plans. Dollar costs were not estimated for any such delays because the complexities of such estimates go far beyond the scope of this work. It is intuitively obvious, however, that with a project of the magnitude of the Susitna Hydroelectric Project any delays from the planned schedule will have major construction cost ramifications due to inflation and social cost resulting from the inability to meet the demand for power.

1.5 - Organization of Report

The objective of the report is to present a series of alternative access plans which serve the needs of the Susitna Hydroelectric project. The report does not include a single recommended plan.

The body of the report contains a discussion of the pertinent features. Detailed technical information is contained in a series of appendices. The report is organized as follows.

Section 1. Introduction

Section 2. Summary

The section contains a complete Summary of the report.

Section 3. Scope of Work

This section outlines the Scope of Work associated with the results presented with this document.

Section 4. Previous Studies

This section briefly summarizes the access information available in previous Susitna Basin Studies done by others.

Section 5. Project Design

This Section briefly describes the Susitna Hydroelectric Project in a way that sets the stage for the remainder of the access analysis.

Section 6. Project Schedule

This section discusses the overall planned schedule for the Susitna Hydroelectric Project and identifies the scheduling requirements for construction of the access facilities.

Section 7. Logistics Requirements

This section presents the estimated quantities of the major items of equipment, materials and supplies that must be transported to the site during the course of construction, including the supplies necessary for the construction camp. Any particular constraints affecting the mobilization and/or movement of material for access construction are also discussed.

Section 8. Access Design Parameters

This section discusses the specifics of the basic design parameters for both road and railroad construction. The parameters discussed include curvature, maximum grades, horizontal and vertical clearance requirements, load requirements and surfacing requirements.

Section 9. Corridor Selection

This section discusses the process by which the suggested corridors were selected for study and includes a discussion of each of the alignment segments originally investigated.

Section 10. Access Plans

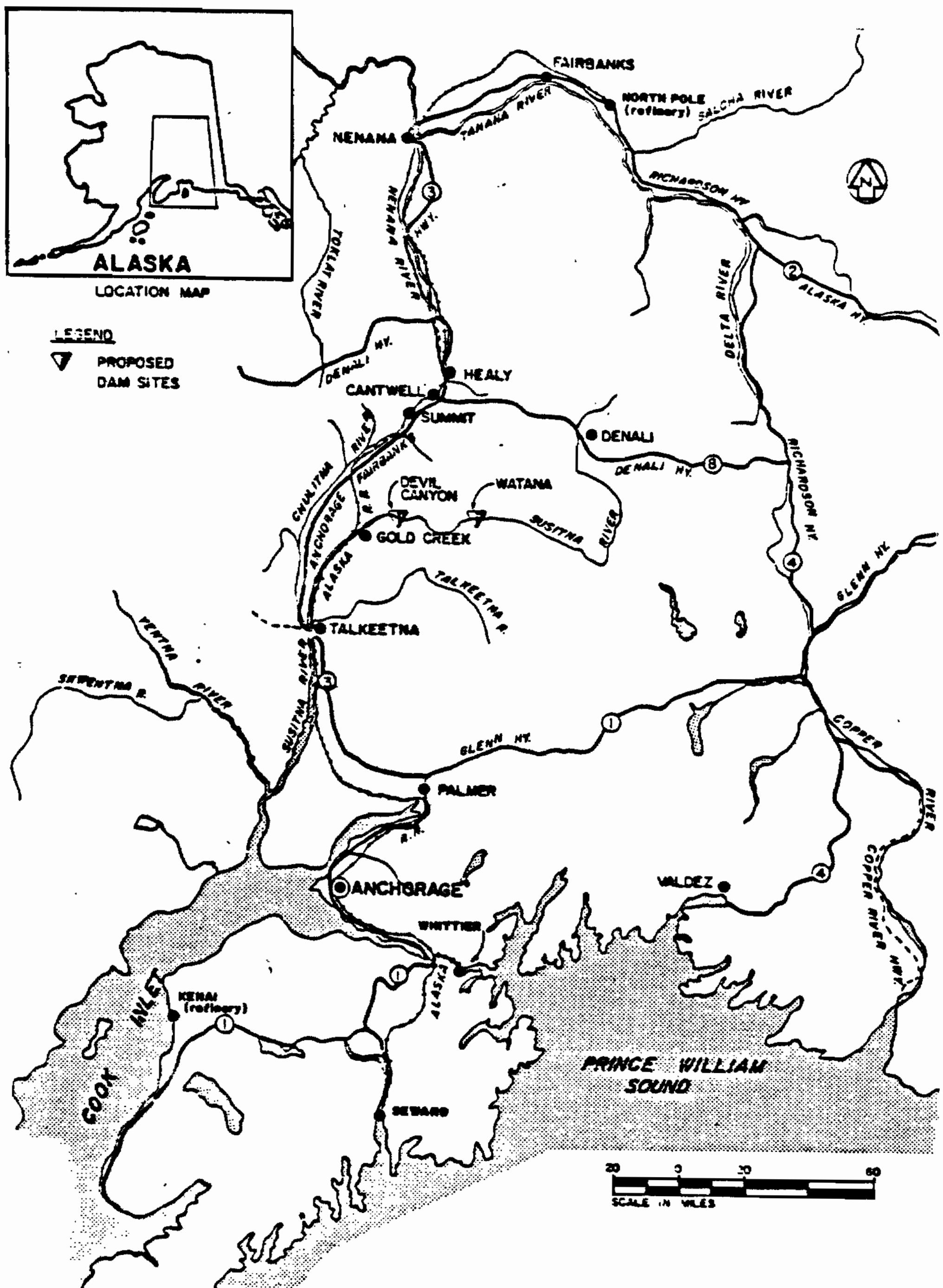
This section presents a series of alternate access plans including a discussion of the pros and cons of the various available ports, shipping options, and land transportation modes. Cost estimates for each plan are developed which include construction, maintenance and logistics costs.

Section 11. Conclusions and Recommendations

Conclusions and recommendations are not a part of this report because additional environmental data is to be considered along with the data presented here. A final recommendation is expected to result from that analysis combined with the results of this study.

APPENDICIES

Appendix A	Preliminary Design Development
Appendix B	Proposed Alternative Segments
Appendix C	Alternative Comparison - Grade, Curvature and Distance
Appendix D	Terrain Unit Maps
Appendix E	Environmental Concerns
Appendix F	Alternative Plans
Appendix G	Borrow Pits



LOCATION MAP

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LOCATION MAP

FIGURE 1.1

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ACCESS STUDY LOGIC DIAGRAM

FIGURE 1.2

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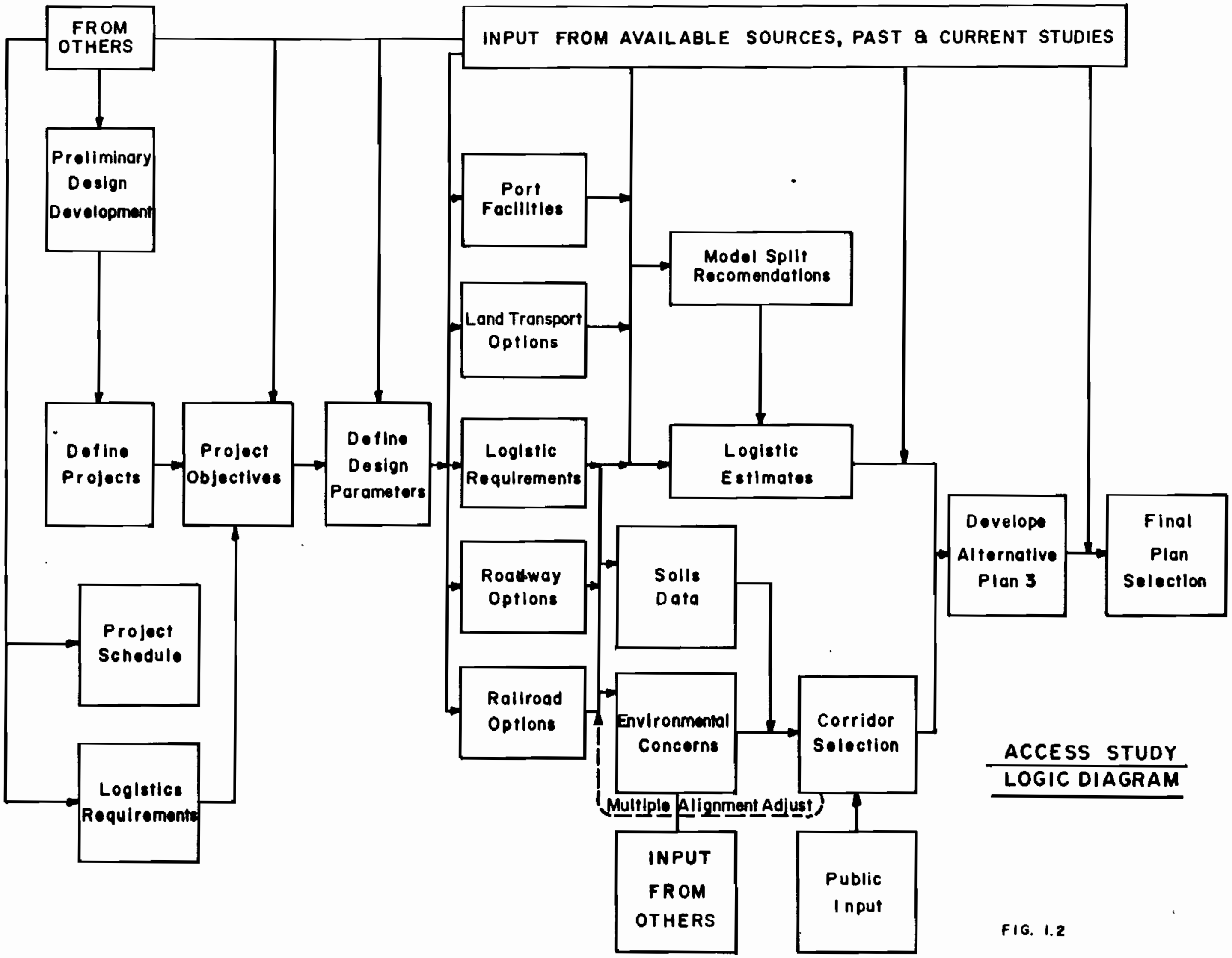


ACCESS STUDY
LOGIC DIAGRAM

FIG. 1.2

SUMMARY

2 - Summary

This summary is intended to provide a brief overview of the access study, its methods and results.

2.1 - Scope of Work

The scope of work for the Susitna Access Study was defined in general terms in the original Plan of Study (POS) for the Susitna Hydroelectric Project. The POS required that three corridors be examined and the both road and rail options be included. The access plan was required to serve both Watana and Devil Canyon Dams and be able to satisfy the desired project schedule.

2.2 - Previous Studies

Previous studies of the Susitna Hydroelectric project were reviewed to determine the extent of work that had been done relative to access. Very little had been done. The Corps of Engineers had carried the access question the furthest and their 1975 reports included a roadway that followed closely the alignment described as Plan 1 from Parks Highway to Watana on the south side of the river via Gold Creek.

2.3 - Project Design

Preliminary design of the hydroelectric project provided input to the access study. The quantities of materials to be imported to the project site and the size of the work crews were considered in estimating the costs of transportion and in selecting the ports and land transportation modal splits suggested in the various plans.

2.4 - Project Schedule

The overall schedule for the Susitna Hydroelectric project has been set based on projected power requirements in the region. These studies show that power from Watana Dam is needed first with power on line required in 1993. A period of eight years is projected to build the facility. This requires initial construction in 1985. The Federal Energy Regulatory Commissions license is anticipated in late 1984 on early 1985. Construction of access facilities cannot predate the FERC license therefore an access plan was desired that would allow mobilization and resupply activities to occur in 1985. This meant a plan providing access to Watana that could be made passable in one construction season. The estimated construction time for Devil Canyon is seven years with construction projected to begin in 1993.

2.5 - Logistics Requirements

The primary requirements for imported material and supplies were provided by other tasks. The volumes of materials were combined with planned construction schedules to project required average rates of flow for supplies.

TABLE 2.1

Major Quantities in the Dams

	Watana	Devil Canyon
Excavation (Rock & Earth)	22,000,000 c.y.	5,000,000 c.y.
Fill	76,000,000 c.y.	1,335,000 c.y.
Construction Equipment	16,000 ton	5,000 ton
Explosives	20,000 ton	3,000 ton
Cement	350,000 ton	650,000 ton
Reinforcing Steel	33,000 ton	22,000 ton
Rock Bolts	12,500 ton	3,000 ton
Steel Support & Liners	3,600 ton	2,200 ton
Mechanical, Structural & Electrical Equipment	15,000 ton	13,500 ton
Fuel	75,000,000 gal.	17,000,000 gal.

Camp populations were estimated at 4,500 persons for Watana and 3,100 persons for Devil Canyon. Past experience shows that camps of this size require 13 pounds of food and supplies per occupant and 1.1 gallons of fuel oil per occupant on a daily basis.* These quantities where combined with the construction schedules to develop the following average material flow requirements for the project.

* Data provided by Arctic Hosts, Inc., Anchorage Alaska.

TABLE 2.2

SUMMARY OF REQUIRED AVERAGE MATERIAL FLOW RATES

	Watana Dam	Devil Canyon Dam
Trucks	90	110
Contingency & Misc.	18	22
Total	108 Truck Loads/week	132 Truck Loads/week
Rail Cars	39	44
Contingency & Misc.	8	9
Total	47 Rail Car Loads/week	53 Rail Car Loads/week

2.6 - Project Parameters

The required freight movements and the size and weight of transformers and other major components were used to establish parameters for line, grade and load requirements for both railway and roadway options. These parameters were then used to identify potential access routes and are based on standards published by The American Association of State Highway and Transportation Officials (AASHTO) and the American Railway Engineering Association (AREA).

TABLE 2.3

APPROVED ROADWAY DESIGN PARAMETERS

Design Speed	60 mph
Maximum Grade	6%
Maximum Curvature	5%
Design Loading (Construction Period)	80 Kip Axle & 200 Kip total
Design Loading (After Construction)	HS-20

TABLE 2.4

APPROVED RAILROAD DESIGN PARAMETERS

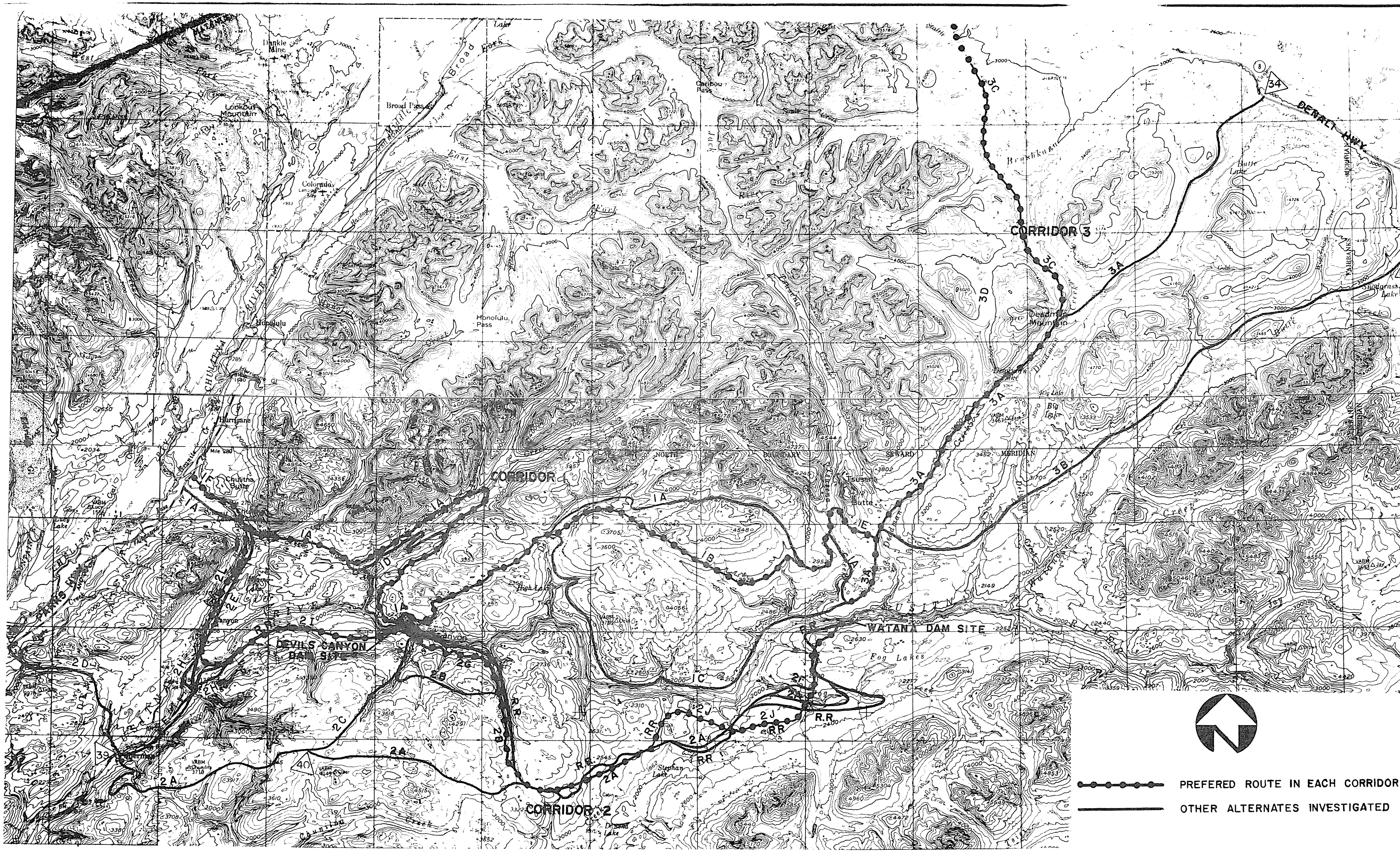
Maximum Grade	2.5%
Maximum Curvature	10°
Loading	E-72.

2.7 - Alternatives Segments

The design parameters were used to define a series of alternative alignment segments that could be mixed and matched to define alternate access routes meeting project requirements. The segments as originally defined were given to the soils and environmental teams for their input. That input, along with engineering considerations was used to eliminate some segments and modify others. The remaining segments were combined to establish preferred routes in each corridor. These corridor alignments are shown on Figure 2.1.

2.8 - Alternative Access Plans

Alternative access plans were developed. Each plan included recommended Alaskan ports, line haul mode, location of transfer points and delivery mode.



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PROJECT ACCESS LOCATION ALTERNATIVES

FIGURE 2.1

The sea ports checked include the following:

Anchorage
Seward
Whittier
Valdez

Anchorage is the preferred port for those items suitable for shipment in conventional containers and trucks. The port has the apparent adequate capacity and the best facilities of the four. The drawback in Anchorage is a lack of capabilities for roll-on roll-off rail shipment. Anchorage does, at times, have an ice problem.

Seward is unable to compete directly with Anchorage in facilities or capacity. Seward is suitable for an overflow port as there is equipment available to handle container cargo and there is direct rail and highway access. Seward is an ice free port.

Whittier is unique in that there is roll-on roll-off rail capability. Because of freight rates and handling charges Whitter is the obvious choice for arrival of all materials that can be shipped by rail car.

Valdez has a considerable capacity and is expanding its port facilities. Valdez has been eliminated from major consideration for a number of reasons that would contribute to increases in project cost.

- Lack of Rail Service
- Highest Wharfage and Handling Costs of Any of the Four
- Longest Truck Haul to the Project

Anchorage and Whittier are the ports selected and are common to all plans.

Line haul rates were collected from the Alaska Railroad and several trucking firms. A comparison of line haul rates is shown below.

TABLE 2.5

LINE HAUL RATES IN DOLLARS/TON-MILE

Item	Rail	Truck
Equipment	0.1878	0.2069
Steel	0.2577	0.2069
Cement	0.1565	0.2069
Fuel	0.1450	0.2069
General Cargo	0.1262	0.2069
Explosives	0.6267	0.2069

While certain items may move by truck with lower costs, the mix of items and quantities make it clear that the overall most cost effective line haul mode is rail. For this reason all plans contemplate rail haul to the maximum extent practicable.

A total of eleven access plans have been outlined. There are no plans including the segments around Portage Creek as the engineering, soils and environmental problems have combined to make the Portage Creek drainage very undesirable.

Plan 1 serves both Devil Canyon and Watana Dam by road south of the Susitna River. This plan includes a rail head at Gold Creek and road access to the Parks Highway. This plan encounters significant amounts of critical wildlife habitat around Stephan and Fog Lakes. There are some extensive areas of deep organic soils and soils containing massive ice near Stephan Lake. There are major schedule constraints involving two major bridges and extensive rock construction. The schedule constraints are such that the construction of Watana could be delayed by as much as three years.

Plan 2 is the railroad alternative to Plan 1. Plan 2 also does not satisfy the requirement of being able to allow resupply of construction activities at Watana in one construction season.

Plan 3 serves Watana by road from the Denali Highway east of Cantwell. A railhead is called for at Cantwell. Access to the Devil Canyon Dam is by road with a railhead at Gold Creek. This plan meets all primary objectives of the study but does not include a direct connection between Watana and Devil Canyon. The roadway from Denali Highway can be made usable for construction equipment and resupply in one construction season allowing access to Devil Canyon to be constructed as required.

Plan 4 is similar to Plan 3 except that access to Devil Canyon is to be by rail rather than road.

Plan 5 uses all roadway connecting with the Parks Highway and a railhead at Gold Creek. The south side of the river is followed to Devil Canyon. At this point the plan calls for a low bridge over the Susitna River during construction, to be replaced by a road across the Devil Canyon Dam crest when that is completed. The road would then follow the north side alignment between Devil Canyon and Watana. This plan avoids the majority of the identified environmentally critical areas of all three corridors. The steep terrain in the location of the Devil Canyon low level crossing necessitates below standard road parameters. The design speed would be reduced to 30 mph.

Plan 6 is the same as Plan 4 except that a road is included between Watana and Devil Canyon for the exclusive use of the maintanance and operations personnel. This plan satisfies all major objectives of the study.

Plan 7 is the same as Plan 3 except that a road is included between Watana and Devil Canyon for the exclusive use of the maintenance and operations personnel. This plan satisifies all major objectives of the study.

Plan 8 is similar to Plan 5 except that there is no road access between the Parks Highway and the rail head at Gold Creek. Supplies are hauled by rail to Gold Creek, then shuttled by truck to the two damsites. The advantage of this plan is a total lack to public access.

Plan 9 is similar to Plan 8, except that rail replaces road access from Gold Creek to Devil Canyon. A road then continues from the railhead at Devil Canyon to Watana along the north side. This plan, while good from an environmental aspect, still has the major design constraint of the low construction bridge at Devil Canyon.

Plan 10 is similar to Plans 1 and 2. Corridor Two, along the south side is used. Access is by rail, from Gold Creek to Devil Canyon, then by road, along the south side, to Watana. This plan has the same environmental and engineering constraints as Plan 1 in the vicinity of Stephan Lake and Fog Lakes. The Fog Creek Bridge is a time constraint that could cause a delay of up to three years.

Plan 11 serves the entire project from the Denali Highway. No access is provided at Gold Creek. Supplies are shipped by rail to a railhead at Cantwell, then trucked to Watana via the Denali Highway, then on to Devil Canyon along the north side. This plan has the advantages of no major bridges, no major environmental conflicts and no scheduling delays. The longer haul, however, makes this route the most expensive from a logistics standpoint.

The final choice of access plan will be made after additional input from the remainder of the study team can be evaluated.

SCOPE OF WORK

3 - SCOPE OF WORK

The Scope of Work discussed in this Section includes the development and selection of corridor alignments, an analysis of modal split options and selection of alternative access plans designed to provide a cost effective access system that will satisfy the project requirments while meeting the project schedule.

Further details of the Scope of Work may be found in Acres' Plan of Study (POS).

3.1 - Corridor Selection

The initial step in selecting the corridors was definition of the parameters that control line and grade. Preliminary estimates of the size and weight of the critical components were made and the width, grade and curvature parameters were selected to allow movement of those components

After the controlling parameters were defined, possible alignments were identified using 1:63,360 scale contour maps. A number of alternate segments were identified for further analysis. Potential corridors were to be identified on both sides of the Susitna River from the Parks Highway to Watana and, from Watana north to the Denali Highway. At least one corridor was to include a potential for rail service to both Dam sites.

The alternative segments were grouped into possible total routes. The possible routes were compared with regard to alignment, gradient, soil conditions, environmental constraints and other considerations to determine the most favorable alignment within each corridor.

3.2 Modal Split Analysis

The modal split analysis was necessary to suggest the optimum mix of transportation modes and the most advantagous transfer point between modes.

Potential seaports and the cargo handling capability of the respective ports are of prime importance. It was necessary to determine if roll-on roll-off rail barge service was possible or if material must come by barge and be transfered to rail and/or truck.

Freight rates for the railroad and for truck haul were checked to determine the most economical way to ship various items within the State of Alaska.

The estimated quantities of the major items were supplied from other tasks. Using these quantities and the rate information a variety of modal mix options were examined to determine the cost effectiveness of the apparent options.

3.3 Access Plan Development

This effort is a mix and match exercise in which the various combinations of potential corridor segments and modal split options are tested to compare cost effectiveness of the over all plan and the degree to which overall project time schedules are served. The cost effectiveness of the various plans are based on combined costs of construction, maintenance and logistics over the construction life of the project. The degree to which the overall time schedule can be satisfied is based on two factors, estimated construction time for the access facility and whether the plan will allow inital work on the dams to begin as planned.

PREVIOUS STUDIES

4 - PREVIOUS STUDIES

The studies done by the various agencies that have looked at the Susitna Hydroelectric project have presented much information on the many alternative power developement plans. These same studies have included very little data on access to the project. Generally, construction of a road is presumed and little else is mentioned.

4.1. U.S. Corps of Engineers

The 1975 report prepared by the Corps of Engineers incorporated a road access that corresponds very closely with one of the corridors defined in the study. That access proposal began at the Parks Highway near Chulitna Station, parallels the Alaska railroad south and east to a crossing of the Susitna river then proceeds up the south side of the river to Devil Canyon and on the the Watana site via the north end of Stephan Lake and the west end of Fog Lakes. The facility contemplated was a 24-foot wide roadway designed for 30 miles per hour. A rail head was planned at Gold Creek also.

4.2 Others

Other studies done on the Susitna Hydroelectric project over the years mentioned access only in passing and and did not develop access plans.

PROJECT DESIGN

5 - PROJECT DESIGN

The Susitna Hydroelectric Project is developing as a two dam system. The total system will include, in addition to the dams themselves, all associated on-site power generating facilities, and transmission facilities. A large construction camp with all of the required support facilities will be needed during construction, at each dam, and a permanent village for the operating and maintenance staff will be necessary after construction is complete. An airstrip and other access facilities over which all of the equipment, personnel and supplies will reach the project site must be provided as early in the project as possible.

5.1 - The Dams and Related Facilities

(a) The Watana Dam is projected to be a large earth and rockfill structure involving placement of approximately 76 million cubic yards of zone type embankment that will come largely from borrow areas near the site. The dam is to be located on the main stream of the Susitna River a short distance above the mouth of Tsusena Creek. During construction, the river is to be diverted through tunnels which will be gated and used for other purposes after completion of the work. The Power house is planned to be underground while the spillways are to be surface structures configured to prevent nitrogen saturation of downstream waters. Staging areas for construction activities are available on both sides of the river at the Watana Site.

(b) The Devil Canyon Dam is projected to be a concrete arch structure set in the section of the Susitna River known as Devil Canyon. To achieve planned pool elevation, a low saddle dam will be required south of the main dam. River diversion will again be through tunnels during the construction period and the power house for this structure will also be underground. Construction activities will probably be staged from the south side at Devil Canyon because of the terrain.

(c) The Transmission Lines are proposed for the north side of the river from Watana west to a connection with the Anchorage-Fairbanks intertie near Chulitna Pass. The final location of the transmission corridor has not been selected as of this time.

5.2 - Construction Camps

A Construction Camp is expected to be located near the Watana site and probably on the north side of the river. Manpower requirements based on quantities of materials and projected construction schedule show a need for up to 4,500 persons during the peak of construction activities at Watana. Current plans call for a construction camp at each of the dams. There is a shortage of land suitable for a camp near the Devil Canyon site, however, there is one site near the south end. Manpower projections for Devil Canyon construction indicates a peak population of 3,100 persons.

5.3 - Permanent Village

The size and complexity of the overall system will require a full time maintenance and operations staff. Projections show that this staff including their dependents will require a permanent village of approximately 45 dwelling units plus support buildings.

5.4 - Airstrip

Over-all project development, the size of the work force involved and the remote nature of the site indicate that an airstrip will be desirable for a wide variety of reasons including the movement of personnel and a need of rapid emergency evacuation capability. To that end, a runway site has been located on the north side of the Susitna River near the proposed site for the Watana construction camp. It is expected that the airstrip will be constructed very early in the project. The proposed facility would be adequate for aircraft up to and including a C-130. The location study for the airstrip has been done as a part of another task.

5.5 - Project Access

Providing access into a remote area such as the upper Susitna, while small in comparison to the total project, is a major undertaking in itself. Massive quantities of material, supplies, equipment and fuel must be moved to the project site in an uninterupted flow. Estimates of the amounts of the principal materials to be imported to the site and used in construction of the dams and related facilities are included in Appendix A. The movement of materials in such quantities requires a railroad or a high type of highway comparable to rural highways throughout the country. The access to the project is the topic of this study.

PROJECT SCHEDULE

6 - PROJECT SCHEDULE

The Susitna Hydroelectric project is intended to provide electrical power to the Alaska Railbelt region. The time frame for providing the required generating capacity has been determined as a result of Task 6 "Design Development".

6.1 - Power Demand Growth

The load and demand growth projections presented in the Task 6 "Design Development" report indicate that more electrical power will be required by the year 2000 than can be generated by the Susitna Hydroelectric Project alone. The demand over and above that which Susitna can satisfy will have to be provided from other sources, quite probably fossil fuel fired steam generators. The demand growth curves indicate that power from the Watana Dam is needed in 1993 and power from Devil Canyon Dam in needed by 2000. The Watana generating capacity can be installed in stages with the initial 400 megawatts available in 1993 and the second 400 megawatts on line in 1996.

6.2 - Generating Facility Schedule

Construction periods for Watana Dam and Devil Canyon Dam are projected as eight years and seven years respectively. If power from Watana is needed in 1993 and an eight-year period is required to construct the dam then construction must begin in 1985. Power from Devil Canyon is needed in 2000. Backing up seven years indicates that construction must begin in 1993. The construction schedules currently show access construction beginning January 1985 with work on the diversion tunnels beginning during the second quarter of 1985 and on the cofferdams and main abutments of Watana in the third quarter of 1985.

6.3 - Access Facility Schedule Constraints

Access is an integral part of the total project and as such may be subject to FERC approval for construction. Current project schedules are based on FERC licensing in late 1984. Access construction is currently planned to begin in very early 1985, as soon as possible following FERC licensing. If access construction is to begin in 1985 and construction activities on the dam are to begin in mid to late 1985 then it is necessary that an access facility be provided that can be passable for heavy equipment, explosives and fuel supplies sometime during the 1985 construction season. Any access plan that cannot be brought to rough grade and kept passable in a single construction season will require one of two schedule adjustments, access construction prior to FERC licensing or delay in work on the Watana Dam. Early reactions from regulatory agencies indicate a strong reluctance to issue the necessary permits for even a pioneer road prior to FERC licencing, however there has been no definite position taken.

LOGISTICS REQUIREMENTS

7 - LOGISTICS REQUIREMENTS

The dams and associated facilities are of a size that require vast quantities of equipment, materials, supplies and personnel for construction. Because of the remote location, a base camp must be provided that will resemble a small town complete with all essential services near each dam site. A permanent village must also be provided for the operations and maintenance personnel who will be stationed at the project when construction is completed.

The principle logistics requirements include the equipment, materials and supplies necessary for the dams and related facilities including the camp and permanent village, the food and other items necessary to provide for the crew during construction and the logistics requirements for construction of the access facilities. The requirements for the dams and related facilities and the camp supply needs will be discussed here. Logistic requirements for the alternate access plans will not be discussed in detail. Logistic requirements at access construction will vary with location, length, and bridge requirements. Significant constraints of access construction will be identified. The cost of this element of logistics will be included in the estimated construction costs.

7.1 - Construction Equipment, Materials and Supplies

The following estimates of equipment, materials and supplies are presented as a basis for the cost estimates to be generated as a part of analyzing and comparing the various access plans to be presented.

The major quantities to be incorporated into the project are shown in Table 7.1.

Table 7.1 Major Quantities in the Dams

	Watana	Devil Canyon
Excavation (Rock & Earth	22,000,000 c.y.	5,000,000 c.y.
Fill	76,000,000 c.y.	1,335,000 c.y.
Construction Equipment	16,000 ton	5,000 ton
Explosives	20,000 ton	3,000 ton
Cement	350,000 ton	650,000 ton
Reinforcing Steel	33,000 ton	22,000 ton
Rock Bolts	12,500 ton	3,000 ton
Steel Support & Liners	3,600 ton	2,200 ton
Mechanical, Structural Electrical Equipment	15,000 ton	13,500 ton
Fuel	75,000,000 gal.	17,000,000 gal.

Additional items that will be required for each dam include: Tires, Equipment Parts, and miscellaneous lumber and building material. Actual estimated quantities are not available and are largely a function of the contractor's operation.

For a comparison of transportation costs only the easily identified major items will be listed individually. These items will allow comparisons of the relative differences in transportation costs when reviewing alternative plans.

In order to estimate quantities of fuel, tires and parts required at each site, estimates of equipment fleets with average unit fuel consumption figures were made. See Table 7.2.

The fuel consumption rates shown in Table 7.2 are estimates based on Alaskan General Contractors experience with similar equipment.

Table 7.2 Construction Fleet

Equipment	Fuel Per Unit (1 gallon/hr.)	# Units * Watana	Devil Canyon
40 C.Y. End Dumps	21	40	6
8 C.Y. Loaders	15.5	10	5
Motor Patrols (Cat 14)	6.5	8	4
D-9	17	30	5
D-7	8	10	3
Cranes	10	2	4
Rock Crusher	20	1	2
Screening Plant	10	1	2
Concrete Plant	10	1	2
Mixer Trucks	10	3	3
Fork Lifts	5	6	6
Dump Trucks	10	10	2
Compactors	8	6	2
Power Generator	20	2	2
Miscellaneous	7	20	15
Pickups and other Gasoline Vehicles	2	60	30

Equipment Shipping Mode	Watana	Devil Canyon
By Rail: Flat car loads	133	66
By Road: Truck loads	67	31
self driven units	143	62
Total Units	210	93

* The number of units represents the anticipated number of pieces necessary based on the materials needed to be moved, amount of time per machine to move them and the total time frame provided to complete the task. When this input was not available it is a result of estimates from previous project experience.

Table 7.3

WEEKLY DIESEL FUEL REQUIREMENTS FOR CONSTRUCTION

Equipment Type	Watana gallons/week	Devil Canyon gallons/week
End Dumps	94,080	14,100
Loaders	17,360	8,680
Motor Patrols	5,820	2,900
D-9	57,120	9,520
D-7	8,960	2,700
Cranes	2,240	4,480
Crushers	2,240	4,480
Screening Plant	1,120	2,240
Concrete Plant	1,120	2,240
Mixer Trucks	3,360	3,360
Fork Lifts	3,360	3,360
Dump Trucks	11,200	2,240
Compactors	5,380	1,790
Power Generator	4,480	4,480
Miscellaneous Vehicles	15,680	11,760
** Total Gallons per week	227,700	78,330

* Assume 24 hours per day and seven days per week. An assumption has been made that 1/3 of the equipment will be down for service and maintenance at all times this provides for 112 hours/week base.

** This is an estimated average fuel flowage during the major portion of the activity. Actual flowage may vary significantly.

Table 7.4

REQUIRED DIESEL FUEL

	Watana	Devil Canyon
Diesel Fuel	227,700 Gal./wk.	78,330 Gal./wk.
Truck Loads @ 7,500 Gal./load ***	30 Loads/wk.	10.4 Loads/wk.
Rail Car Loads @ 20,000 Gal/load ***	11 Loads/wk.	4 Loads/wk.

*** Sizes of loads are typical of what is currently available.

TABLE 7.5

REQUIRED MATERIAL FLOW RATES

	Watana	Devil Canyon
Gasoline	20,160 Gal./wk.	10,000 Gal./wk.
Truck Loads @ 7,500 Gal./load	3 Loads/wk.	1.3 Loads/wk.
Rail Car Loads @ 20,000 Gal./load	1 Load/wk.	0.5 Load/wk.
Time Requirement***	7 yrs.	6 yrs.
Cement	350,000 ton	650,000 ton
Quantity per week	1154 ton/wk.	2,500 ton/wk.
Truck Loads @ 30 ton/Load*	38.5 Loads/wk.	83.3 Loads/wk.
Rail Car Loads @ 75 ton/Load*	15.4 Load/wk.	33.3 Load/wk.
Steel (all)	49,100 ton	27,200 ton
Quantity per week	162 ton/wk.	105 ton/wk.
Truck @ 30 ton	5.4 Loads/wk.	3.5 Loads/wk.
Rail Car Loads @ 75 ton	2.2 Loads/wk.	1.4 Load/wk.
Explosives	20,000 ton	3,000 ton
Quantity per week	66 ton/wk	11.5 ton/wk
Truck loads @ 30 ton	2.2 load/wk	0.4 load/wk
Rail Carloads @ 75 ton	0.9 load /wk	0.15 load/wk
Mechanical, Structural Electrical	15,000 ton	13,500 ton
Quantity per week	49.5 ton/wk	52 ton/wk
Truck loads @ 30 ton	1.6 load/wk	1.7 load/wk
Railcars loads @ 75 ton	0.7 load/wk	0.7 load/wk
Tires and Parts ** Truck loads	2 Loads/wk.	2 Loads/wk.
Subtotal Trucks Loads/wk.	52.7	92.2
Subtotal Rail Cars Loads/wk.	22.2	38.1

* Sizes of loads are typical of what is currently available.

** This Figure represents a rough estimate of truck/rail car loads of materials that will be needed for maintenance of construction equipment.

*** Assumed deliveries over 10 months per year activity and 1 year less than total construction time. The schedules show startup period of about one year before the peak activity levels are approached.

7.2 - Support Requirements

Supplies and fuel for the base camps must flow steadily and smoothly. It has been estimated the construction camp population will be approximately 4,500 for Watana and 3,100 for Devil Canyon. A camp operation report together with information from experienced arctic work camp contractors indicates a camp of 3,000-5,000 people would require approximately thirteen (13) pounds of food and supplies per person per day and fuel for power and heat at 1.1 gallons per person per day. These figures convert to the following delivery rates:

Camp Supplies

$$\frac{4500 \text{ persons}}{2000 \text{ lb./ton}} \times \frac{13 \text{ lb.}}{\text{man-day}} \times \frac{7 \text{ days}}{\text{week}} = 204.8 \text{ tons/week (Watana)}$$

$$\frac{3100 \text{ persons}}{2000 \text{ lb./ton}} \times \frac{13 \text{ lb.}}{\text{man-day}} \times \frac{7 \text{ days}}{\text{week}} = 141.1 \text{ tons/week (Devil Canyon)}$$

	Watana	Devil Canyon
Truck Loads @ 30 tons each =	6.8 load/wk	4.7 load/wk
Rail Cars @ 75 tons each =	2.7 load/wk	1.9 load/wk

Camp Fuel

$$\text{4500 persons} \times \frac{1.1 \text{ gal.}}{\text{day}} \times \frac{7 \text{ days}}{\text{week}} = 35{,}000 \text{ gal./week (Watana)}$$

$$\text{3100 persons} \times \frac{1.1 \text{ gal.}}{\text{day}} \times \frac{7 \text{ days}}{\text{week}} = 24{,}000 \text{ gal./week (Devil Canyon)}$$

Truck Loads @ 7,500 gallons = 5 loads per week for Watana; 3½ per week for Devil Canyon.

Rail Car Loads @ 20,000 gallons = 2 loads per week for Watana; 1¼ per week for Devil Canyon.

7.3. - Permanent Village

The permanent Village is estimated as 45 dwelling units. It is expected that construction of the village will occur over a period of two years at an average of two truck loads of materials per dwelling unit.

7.4 - Summary of Freight Movements

The following summary of freight movements is intended to show the order of magnitude for transport requirements on the access facility.

Table 7.6
SUMMARY OF REQUIRED AVERAGE MATERIAL FLOW RATES

	Watana Dam	Devils Canyon Dam
Trucks	95	111
Contingency & Misc.	19	22
Total	114 Trucks Loads/week	133 Truck Loads/week
Rail Cars	38	45
Contingency & Misc.	8	9
Total	46 Rail Cars Loads/week	54 Rail Cars Loads/week

Note: Total includes Tables 7.4, 7.5, camp supplies and camp fuel. Total does not include initial mobilization of construction equipment or materials for permanent village.

7.5 - Personnel Movements

In addition to the requirements for moving freight the workers themselves must be moved to the site. There are at least four options for accomplishing the movement of personnel depending on the nature of the access facility provided and the types of controls put on the construction personnel. Construction crews and support personnel will be working 7 days per week and three shifts per day. Even with this kind of schedule large numbers of people will be off shift at any one time. It would seem appropriate that these people have some way of leaving the area. Options include the following:

1. An aircraft shuttle
2. A rail shuttle if rail only is provided
3. A bus shuttle
4. Private vehicles

An aircraft shuttle could be used for the movement of personnel to the construction camp. Transportation costs would be high and the mode is extremely vulnerable to weather limitations.

Several of the access plans outlined herein include options for access to all or part of the project by rail only. The camp populations are such that a steady flow of personnel to and from camp may be expected. If only ten percent of the population travels on a given day, the total person trips will be in the range of 300 to 500 daily.

Rail coaches normally seat 50 to 80 persons. If access to either dam is limited to rail only, then a regularly scheduled shuttle train of an engine and two to four passenger cars will be needed to provide the required service. This service combined with the freight haul requirements will necessitate additional rail sidings and a much more complex communication system on the rails.

If roads are provided as primary access to the job site, a bus shuttle could be provided for personnel movements. This would best be handled by commerical carrier. The cost could be born either by the individual or the project.

The use of private vehicle would be the simplest method to administer. It would also allow the workers the greatest flexibility. If only 10% of the population travels on a given day, traffic volumes on the access road could exceed 500 vehicles per day. Traffic volumes at this level normally warrant a paved surface rather than a gravel surface.

For the purpose of comparison, in this report, logistics costs will not include passenger transportation.

ACCESS ROUTE
DESIGN PARAMETERS

8. - ACCESS ROUTE DESIGN PARAMETERS

The plan of study for the Susitna Project calls for the analysis of three general routes and two transportation modes to provide access to the proposed dam sites from port facilities or instate sources of supply. Consideration must be given to using road, railroad or a combination of both to serve the project.

The alternate routes to be studied were required to accomodate the following:

- Serve all dam sites that might be proven feasible by other portions of the overall study.

- Corridors had to be included on the North and South sides of the Susitna River with connections to the Alaska Railroad near Gold Creek, to the Parks Highway and to the Denali Highway.

In order to be able to make a valid comparison between alternatives a basis for that comparison must be established, with this thought in mind, proposed design criteria were developed.

8.1 - Roadway Parameters

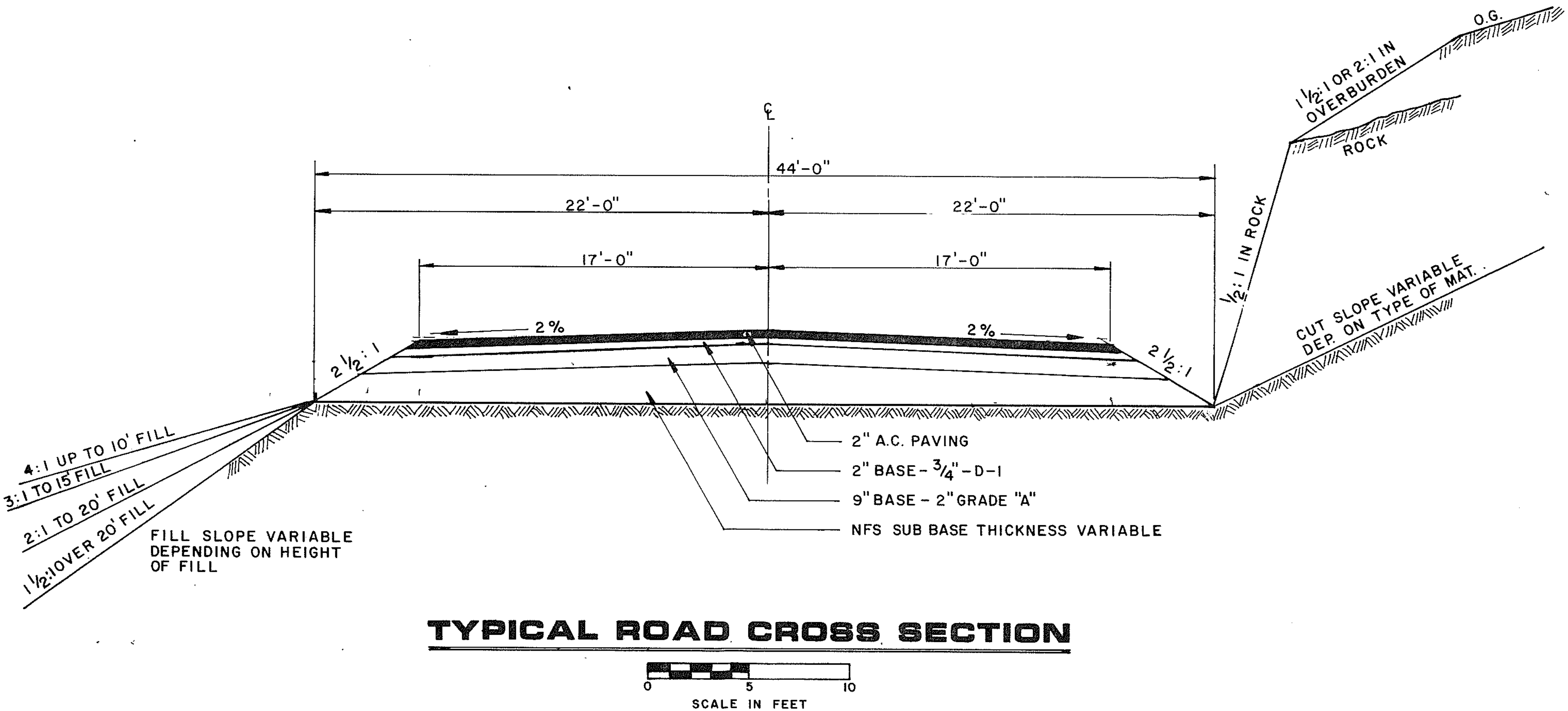
Originally the access road was envisioned as a low volume service road. The road was to be adequate for moving the necessary amounts of material and personnel but not necessarily in conformance will all requirement for a major public highway. As a result the original proposed design parameters were for a 30 mile per hour design with a 30 foot top width.

TABLE 8.1
ORIGINAL PROPOSED DESIGN CRITERIA

	Road
Design Speed	30 mph
Maximum Grade	10%
Maximum Curvature	19°
Design Loading	HS-20

Design criteria such as these are used to establish guidelines for design. The designer normally attempts to provide horizontal and vertical alignment that is better than the minimum alignment such limits would provide. In order to maintain schedule, work began on a number of possible alignments prior to approval of the proposed criteria. While the corridor definition work was in progress information on certain primary dam components was developed that required flatter grades and curves. Satisfying these criteria would provide a roadway that would essentially conform to a 50-60 mile per hour design speed. Subsequent work confirmed the need for roadway design criteria for 60 mile per hour design speed. The relatively high roadway design parameters are required because of the size and weight of certain components of the dams that must be manufactured and imported to the site. The approved roadway design parameters are given in Table 8.2. With acceptance of the design parameters, a typical cross section was developed and is depicted in Figure 8.1.

Projected traffic volumes suggest that asphalt pavement should be provided if personnel access to the construction camps is by private auto.



TYPICAL ROAD CROSS SECTION

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R&M CONSULTANTS, INC.

TYPICAL ROAD CROSS SECTION

PREPARED FOR:

ACRES

FIGURE 8.1

The 60 mph design criteria was attainable in all major corridors except one - the crossing of Devil Canyon to join the south corridor to the north corridor. The precipitous terrain in Devil Canyon can be crossed by a high suspension bridge spanding from the south bluff to the north bluff, or by a low bridge just above the high water level. The low bridge could be reached only by a 30 mph road (10% grades, 19° curves) cutting into the sides of the bluffs. The low level crossing would be needed in any event as a pioneer road, because a high suspension bridge would require 3 years to construct. For the purposes of this report, the low level crossing has been used for the entire construction period. After the Devil Canyon Dam has been constructed, access will be rerouted to cross the dam along its crest. The rerouted access will be built at the 60 mph criteria.

TABLE 8.2
APPROVED ROADWAY DESIGN PARAMETERS

Design Speed	60 mph
Maximum Grade	6%
Maximum Curvature	5°
Design Loading (Construction Period)	80 Kip Axle & 200 Kip total
Design Loading (After Construction)	HS-20

8.2 - Rail Road Parameters

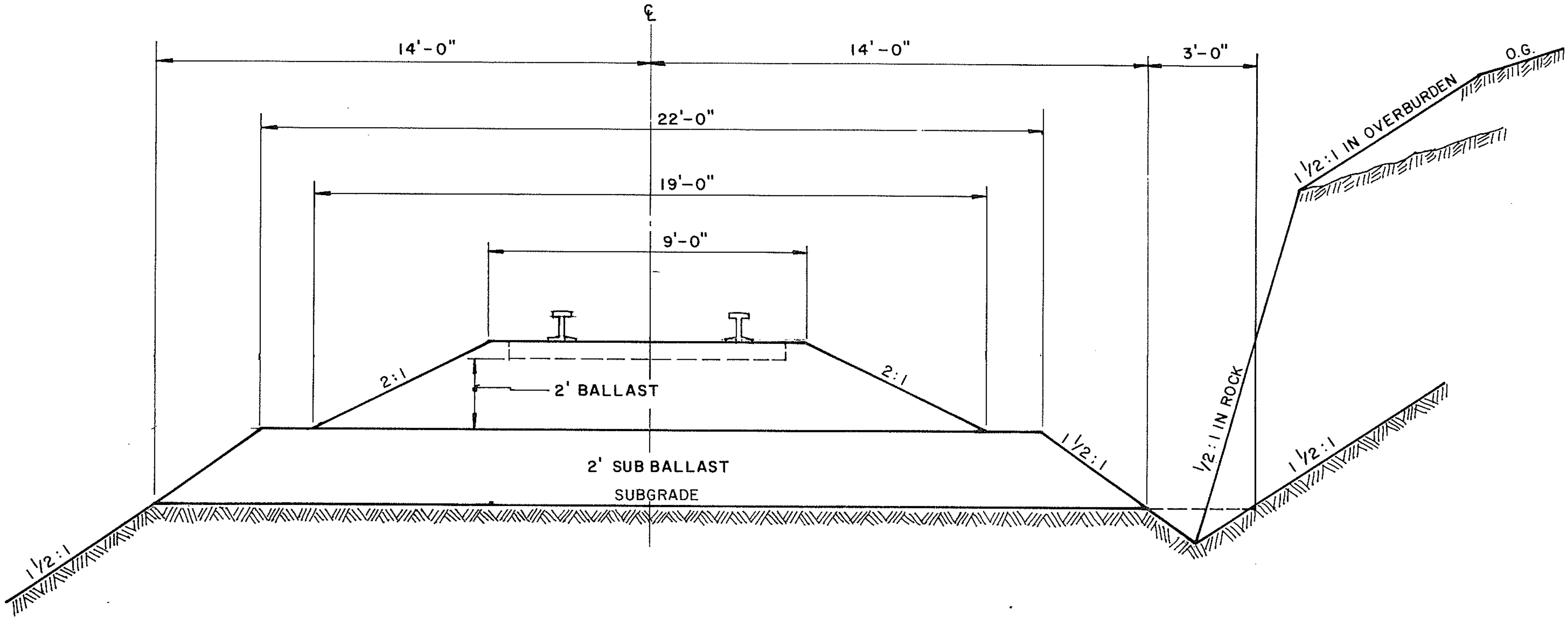
The volume of bulk materials to be moved to the Susitna project during the fifteen year period of construction make consideration of rail service mandatory. The principle concern with using the Alaska railroad was the load capacity of existing trackage and bridges. Horizontal and verticle clearences governing the overall size of loads that can be moved by rail are controlled by existing facilities. The exisiting facilities conform to the American Railway

Engineering Association (AREA) standards. The Engineering office for the Alaska Railroad states that the ARR is currently rated as an E-50 railroad. They are in the process of up grading to E-80 facilities. The Chief Engineer for the ARR recommended using an E-72 loading for railway planning. Input from the railroad engineering staff and AREA standards suggest the following design parameters would be appropriate.

TABLE 8.3

APPROVED RAILROAD DESIGN PARAMETERS

Maximum Grade	2.5%
Maximum Curvature	10°
Loading	E-72.



TYPICAL RAILROAD CROSS SECTION

0 1 2 3 6
SCALE IN FEET

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TYPICAL RAILROAD CROSS SECTION

PREPARED FOR:

ACRES

FIGURE 8.2

CORRIDOR SELECTION

9.0 - CORRIDOR SELECTION

The general locations for the potential access corridors were defined in the POS. The next step in the process was the determination of where within these general corridors facilities could be built that would conform to the required design parameters. To that end, a series of alternate segments were identified and then evaluated. This section documents the process by which this segment selection was done and the results of the evaluation.

9.1 - Methodology

The Susitna Hydroelectric Project is located on a section of the Susitna River that is remote wilderness. Earlier studies by government agencies had generated some contour mapping in the vicinity of the proposed dam sites. The only other available contour information was USGS mapping on a one-inch (1") equals one (1) mile scale with one-hunderd foot (100') contour intervals. To aid the project team in selecting possible routes, a low level helicopter flight was made in late March, 1980. A mosaic was then made of the USGS mapping from Gold Creek and the Parks Highway through the Watana site and out to the Denali Highway north of Watana. Using the preliminary design parameters and information gained from the overflight of the project area, a number of possible alignments were laid out on the map mosaic.

The various alternatives were split into convenient segments. Some of these segments were unique while others could be common to two (2) or more alternatives. Each segment was analyzed for grades on a section by section basis. Each curve was checked for degree of curve and deflection angle. Each curve and each identifiable gradient section were then tabulated. The various segments considered were combined to provide a total of thirty-six (36) possible alignment alternatives that could conceivably be constructed to provide access to one or both of the principle dam sites. The various combinations of segments making up potential access route alignments were compared. The alignments identified as being the most attractive within each of the three (3) general corridors required by the plan of study was selected for further work. A low level reconnaissance flight with part of the environmental team was made April 30, 1980 to review the proposed corridor alignments prior to the photographic flights. Valuable input for future analysis was gained, and there was nothing identified that would force a major line change at this early stage of the work.

On May 5, 1980 the proposed corridor alignments were approved for photographic flights.

For the purpose of analysis the proposed general corridors are identified as follows:

Corridor 1 — On the north side of the Susitna River between the Parks Highway and the Watana Camp.

Corridor 2 — On the south side of the Susitna River between the Parks Highway and Watana Dam site. This corridor is being studied for railroad possibilities as well as road. Included in this corridor are the possible connections to Corridor 1.

Corridor 3 — Connecting Watana Camp with the Denali Highway to the north.

9.2 - Discussion of Alternative

A number of alternative segments were considered within each of these three (3) general corridors. The alternative segments within the respective corridors are discussed below and shown in Appendix B.

(a) Segment 1-A

(i) Description

This segment begins near MP 156 on the Parks Highway in the vicinity of Chulitna Pass. The line runs south east through Chulitna Pass crossing the rail road near summit lake, then proceeds easterly across Indian River and on to the Portage Creek Canyon. The line travels northeasterly for several miles while desending into a crossing of Portage Creek then south westerly while climbing out of Portage Creek to the north side of the Devil Canyon Dam Site. From Devil Canyon the line proceeds north easterly crossing into the upper reaches of Devil Creek then easterly through a 4,000-foot high pass and follows a drainage to a crossing of Tsusena Creek then south to the north side of the Watana Dam Site. Over-all length of the line is sixty four and seven tenths miles. The segment is shown on Figure 9.1.

(ii) Line and Grade

Segment 1-A is well within the desired limits with regard to alinement and grade with the exception of the portion through Portage Creek and near Devil Canyon. The terrain in Portage Creek Canyon is very difficult. Providing an alignment through Portage Creek Canyon that conforms with the design parameters will require very heavy earthwork and several small to medium length bridges across the side drainages.

(iii) Drainage Features

Most of the drainages along 1-A carry flows which can be passed through standard culverts quite satisfactorily. Bridges will be required for Indian River, and Portage Creek; multiplate at Devil Creek and Tsusena Creek.

(iv) Bridges

As stated, at least two bridges are expected. The Indian River bridge is a 440-foot long three span structure whose configuration is dictated more by the shape of the crossing than by the quantity of water in the river. The Portage Creek bridge will be a two or three span structure approximately 200 feet long. Any construction within the Portage Creek Canyon will require additional structures in the under 200-foot class at several side drainages.

(v) Soils

Much of the alignment for segment 1-A from the Parks Highway to Devil Canyon traverses frozen soils, generally basal till with moderate side slopes. Drill holes indicate permanent ice beginning at depths of around fifteen feet. The material consists of gravels, sands and silts. Properly handled the material can be used to construct road bed, however the silts and sands will erode readily unless protected. The material is generally frost susceptible due to the silt content which will require a substantial non-frost susceptible subbase layer in the road bed. The soil is very susceptible to thaw settlement making it necessary to severly limit the depth of excavation and then requiring extensive borrow areas to provide roadway embankment.

There are extensive organics in the section of line from the Parks Highway through Chulitna Pass. This material is ten to twenty feet deep and will be difficult to build on. The remainder of the segment encounters occasional small areas of organic soils. With the exception of the crossings of Portage and Tsusena Creeks these areas of organics can be avioided.

The Portage Creek Canyon section traverses very steep cross slopes. Because of the frozen soils any road-way construction in the area could result in major erosion and thaw settlement problems at deep cuts will be unavoidable.

The section of 1-A from Devil Canyon to Watana traverses soils with shallow to exposed bedrock. Most of this section traverses relatively gentle cross-slopes. These conditions will allow road bed construction without undue problems with erosion and thaw settlement. Borrow sources are available close by the alignment.

(vi) Environmental Concerns

Portions of Segment 1-A have significant potential environmental problems. The section between the Parks Highway and Chulitna Pass traverses an obvious wetland area and encroaches on the Denali State park. Both Indian River and Portage Creek are anadromous fish streams. Indian River could be crossed without a serious conflict with the fish, however the potential for erosion that would result from construction in the Portage Creek Canyon may well pose a threat to the Portage Creek fish runs. The lower Portage Creek area has been identified as a potential raptor area and most of Portage Creek is known furbearer habitat. The alignment between Devil Canyon and Watana does not encroach on any environmentally sensitive areas.

(vii) Segment Suitability

Segment 1-A is actually a full length alternate alignment. The section from the Parks Highway to Devil Canyon is not considered suitable for access construction. This section has numerous construction, soils and environmental problems. The section from Devil Canyon to Watana remains viable.

(b) Segment 1-B

(i) Description

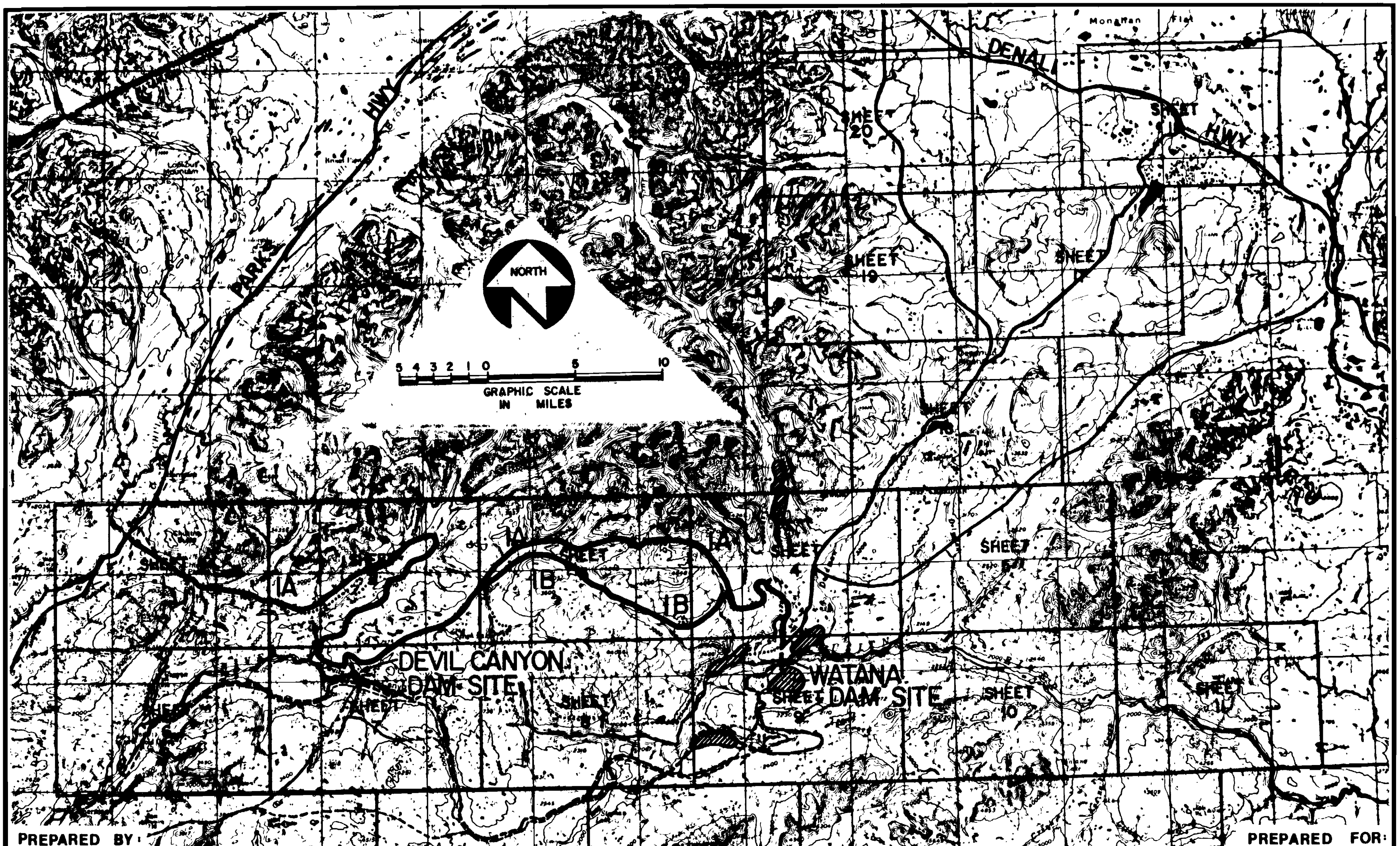
Segment 1-B is an alternate to a portion of 1-A between Devil Creek and Tsusena Creek. The segment begins just west of Devil Creek and drops into the Devil Creek drainage, crossing the creek, and swings north and east past Mama Bear Lake, then south easterly through a wide pass at 3,400-foot elevation, then proceeds easterly to rejoin segment 1-A before reaching Tsusena Creek. See Figure 9.1.

This alignment lies south of 1-A and utilizes a broader, lower pass which should be easier to keep open during and after snow storms. The cross slopes are gentle to moderate with the steepest being as the line climbs out of Devil Creek.

This segment is 16.2 miles in length

(ii) Line and Grade

Alignment and grade on this segment are well within the required parameters.



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SUSITNA ACCESS CORRIDOR

SEGMENT 1A=64.7 MI. SEGMENT 1B=16.2 MI.

FIGURE 9.1

(iii) Drainage Features

Segment 1-B encounters no major or complicated drainage features. Cross culverts will be required at intervals. The only major stream crossing is Devil Creek, which can be spanned by culverts.

(iv) Bridges

No bridges in this segment

(v) Soils

Some frozen Basal till with shallow bedrock occurs as the line drops into Devil Creek. Cross slopes are such that heavy cuts should not be required. Erosion and thaw settlement problems should be kept to a minimum. The crossing of Devil Creek is on thawed soils generally Ablation tills and flood plain deposits which are good soils for road bed construction. Climbing out of Devil Creek, the line crosses good soils with bedrock at or near the surface. Frozen soils are not encountered untill the east end of Mama Bear Lake. The remainder of the alignment is sporadically frozen soils however the terrain has gentle to moderate slopes which will allow road bed construction without heavy cuts.

(vi) Environmental Concerns

This segment does not appear to cross any environmentally sensitive areas. The alignment is generally at or above the tree line and conflicts with wildlife appear to be minimal. Where erodable soils are encountered, slopes are flat enough that a minimum of soil will be exposed thereby keeping the potential for erosion down.

(vii) Segment Suitability

Segment 1-B is a viable alternate. It does exhibit some advantage over 1-A in that the pass is lower and such that snow control should be easier.

(c) Segment 1-C

(i) Description

This segment leaves 1-B at Devil Creek and descends Devil Creek to the Susitna River then up the Susitna River crossing Tsusena Creek near its mouth and climbing to the north end of the Watana Dam. This alignment was intended to provide a water level access along the Devil Canyon reservoir. See Figure 9.2.

The segment is 27.5 miles in length.

(ii) Line and Grade

This segment can be constructed to meet 30 mph design speed but cannot meet the desired parameters. There are two sections where grades approaching eight percent cannot be avoided.

(iii) Drainage Features

This segment is generally side hill construction with numerous stream crossings. With the exception of Devil Creek and Tsusena Creek, culverts should handle the drainage concerns with no more than normal considerations.

(iv) Bridges

Two bridges are positively identified at Devil Creek and at Tsusena Creek. Both bridges would be in the one hundred fifty to two hundred foot catagory with two or three spans.

(v) Soils

This alignment crosses generally marginal soils with some scattered frozen materials near Watana Camp. The portion of Alternate 1-C along the Susitna River is mostly in frozen materials composed of solifluction deposits which are composed of saturated soil material and rock debris especially subject to frost creep or down slope movement. In addition there are large slide scar areas crossed and one apparently active landslide area (see Appendix D). The unfrozen and organic soils at the surface are covering sections of permafrost and these soils are prone to frost heave and thaw settlement. Since the majority of the slopes face the south, thawing is more likely giving lower bearing strengths and very low slope stability as evidence by the existing slide scars.

(vi) Environmental Concerns

There are a number of potential environmental concerns with this alignment. Erosion from cut and fill slopes in frozen soils and existing slides would be a major problem. The timbered side hills are important moose and black bear habitat. The most important habitat area is near the mouth of Tsusena Creek.

(vii) Segment Suitability

This segment is not very suitable; poor soils conditions, the inability to meet grade requirements, and the encroachments on wildlife habitat make this segment unattractive. In addition, the alignment encroaches on a borrow area needed for construction of Watana Dam (Borrow Area C) and crosses a portion of the construction area.

(d) Segment 1-D

This alignment is a shorter, steeper crossing of Portage Creek. The alignment uses switch backs, steep grades and sharp curves to minimize the amount of damage in the Portage Creek Canyon. See Figure 9.2.

The segment is 9.0 miles in length.

(ii) Line and Grade

Vertical and horizontal alignment violate the desired parameters. There is no possibility of constructing an alignment on this segment that satisfies the design parameters.

(iii) Drainage Features

There are no significant drainage features on this alignment. Ditches and cross culverts would be standard type construction.

(iv) Bridge

A bridge would be required at Portage Creek very similar to the segment 1-A Portage Creek Bridge; a three span structure approximately 200 feet long.

(v) Soils

This segment traverses some very steep ground completely characterized by frozen soils which are highly subject to erosion, thaw settlement and frost heave.

(vi) Environmental Concerns

Portage Creek is an anadromous fish stream and there is concern that erosion of cut and fill slopes would be detrimental. In addition the alignment traverses known furbearer habitat and potential raptor nesting areas.

(vii) Segments Suitability

This segment is not considered to be suitable for further consideration.

(e) Segment 1-E

(i) Description

This segment is an alternate crossing of Tsusena Creek upstream from the 1-A crossing and connects with 3-A near Deadman Creek. See Figure 9.2.

This segment is 7.5 miles long.

(ii) Line and Grade

While longer than the 1-A crossing, this segment crosses Tsusena Creek with easier grades and good horizontal alignment.

(iii) Drainage Features

There are no significant drainage features on this segment. Normal ditch and culvert construction will serve.

(iv) Bridges

No bridges are needed on this segment.

(v) Soils

This segment crosses generally thawed soils exhibiting good road building characteristics.

(vi) Environmental Concerns

The crossing is far enough up Tsusena Creek to avoid the most critical moose habitat. The soils are such that the erosion possibilities are low, making this an attractive option.

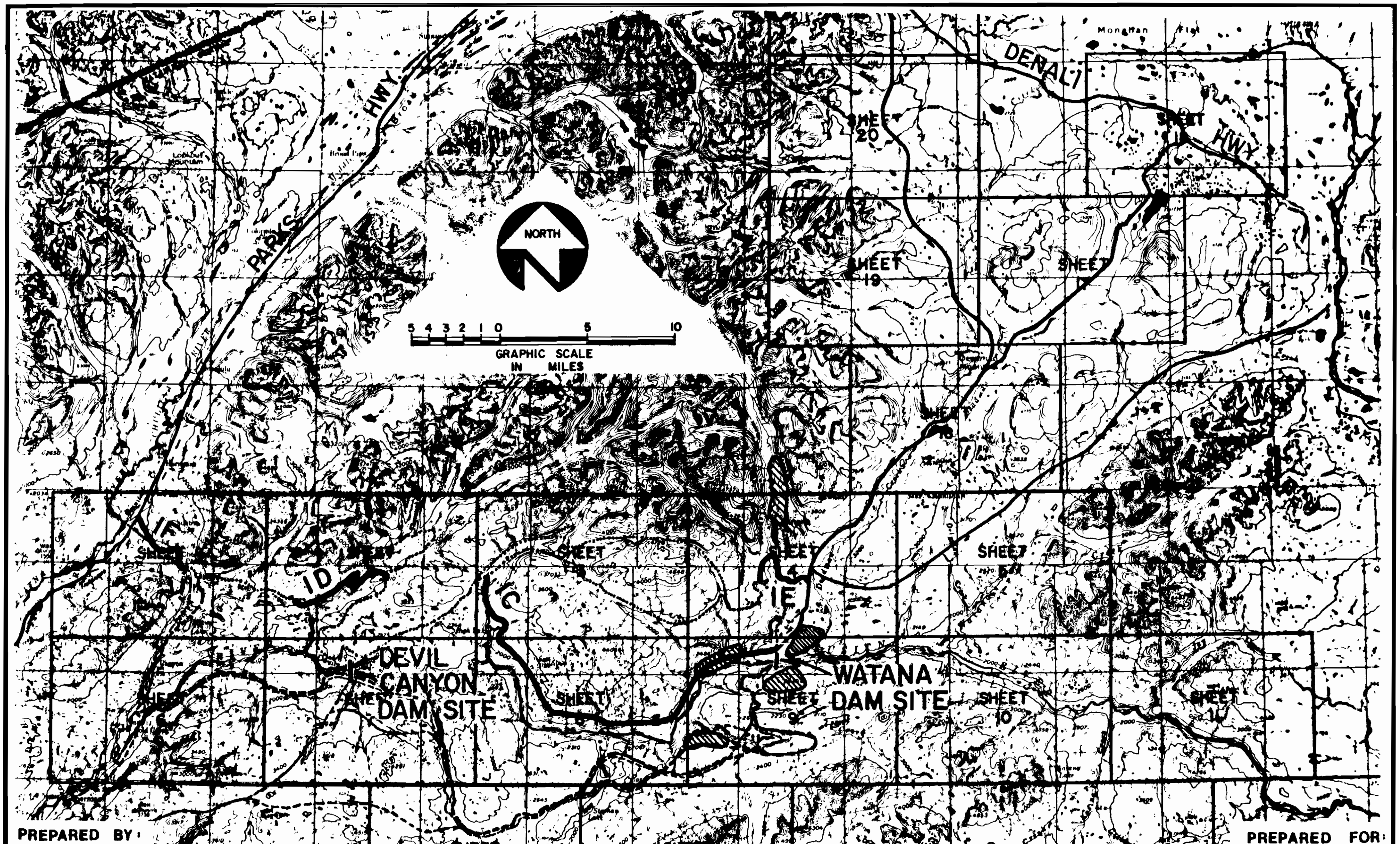
(vii) Segment Suitability

This is a good segment much more suitable than 1-A in the Tsusena Creek drainage. The bridge crossing is good and cross slopes are moderate.

(f) Segment 1-F

(i) Description

This segment is an alternate to the section of 1-A from Parks Highway through Chulitna Pass. This segment crosses the railroad track closer to the highway and traverses the base of Chulitna Butte against the railroad tracks connecting with 1-A east of Summit Lake. See Figure 9.2.



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SEGMENT 1C=27.5 MI. **SEGMENT 1D=9 MI.**

SEGMENT 1E=7.5 MI. **SEGMENT 1F=4.1 MI.**

FIGURE 9.2

ACRES

This segment is 4.1 miles long.

(ii) Line and Grade

This segment conforms with the preferred design parameters although is not as straight and flat as the comparible sections of 1-A.

(iii) Drainage Features

No major drainage features are encountered. There are a few small streams crossed which can be handled with culverts. The line does avoid the wetland area traversed by 1-A.

(iv) Bridges

This segment does not include any bridges.

(v) Soils

This section crosses frozen basal till and organic soils just as 1-A does, however, the extent of organics is much smaller. 1-F is further up slope and on moderate cross-slopes. The terrain is generally suitable for fill type construction often used to bridge organics and insulate frozen soils. As with other areas of the project there is some 10-15 feet of unfrozen soil over the permafrost; at least a portion of which can be worked in normal fashion provided due care is used with regard to erosion, thaw settlement and frost heave.

(vi) Environmental Concerns

The first two miles of the line encroach on a corner of Denali state park essentialy parrallel to the rail road. This alignment may require the taking of some dwelling units in the Chulitna Pass area. No critical habitats area appear to be impacted.

(vii) Segment Suitability

This segment essentially parallels the railroad and in so doing should have minimal added environmental impact. The wetland area in the pass is avoided and, while frozen and organic soils are a factor, they can be dealt with. This segment is preferable to the corresponding section of 1-A.

(g) Segment 2-A

(i) Description

This segment begins at Sherman on the Alaska railroad south of Gold Creek. The alignment climbs the river bluffs via switchbacks to the higher ground near the head of Gold Creek. From there the line runs generally east on the high ground to the divide above Prairie Creek. The line then desends along a ridge and passes just north of Stephan Lake then proceeds easterly to a crossing of Fog Creek and north to the Watana Dam site past the west end of Fog Lakes. See Figure 9.3.

This alignment is 56.7 miles long.

(ii) Line and Grade

This alignment conforms quite well with the design parameters except for the climb from Sherman to the head of Gold Creek. This section is switchbacks using grades to ten percent and very sharp curves.

(iii) Drainage Features

Drainage features along this route are routine. The only problem areas being the west area near Stephan Lake and near Fog Lake where flat, boggy and frozen ground will be difficult to drain.

(iv) Bridges

The only Bridge involved with this alignment is the crossing of Fog Creek. This is a major bridge. The canyon is fairly deep with near vertical rock walls. The length of the crossing is approximately 600 feet. The probable structure type is a continuous deck truss that can utilize cantilever type construction techniques. This bridge will take eighteen to twenty four months to construct and will require a passable road over which to transport materials. This bridge could be a major schedule constraint.

(v) Soils

This alignment traverses a variety of soils. The climb through the switchbacks from Sherman is in an area of frozen Basal till over bedrock. The steep terrain will require heavy cuts and fills which will not be suitable. The Basal till is erodable and subject to frost heave and thaw settlements all of which would be major problem in the switch back area.

The section from the head of Gold Creek to the Prairie Creek divide crosses sporadically frozen soils and colluvial deposits mixed will bedrock. The material is generally acceptable for roadbed construction provided proper care is exercised with regard to frost susceptibility and erosion control. Scattered pockets of shallow organics exist that could be largely avoided.

From Prairie Creek divide to Watana the soils are Lusterines over frozen tills with pockets of organics and some bedrock near Fog Creek. The soils are acceptable for roadbed construction provided that consideration is given to frost susceptability, and thaw settlement and erosion. The soils near the end of Stephan Lake show evidence of massive ice. This area should be avoided if possible.

(vi) Environmental Concerns

The environmental concerns along this alignment are in the Stephan Lake - Fog Lakes area. These areas are prime habitats for varity of big game animals, waterfowl, and fur bearers. There is a potential for raptor use in the Fog Creek area. These same areas have been identified as having archeological sites of potential significance. There is a concern that public access to these area will have detrimental effects on big game populations and on the archeaological sites.

(vii) Segment Suitability

The portion from Sherman to the Prairie Creek divide is not considered as suitable because of difficult line and grade restrictions above Sherman and the fact that this line does not directly serve Devil Canyon.

The portion from the Prairie Creek divide to Watana is suitable for construction although there are some unavoidable environmental concerns. A portion of the line passes through borrow area H designated for use in construction Watana Dam. Some re-routing would be required to avoid the massive ice near Stephan Lake.

(h) Segment 2-B

(i) Description

This segment begins in at the south side of the Devil Canyon Dam site and travels south, up Cheechako Creek, about two miles before turning east and crossing the creek. The line then continues south easterly for about five miles while climbing to the top of a deep gorge. At this point the segment turns southerly following the top edge of the gorge to its head and join 2-A at the Prairie Creek divide. See Figure 9.3.

This segment is 13.6 miles in length.

(ii) Line and Grade

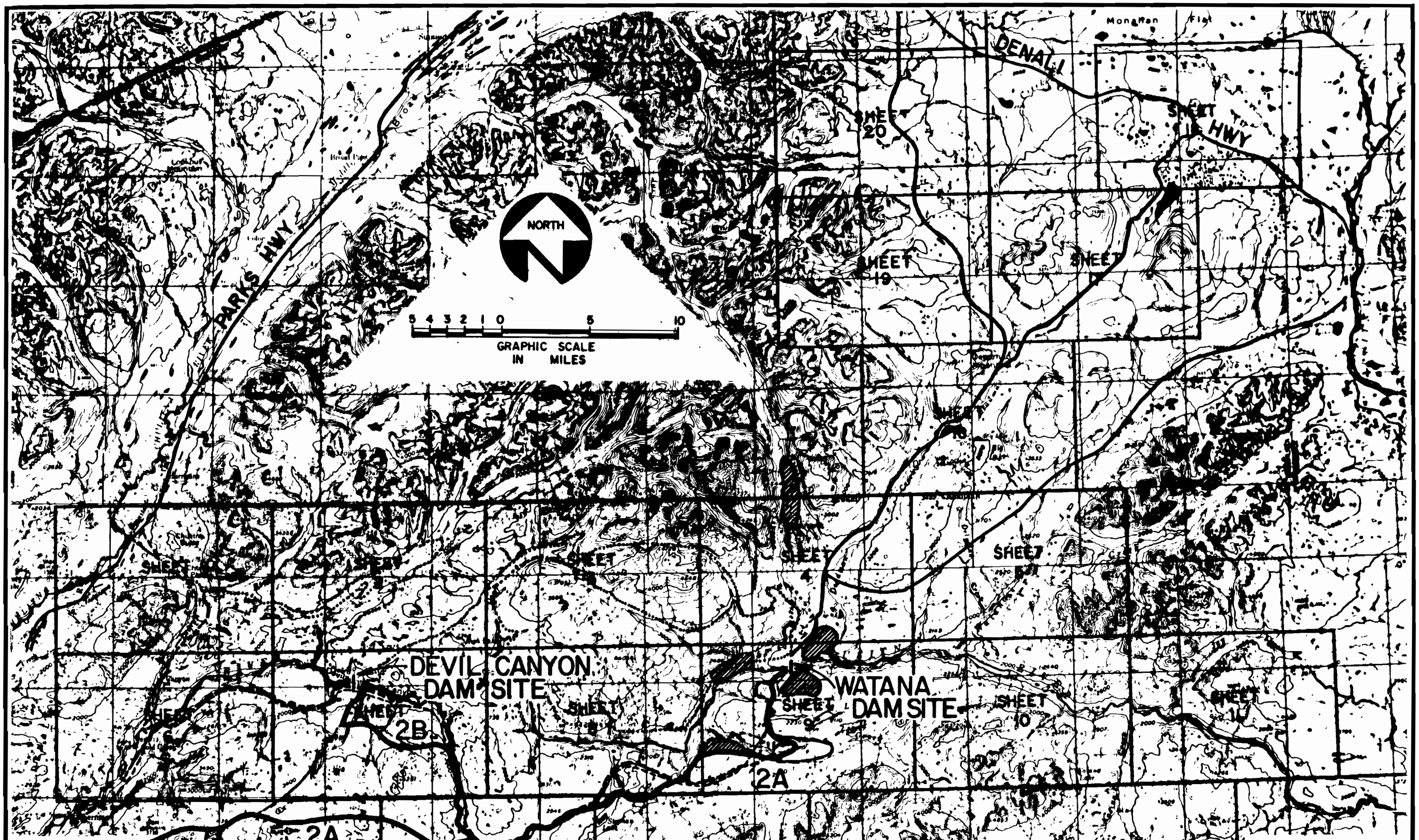
The horizontal alignment on this segment is acceptable. It is not possible to bring the portion south of Devil Canyon into conformance with the required gradient criteria. 7% to 10% grades would be required for about two miles.

(iii) Drainage Features

This alignment is located on high ground with little or no drainages involved. The one exception is a three mile reach that follows a small stream. The line appears to be above the stream far enough to avoid direct conflicts and should be no problem.

(iv) Bridges

One Bridge will be required crossing Cheechako Creek. This will be over a deep rock gorge. It will be curved and will



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SUSITNA ACCESS CORRIDOR

SEGMENT 2A=56.7 MI. SEGMENT 2B=13.6 MI.

FIGURE 9.3

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require long spans and some tall towers for the intermediate supports. Because the bridge will be on a curve it will likely be a steel box girder structure. A second, more conventional bridge may also be required across a tributary of Cheechako Creek.

(v) Soils

The soils are Basal till over bedrock - generally frozen along the first part of the line and bedrock or colluvium over bedrock along the remainder. The frozen till is on variable cross slopes much of it steep enough to require large fills to avoid cuts in frozen soils. Extensive borrow may be required to provide material for the fills.

(vi) Environmental Concerns

Portions of this segment traverse areas used by caribou as winter range because the wind keeps the ridge tops blown of snow. No other environmental conflicts have been identified.

(vii) Segment Suitability

The westerly section of 2-B near Devil Canyon is not suitable in that excessive grades cannot be avoided. The easterly end along the deep gorge approaching the Prairie Creek divide is highly suitable in that soils are rock, grades and alignment are satisfactory.

(i) Segment 2-C

(i) Description

This segment runs south from 2-B near Devil Canyon up the Cheechako Creek drainage to join 2-A. This was intended to be the side connection to serve Devil Canyon from 2-A. See Figure 9.4.

This segment is 7.5 miles long.

(ii) Line and Grade

The horizontal alignment on this segment is satisfactory however grades exceed the desired maximum with no way of improving it. Over four miles of the line would be in the 7% to 9% range.

(iii) Drainage Features

There are no special drainage features along the segment. Several cross drainages exist; however standard ditchs and culverts will serve.

(iv) Bridge

There are no bridges on this segment.

(v) Soils

This segment crosses unfrozen colluvial deposits and bedrock generally acceptable for normal roadway construction with proper attention to erosion control and frost classification of materials.

(vi) Environmental Concerns

There have been no significant environmental conflicts identified along this alignment.

(vii) Segment Suitability

This segment is not considered suitable because of excessive grades.

(j) Segment 2-D

(i) Description

This section begins at Sherman, crosses the Susitna River and cuts through a pass inside Denali State Park to connect with the Parks Highway. See Figure 9.4.

This segment is 10.7 miles long.

(ii) Line and Grade

All of this segment conforms to the requirements for horizontal and vertical alignment. The grades do approach 6% however.

(iii) Drainage Features

This segment is located nearly in the bottom of drainages and may generate some conflicts with the streams. In addition there is a wet area in the pass west of the river which may result in surface drainage problems.

(iv) Bridges

A major bridge over the Susitna River will be required. The bridge will be a mulitspan structure, probably welded plate girders, and approximately 1,000 feet long.

(vi) Soils

The soils along this corridor have not been mapped. The material immediately north has been mapped and is frozen basil till over bedrock with some pockets of organics interspersed.

(vi) Environmental Concerns

This segment cuts directly through Denali State Park. Some wetlands are involved, and while not verified, the vegitation is typical of other areas that have been identified as Moose habitat.

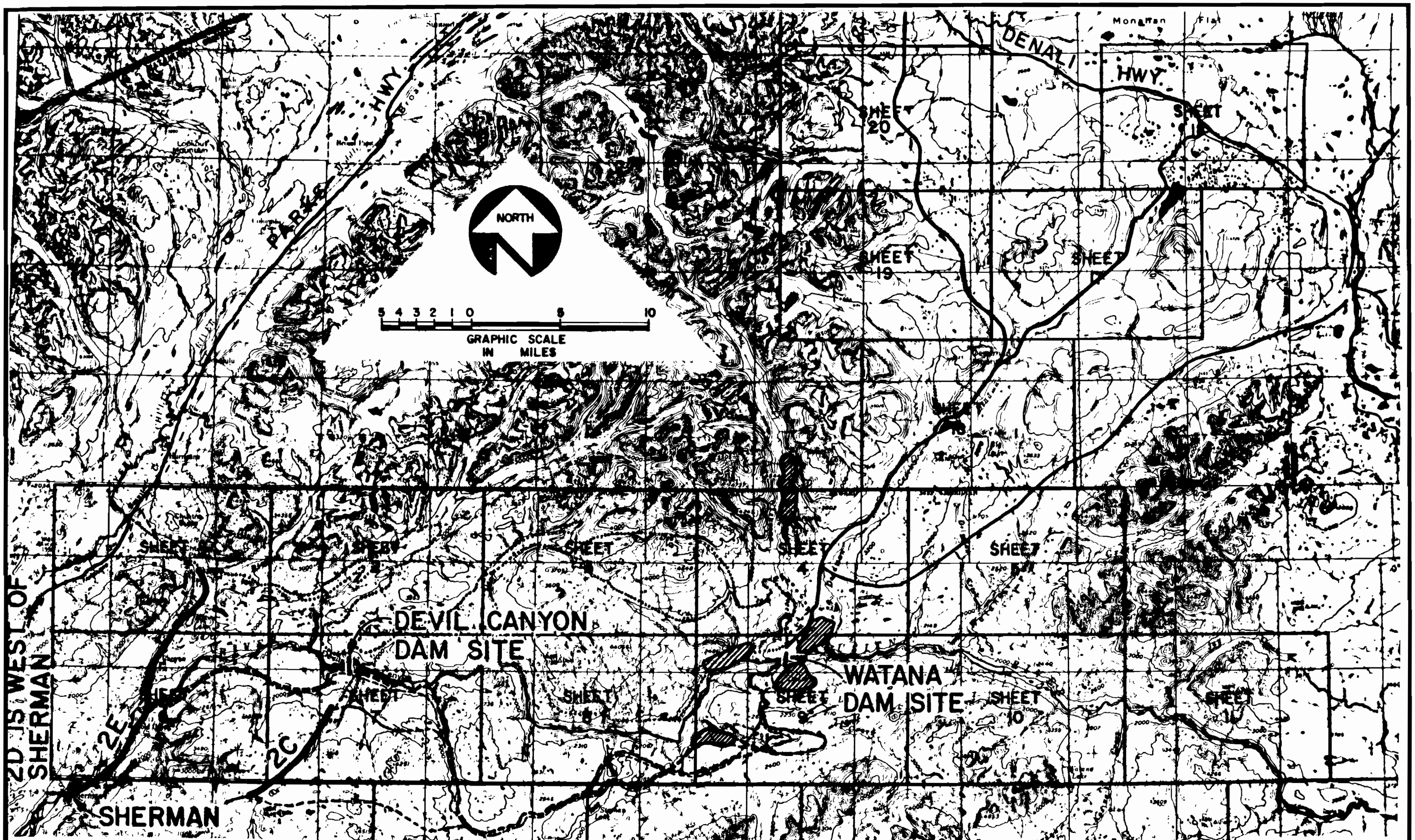
(vii) Segment Suitability

This segment is not considered viable because it passes through Denali State Park and would disrupt the Park without demonstrating an off setting distinct advantage.

(k) Segment 2-E

(i) Descriptions

This segment connects 2A and 2D at Sherman with 1-A at Chulitna Pass. The line generally parallels the railroad and was looked at as an alternative to 2-D in connecting with the Parks Highway. From Sherman to Gold Creek the alignment runs between the railroad and the base of the mountain. In two locations it is squeezed into some difficult side hill construction. After crossing the Susitna River the line stays back from the bluff above Indian River to avoid some side hill construction. See Figure 9.4.



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SUSITNA ACCESS CORRIDOR

SEGMENT 2C=7.5 MI. SEGMENT 2D=10.7 MI.

SEGMENT 2E=15.6 MI.

FIGURE 9.4

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The length of the line is 15.6 miles.

(ii) Line and Grade

Horizonal and vertical alignment conform with the desired parameters.

(iii) Drainage Features

There are no special drainage considerations on this segment normal ditches and culverts will serve.

(iv) Bridges

There are a total of three bridges identified on this segment. The main stream Susitna River Bridge is located immediately upstream of the Railroad Bridge. The first of two bridges over Indian River is just upstream from the Susitna River and will be an approximately 400-foot, three span structure. The second bridge over Indian River is near Chulitna Pass this will also be an approximately 400-foot, three span structure.

(v) Soils

This segment has a variety of soil types. The portion south of the Susitna River crossing is largely alluvial and flood plain deposits exhibiting good road building characteristics. This material is unfrozen and normal care with erosion contol and frost heave will result in a quality facility. The section north of the Susitna River crosses frozen Basal till and, some floodplain deposits near the stream crossings.

(vi) Environmental Concerns

The principle environmental concerns for the segment result from potential impacts on the Susitna and Indian Rivers. In each case there is a potential for equipment working in the streams. The impacts should be temporary in nature and not adversely effect the fish populations.

The segment does border a State land disposal area known as the "Indian River Remote" disposal.

(vii) Segment Suitability

The entire segment is suitable for construction. Only portions of it may be used depending on the final access plan accepted.

(l) Segment 2-F

(i) Description

Segment 2F is a road alignment developed to shorten the distance traveled by 2A in crossing Fog Creek. The segment uses a bridge and somewhat steeper grade to effect a nearly straight crossing rather than a long switch back. See Figure 9.5.

This segment is 3.9 miles long.

(ii) Line and Grade

This segment does conform to the desired parameters for horizontal and vertical alignment. Grades do approach the 6% maximum. The horizontal alignment can allow safe truck operations on the alignment and need not be designed at the maximum curvature.

(iii) Drainage Features

The segment does not encounter major drainage features other than Fog Creek. A bridge will be required for Fog Creek while other drainage considerations can be treated satisfactorily with normal ditches and culverts.

(iv) Bridges

A major bridge is required on this segment at Fog Creek the structure crosses a deep rocky gorge. The structure type suggested is a deck truss because of the probable span arrangement and height of intermediate support towers. Structures of this type require considerable length of time to assemble. One and one half to two years is probable.

(v) Soils

The soils are Lusterines over frozen Basal tills south of Fog Creek and frozen Basal tills over bedrock north of Fog Creek. There is bedrock at or near the surface at Fog Creek. The south side of Fog Creek is a designated borrow source for Watana Dam.

(vi) Environmental Concerns

The entire area traversed by the segment has been identified as Moose and Caribou habitat. Fog Creek has been identified as potential raptor habitat.

(vii) Segment Suitability

The segment is considered suitable for construction with one exception. The alignment does pass through one of the borrow sources for Watana Dam. For this reason segment 2-F was modified by segment 2-J.

(m) Segment 2-G

(i) Description

Segment 2-G begins at Devil Canyon Dam on the south side and follows the side hill upstream while climbing to join segment 2B as both lines turn south away from the Susitna along the top of a deep gorge. This segment is an alternate to 2-B that can conform with design parameters. See Figure 9.5.

Over all length of the segment is 7.7 miles.

(ii) Line and Grade

This segment has acceptable line and grade. The segment was designed to bypass the grade problems of segment 2-B.

(iii) Drainage Features

Standard culverts and ditches will serve all known drainage considerations for this segment.

(iv) Bridges

This segment includes a major structure over Cheechako Creek just after leaving Devil Canyon. This structure would be a three span deck truss over a deep narrow gorge. This type of structure will require one and one half to two years to construct. A bridge is also required at Station 1490, over an unnamed creek.

(v) Soils

Soils on the segment are varied. Portions of the line cross frozen Basil till with bedrock near the surface, exposed bedrock, and bedrock under Colluvium. Cross slopes are generally steep. This segment will require extensive rock excavation resulting in slow construction.

(vi) Environmental Concerns

The segment passes along the Susitna River banks which have been identified as potential raptor habitat. Extensive side hill construction on fairly steep terrain increases the potential for erosion and slides.

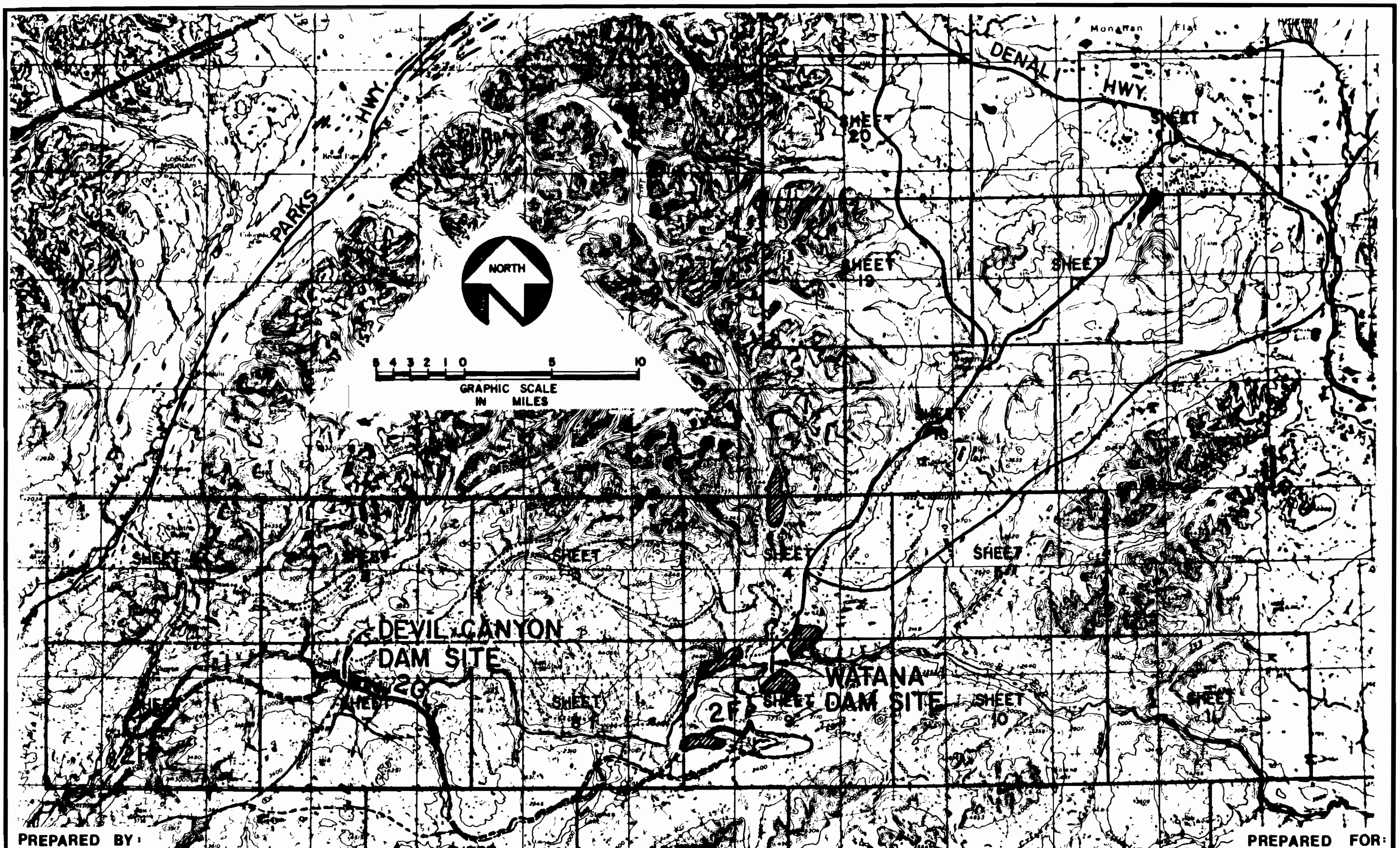
(vii) Segment Suitibility

This segment is suitable for construction should south side road access be selected. There are some scheduling constraints however because of the bridges and the extent of construction in rock.

(n) Segment 2-H

(i) Description

This segment leaves 2-E at Indian River and closely parallels the railroad south across the Susitna River then turns north easterly to connect with 2-I about two miles upstream from Gold Creek. This segment would be one logical route if road



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SEGMENT 2F=3.9 MI. SEGMENT 2G=7.7 MI.

SEGMENT 2H=5.4 MI.

FIGURE 9.5

access were provided from the Park Highway while providing a rail head at Gold Creek. See Figure 9.5.

This segment is 5.4 miles long.

(ii) Line and Grade

The horizontal and vertical alignments for this segment will meet desired parameters.

(iii) Drainage Features

The only drainage features of note on this segment are Indian River and the Susitna River.

(iv) Bridges

Bridges required on this segment would be similar in configuration to those required at the Susitna River and the first Indian River crossing of Segment 2E. The location will vary from the 2-E location, however the general design would be similar.

(v) Soils

The soils encountered along 2-H are largely floodplain and terrace deposits with portions located on frozen Basil till.

(vi) Environmental Concerns

Both the Susitna River and Indian River are anodromous streams at the proposed crossing. Bridge construction would have to be done in a manner approved by the responsible agencies. No other significant environmental concerns have been identified.

(vii) Segment Suitability

This segment is suitable for construction. All or part may be used depending on the final access plan adopted.

(o) Segment 2-I

(i) Description

This segment is located on the south side of the Susitna River slowly accending in elevation to reach the south end of Devil Canyon Dam. The segment begins about 2 miles above Gold Creek. See Figure 9.6.

The segment is 11.4 miles long.

(ii) Line and Grade

This segment has very good horizontal and vertical alignment generally providing an alignment that will be better than the required minimums would provide.

(iii) Drainage Features

Several drainages cross this segment. Some of these may require large culverts such as multiplate or pipe arches of a type common to highway construction. A portion of the alignment follows a small drainage, care must be taken to protect this stream.

(iv) Bridges

It appears that no bridges will be required on this segment.

(v) Soils

Nearly all of this segment traverses frozen Basal till on side slopes varying from flat to moderately steep. Care must be taken not to cut so deep as to disturb the thermal regime without insulation or other special features to protect the underlying conditions. Large quantities of borrow will be required for this section because of the frozen soils.

(vi) Environmental Concern

No major environmental concerns have been identified along this segment. There are small wetland areas that must be considered in final design.

(viii) Segment Suitability

This segment is suitable for construction of roadway. Access to Devil Canyon from Gold Creek could be provided fairly rapidly via this segment.

(p) Segment 2-J

(i) Description

This segment provides an alternative to 2A around Stephan Lake and the borrow area near Fog Creek. The alignment moves north of 2A as it passes Stephan Lake to avoid some wetland and bad soil areas then crosses 2A and runs south and east of 2A joining 2F north of Fog Creek. See Figure 9.6.

The segment is 12.2 miles long.

(ii) Line and Grade

This segment has good line and grade its entire length. There are some maximum (6%) grades at Fog Creek.

(iii) Drainage Features

This alignment crosses several small drainages of the type normally handled with culverts. There appears to be no significant drainage problems.

(iv) Bridges

There is a major bridge over Fog Creek. This bridge would be similar to the structure required on 2-F, multispan, and approximately 1,250 feet in length. It may be possible to use a welded plate girder structure rather than a truss. If so, some six to twelve months could be saved on the construction schedule when compared to the bridges on 2-F. This bridge will still require a year to build.

(v) Soils

The soils along this segment are largely Lusterines over frozen Basal tills. These soils are sensitive and require care in designing slopes, ditches and other features to avoid erosion, frost heave and thaw settlement. Cross slopes are generally gentle to moderate thus allowing cuts to be kept to a minimum.

(vi) Environmental Concerns

The entire segment traverses quality wildlife habitat. Moose, Bear, Caribou, Raptors, and Furbearers use this area. The segment does stay further from Stephan Lake, other than that the impacts would be comparible to 2A.

(vii) Segment Suitability

The segment is suitable for construction. It has two advantages over 2A in that it is further from Stephen Lake and the associated environmental concerns and it skirts the edge of borrow area H for Watana Dam.

(q) Segment 2-K

(i) Description

This segment was proposed as a shorter alternative to a portion of 2-H. The segment leaves 2E as the south side of the Susitna River and turns sharply east climbing to join 2H on top of a bluff. See Figure 9.6.

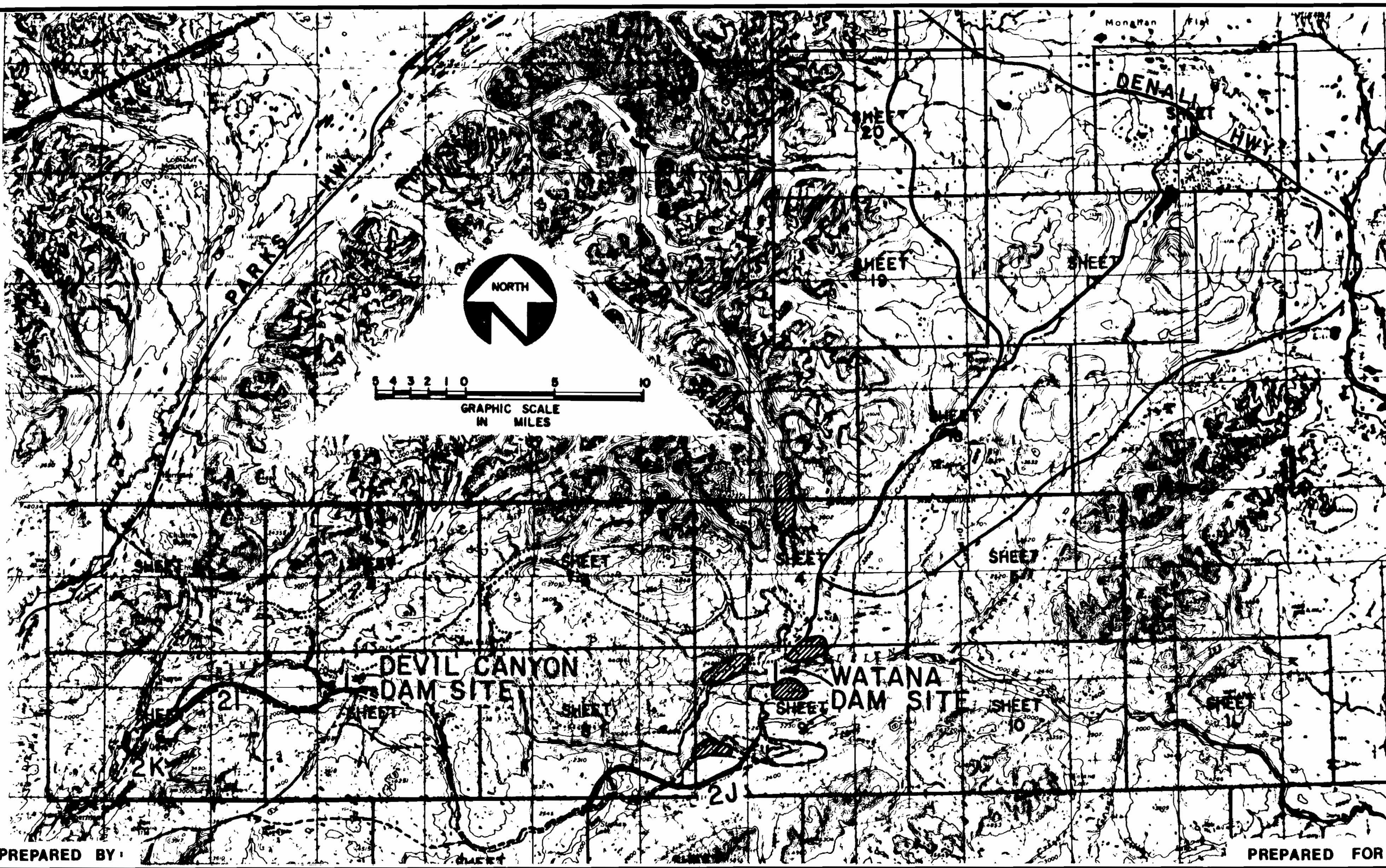
This segment is only 0.9 miles long.

(ii) Line and Grade

This segment conforms to the required parameters however maximum curvature and gradients are involved.

(iii) Drainage Features

No significant drainage features are encountered by this segment.



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SEGMENT 2I=11.4 MI. SEGMENT 2J=12.2 MI.

SEGMENT 2K=0.9 MI.

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FIGURE 9.6

(iv) Bridges

No bridges are involved on this segment.

(v) Soils

The soils crossed are flood plain deposits and frozen Basal tills. Much of the alignment would require high fills constructed of borrow. Some cuts in frozen material are also likely as the line joins 2-H on top of the bluff.

(vi) Environmental Concerns

No major environmental conflicts appear along this segment.

(vii) Segment Suitability

The segment is suitable but not desirable due to the use of maximum curves and grades and the requirment for high fills.

(r) Segment 2-L

(i) Description

This segment is parallel to 2-E connecting 1-A at Chulitna Pass with 2-I east of Gold Creek. Portions are coincident with 2-E. The primary purpose of this alternate is to provide a line that has less potential for conflict with a State of Alaska Land disposal tract. Another potential Susitna River crossing is identified that allows the alignment to avoid going over or around a short, high bluff. See Figure 9.7.

This line is 8.7 miles long.

(ii) Line and Grade

The horizontal and verticle alignments for segement 2-L satisfy all requirements.

(iii) Drainage Features

No abnormal drainage features are encountered. There are several small cross drainages suitable for conventional culverts.

(iv) Bridges

The Susitna River must be crossed. This structure can be a mulitspan continuous welded plate girder structure. The over all length is such that approximately two years will be needed to construct this structure. This segment also requires one bridge over Indian River. This would be a one span steel box girder structure about 180-foot in length.

(v) Soils

The soils traversed by the segment are predominately frozen Basal till. Care must be taken to avoid disturbing the thermal balance. The side slopes are moderate. The line is intended to stay along the break just on the top of a bluff along Indian River.

(vi) Environmental Concerns

There are salmon using Indian River, therefore care should be taken to minimize erosion. There is private property close to the line. Property owners have expressed a negative feeling about having any access facility near them.

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SUSITNA ACCESS CORRIDOR

SEGMENT 2L=8.7 MI.

ACRES

FIGURE 9.7

(vii) Segment Suitability

The segment is suitable for construction and would be preferable to the corresponding section of 2E. It reduces the possibility of any potential encroachment on private property. The line requires one less crossing of Indian River than does 2-E, and provides a good crossing of the Susitna while eliminating the need to build over or around a bluff on the south side of the Susitna River.

(s) Segment 2-M

(i) Description

This segment connects 2-I with 1-A across Devil Canyon. The crossing is via a road that winds down Cheechako Creek Canyon to the south side of the Susitna River, crosses on a low bridge, climbs up the canyon bluff on the north side, then travels up a broad valley to connect with Segment 1-A. The portion within Cheechako Creek Canyon and along the north bluff of Devil Canyon is designed as a 30 mph road; the rest is at the required 60 mph design speed. This line is 7.9 miles long, with 3 miles at 30 mph.

(ii) Line and Grade

As described above, the line has 3 miles of below standard grades (up to 10%) and tight curves. The rest of the line conforms to the 60 mph design standards, but much of it is at the maximum 6% grade.

(iii) Drainage Features

No major drainage features, other than the Susitna River, are crossed.

(iv) Bridges

The Susitna River crossing will be a one lane temporary bridge, such as those made by Bailey Bridges. In order to avoid extremely sharp curves at each end of the bridge, it will be installed a skew. The resulting span will be about 620 feet long. This type of bridge can be installed in the first construction season.

(v) Soils

The road generally traverses exposed bedrock bluffs, with extensive rock work, and frozen basil till.

(vi) Environmental Concerns

The long term impact on the environment by this segment is minimal, because the steep, bluff cut sections are below the final water surface of the reservoir. Since the segment is within the construction limits of the Devil Canyon Dam and camp, no additional short term impact is expected by construction of the road.

(vii) Segment Suitability

Ths segment appears to be the only suitable pioneer connection between Corridor 1 and Corridor 2. It can be used only during construction of the dams, as the flooding of the Devil Canyon Reservoir would submerge it. The segment is very suitable for use as a three year pioneer road while construction the bridge for segment 2-N, or marginally suitable for use during the entire 15 year construction period (if 2-N is not built).

(t) Segment 2-N

(i) Description

This segment connects 2-I with 1-A, crossing Devil Canyon with a high suspension bridge. This bridge would be used only until Devil Canyon Dam is completed after which traffic will cross the crest of the dam.

The line is 7.3 miles long.

(ii) Line and Grade

The line conforms with the desired parameters for road construction, though much of the length is at the maximum 6% grade.

(iii) Drainage Features

No notable drainage features, except the Susitna River, are crossed by this segment.

(iv) Bridges

The Susitna River will be crossed by a 2,600 long suspension bridge, requiring a three year construction period. During bridge construction, the low level crossing, Segment 2-M, with its temporary bridge, would be utilized.

(v) Soils

The soils along this segment are generally frozen basal till.

(vi) Environmental Conflict

As with Segment 2-M, the environmental conflicts of a road in the immediate area of the dam will be a minimal addition to the impact created by the dam construction and activity.

(vii) Segment Suitability

Ths segment has been dropped in favor of Segment 2-M, the low level crossing. The low level crossing would have to be built in any case, as an immediately useable river crossing. The final alignment, after construction of Devil Canyon Dam is completed, will be across the dam crest. The suspension bridge would have to be dismantled after 12 years of use.

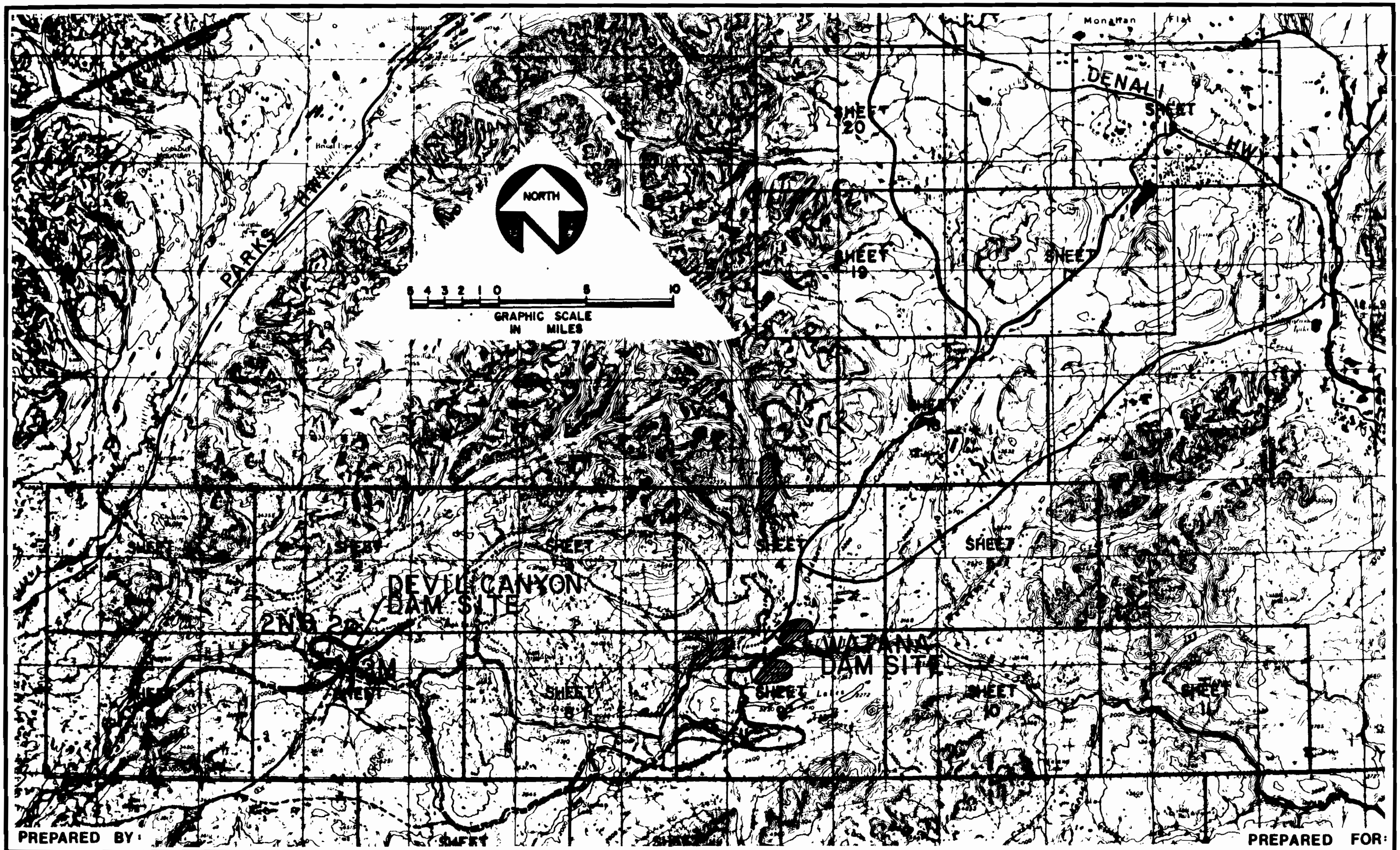
(u) Segment 2-P

(i) Description

This segment connects 2-I with 1-A using the same alignment as Segment 2-N, except that the Susitna is crossed via the Devil Canyon Dam crest. This segment will be built only after the dams are completed and is considered only as a maintenance access road, and not a construction access road. The line is 7.3 miles long.

(ii) Line and Grade

The alignment conforms to the desired parameters, though it reaches the maximum allowed 6% grade over much of its length. Lower speeds would be enforced along the dam crest, due to the volume of pedestrian traffic.



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PREPARED FOR:

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SUSITNA ACCESS CORRIDOR

SEGMENT 2M=7.9 MI. SEGMENT 2N=7.3 MI.

SEGMENT 2P=7.3 MI.

FIGURE 9.8

(iii) Drainage Features

No notable drainage features are encountered, except the Susitna River.

(iv) Bridges

No bridges are needed, as the Susitna River is crossed over the Devil Canyon Dam crest.

(v) Soils

The soils on this segment are generally frozen basal till.

(vi) Environmental Conflict

As with Segments 2-M and 2-N, the environmental conflicts of the road are over shadowed by the impacts created by dam construction and activity.

(vii) Segment Suitability

This segment is suitable for use only after dam construction is completed.

(v) Segment 2-R

(i) Description

This segment is the principle rail alternative identified for the project. The alignment is within corridor 2 on the south side of the Susitna. The line would begin at the railroad at Gold Creek traversing a short section of steep terrain at water level then becoming coincident with Segment 2-I all the way to Devil Canyon. From Devil Canyon 2-R traverses the side hill above the Susitna River parallel to and below segment 2-G turning south and requiring a full bench cut up the side of a steep gorge to the Prairie Creek divide above Stephan Lake. From this point the segment is essentially coincident with Segment 2-A all the way to Watana Dam except for a few sections that require wider swings to maintain the acceptable grades. See Figure 9.8.

The line is 57.7 miles long.

(ii) Line and Grade

The line conforms with the desired parameters for railroad construction. The ruling grade is approximately 2.5% which we are advised is comparable to some mainline sections on the Alaska Railroad.

(iii) Drainage Features

Drainage features along the route include the same small streams and wet areas encountered by the roadway segments. Culverts will handle most cross drainages although a few will be large enough to require multiplate or pipe arch type structures. There are some wetland areas that must be considered also, particularly near Stephan Lake.

(iv) Bridge

The railroad alignment requires two major bridges. The first is across Cheechako Creek just upstream from Devil Canyon. This will probably be a Deck Truss requiring three spans. This type of structure will require about two years to build and no rail service could be provided with any sort of bypass. The second is across an unnamed creek, 1.9 miles beyond Cheechako Creek, at Station 1,455. This structure, due to its proximity, could be built concurrently with the Cheechako Creek bridge.

(v) Soils

This alignment crosses the same general soil type as other segments described. Much of the alignment is on frozen soils that tend to be subject to erosion, frost heave, and thaw settlement with a few sections of deep organic soils and one section between Devil Canyon and Stephan Lake having very heavy rock work.

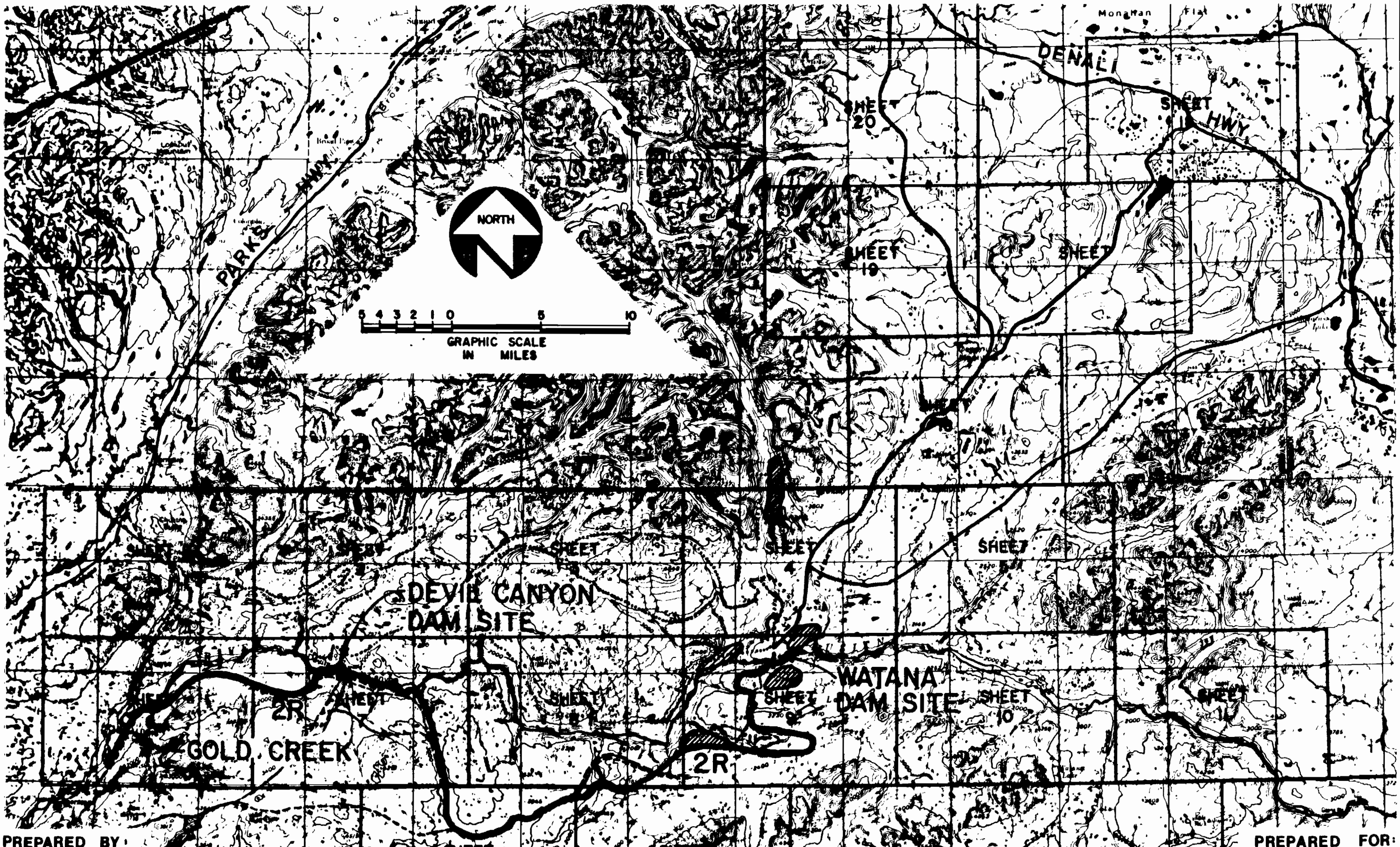
This line also crosses the massive ice area near Stephan Lake.

(vi) Environment Concerns

The Environmental concerns for the railroad are the same as for the roadway. The primary area of environmental concern is near Stephan and Fog Lakes. 2-R does encroach on the borrow area H for Watana Dam.

(vii) Segment Suitability

If railroad is chosen for access this segment is quite suitable. There are however certain schedule constraints to be considered. The Cheechako Creek bridge is a two year construction project. The portion of road bed from Devil Canyon to the Prairie Creek divide is, to a large extent, a rock excavation project requiring extensive blasting. This section alone will take a construction season. The terrain south of the Susitna makes winter mobilization very difficult if not impossible. Summer supply would require extensive roads and resulting environmental damage. It appears that construction of rail access to Watana would require three to four years.



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SUSITNA ACCESS CORRIDOR

SEGMENT 2R=57.7 MI.

PREPARED FOR:

ACRES

FIGURE 9.9

(w) Segment 2-RR

(i) Description

This segment is an alternate railroad alignment in the Stephan Lake area which avoids the worst soils conditions of Segment 2-R in this vicinity. See Figure 9.9.

Length of the segment is 13.6 miles.

(ii) Line and Grades

The alignment conforms to the required parameters for line and grade with no distinct advantage over 2-R.

(iii) Drainage Features

There are no unique or special drainage features on this segment. Standard drainage practice will serve adequately.

(iv) Bridges

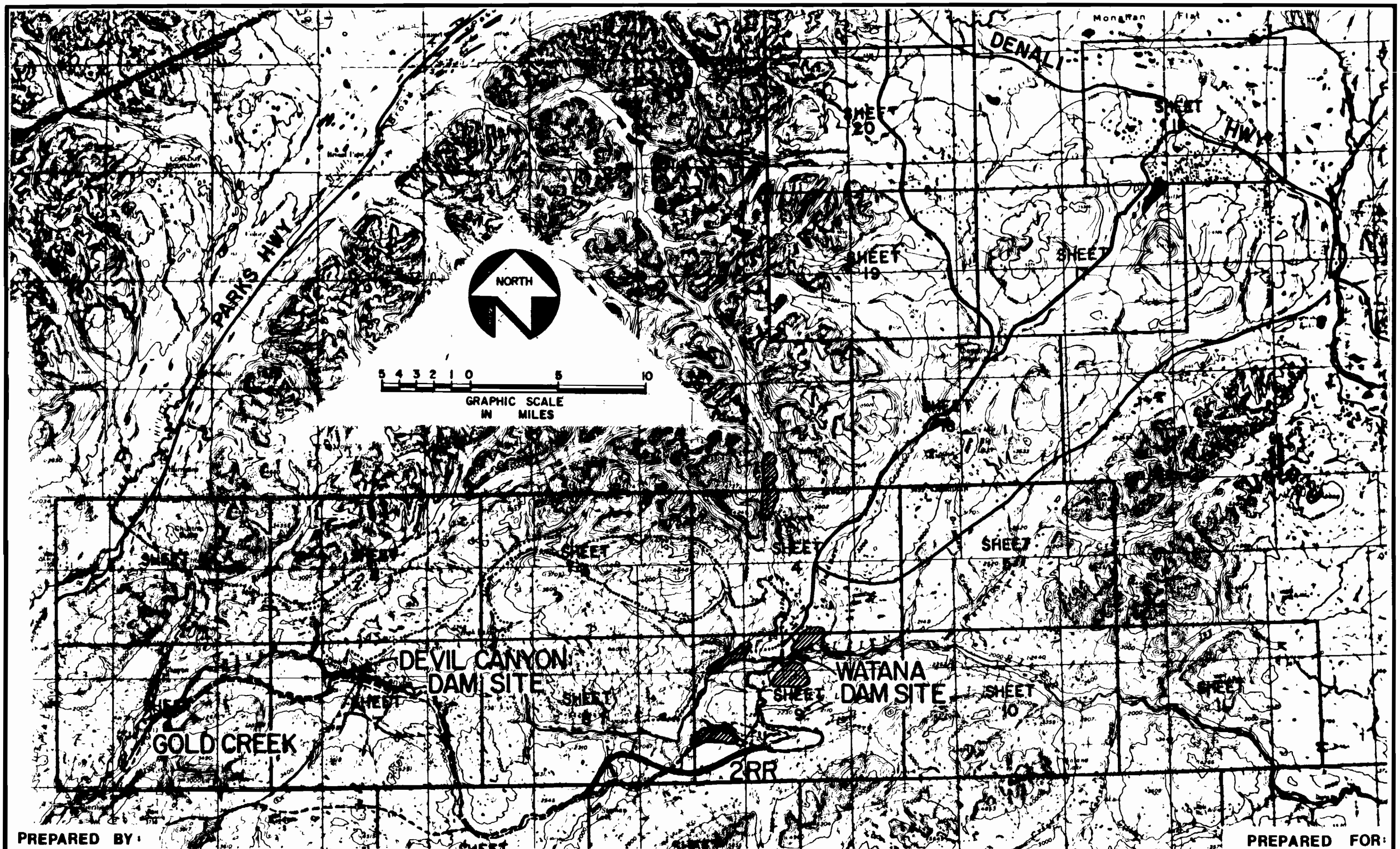
No Bridges are required on this segment.

(v) Soils

The soils are predominately frozen Basal till or Lusterines over frozen Basal till. These materials require care in design and construction. They are common to all segments however.

(vi) Environmental Concerns

All environmental conflicts have been identified. They are essentially the same as for 2-R.



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SUSITNA ACCESS CORRIDOR

SEGMENT 2RR=13.6 MI.

FIGURE 9.10

(vii) Segment Suitability

This segment does have some advantage over 2-R in that it avoids the worst of the organic soils near Stephan Lake and avoids borrow area H as designated for construction of Watana Dam.

(x) Segment 3-A

(i) Description

Segment 3-A begins at Watana Dam on the north side of the river. The alignment proceeds north easterly to Deadman Creek then ascends Deadman Creek on an easy grade past Deadman Lake, continuing onto Butte Lake and connecting with the Denali Highway some 40 miles east of Cantwell. See Figure 9.10.

The line is 38.5 miles long.

(ii) Line and Grade

The horizontal and vertical alignment of this segment are excellent.

(iii) Drainage Feature

All streams and intermitent drainages on this alignment could be served by culverts of varying sizes.

(iv) Bridges

There are no bridges on this alignment

(v) Soils

The soils traversed along this alignment are unfrozen till, frozen Solifluction deposits, flood plain deposits, alluvial fans and Lusterines. The cross slope, with few exceptions are gentle enough so that major cuts and fills can be avoided. This will keep the disturbance of erodible and/or frozen soils to a minimum. The needed borrow areas to provide embankment over frozen soils will be much less than for other segments discussed so far.

(vi) Environment Concerns

The environmental concerns identified to include archaeological finds near Deadman and Butte Lakes. A known Bald Eagle nest tree, and the fact that much of the line traverses areas sometimes used by the Nelchina Caribou herd as calving grounds and summer range.

(vii) Segment Suitability

This segment is suitable for roadway construction. The terrain is gentle enough that by using mulitple contracts and winter mobilization this entire alignment could be made possible in a single construction season, thereby minimizing any potential schedule impact on construction of Watana Dam.

(y) Segment 3-B

(i) Description

This segment leaves 3-A at Deadman Creek and proceeds east into the Watana Creek drainage. The line proceeds up Watana Creek to its head then follows Butte Creek northeasterly to an intersection with the Denali Highway at the Susitna River. See Figure 9.10.

This line is 36.6 miles long.

(ii) Line and Grade

All desired parameters for line and grade are satisfied.

(iii) Drainage Features

No abnormal drainage feature are encountered although crossings of Deadman Creek and Butte Creek are required. These will necessitate small bridges or large pipe structures.

(iv) Bridges

At this time no bridges are planned. The crossing of Deadman and Butte Creek could be accomplished using Pipe arch structures that are much faster and more economical than bridges.

(v) Soils

The soils along this alignment are similar to thoses encountered along 3-A except that more wet ground is encountered as the Denali Highway is approached. The soils along this line were not mapped in detail.

(vi) Environmental Concern

This alignment also serves known Caribou calving grounds.

(vii) Segment Suitability

This segment has been detemined to be less suitable that 3A or 3C for the following reasons.

- The crossings of Deadman and Butte Creeks

- Intersects Denali Highway furthest from the potential railhead at Cantwell, thereby increasing haul distance and the length of Denali Highway to be maintained.

(z) Segment 3-C

(i) Description

This segment leaves 3-A north of Deadman Lake and travels northerly to intersect the Denali Highway west of Seattle Creek some 25 miles east of Cantwell. See Figure 9.10.

This segment is 23.4 miles long.

(ii) Line and Grade

The line and grade for this line are excellent comparing favorably with 3-A.

(iii) Drainage Features

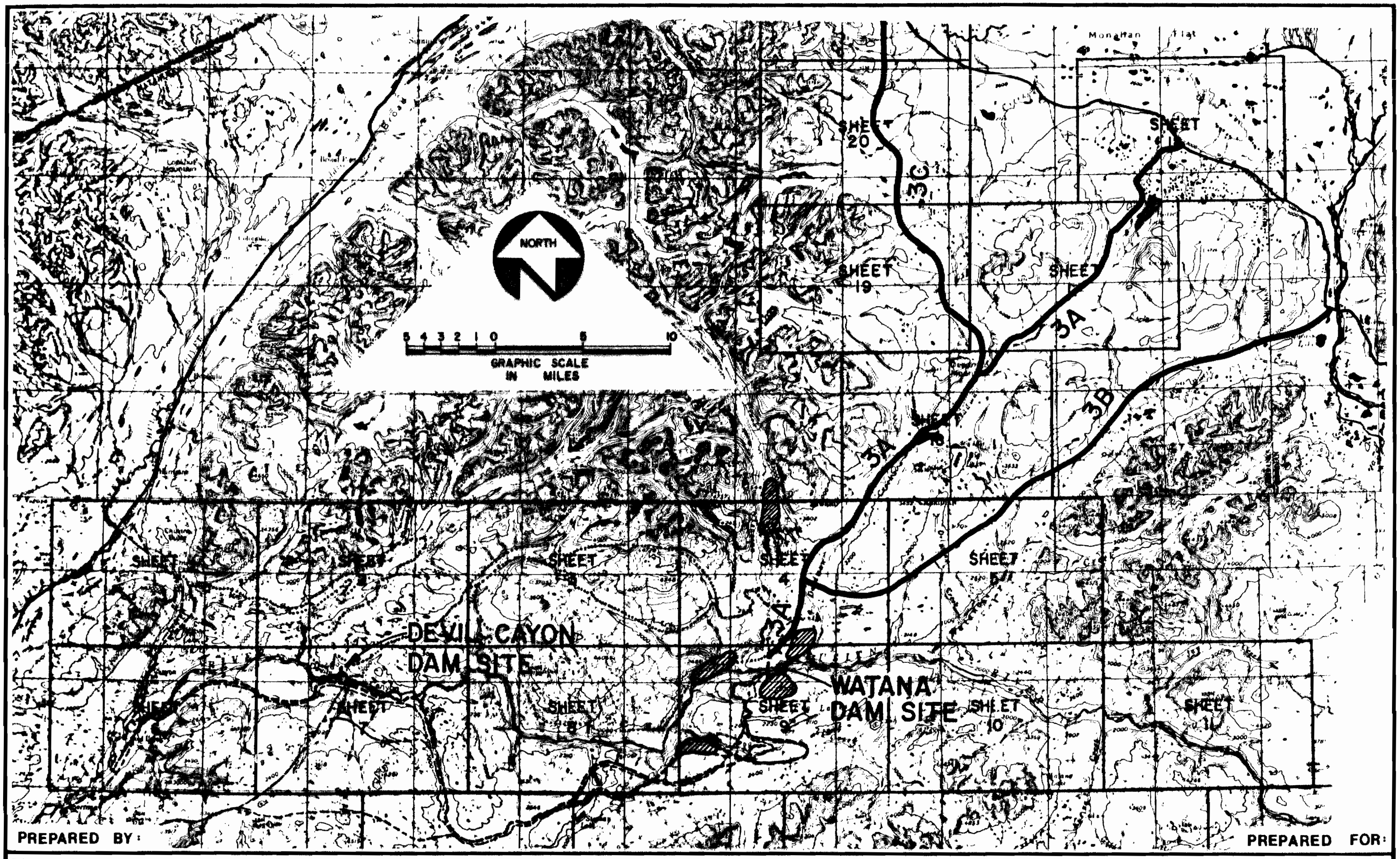
Drainage for the alignment will be by roadside ditches and standard culverts.

(iv) Bridges

No Bridges are required on the alignment.

(v) Soils

This segment shows the largest amounts of unfrozen materials of any line investigated. Because of terrain and soil types nearly all of this alignment can be constructed with side borrow techniques requiring a minimum of disturbance away from the alignment.



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SUSITNA ACCESS CORRIDOR

SEGMENT 3A=38.5 MI. SEGMENT 3B=36.6 MI.

SEGMENT 3C=23.4 MI.

FIGURE 9.11

ACRES

(vi) Environmental Considerations

This line avoids most of the area identified as caribou calving area. Summer caribou range is traversed, however little other environmental impact is identifiable from construction activities.

(vii) Segment Suitabiltiy

This segment appears to be quite suitable for implementation. It largely avoids the principle environmental concern pertaining to caribou calving. It can be made passable in a single construction season and it requires the least reconstruction and maintenance on the Denali Highway.

9.3 - Corridor Summary

With the various segments identified and estimates made of grades and curvature a series of probable combinations were developed and compared. The criteria used to compare the alternative combinations are as follows:

- Overall length to be constructed;
- Average grade;
- Average deflection per mile.

The tabulation of the comparison in included in Appendix C.

The alternatives identified as being most favorable based on length, alignment and grade are as follows:

For Corridor 1. Parks Highway to Watana Dam site - North side Segments 1-A, 1-B, 1-E, and 3-A.

Overall	72.50 Miles
Average Grade	2.4%
Deflection Per Mile	7°06'+

This Corridor will be identified as Alternate A in further studies.

For Corridor 2. Parks Highway to Watana Dam Site - South Side Segments 1-F, 1-A, 2-L, 2-I, 2-G, 2-B, 2-A, 2-J and 2-F

Overall	62.03 Miles
Average Grade	2.2%
Deflection Per Mile	7.°50°±

This Corridor will be identified as Alternate B in further studies.

For Corridor 3. Watana Dam to Denali Highway Segment 3-A and 3-C

Overall	44.32 Miles
Average Grade	1.3%
Deflection Per Mile	1°30'±

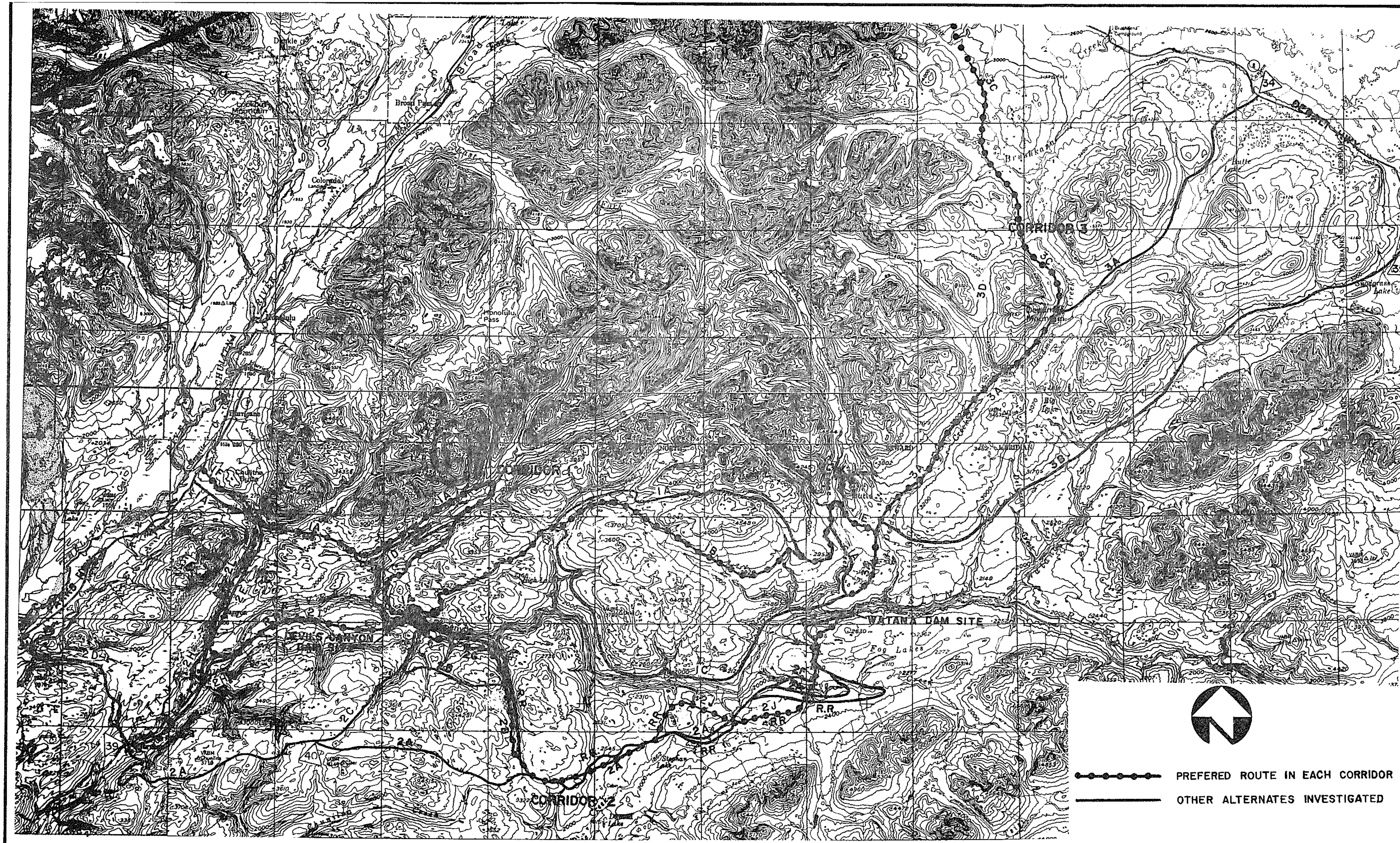
This Corridor will be identified as Alternate C in further studies.

For Railroad. Use 2-R and 2-RR on the south side of the river from Gold Creek to Watana Dam site. This closely follows the preferred road alignment for Corridor 2.

Overall	57.86 Miles
Average Grade	1.5%
Deflection Per Mile	5°11'±

This line will be identified as Alternate R in further studies.

For Corridor 1 to Corridor 2 Connection. Devil Canyon Dam Crossing. Use Segment 2-M during construction and 2-P after the Devil Canyon Dam is complete.



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PROJECT ACCESS LOCATION ALTERNATIVES

PREPARED FOR:

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FIGURE 9.12

ACCESS PLANS

10 - ACCESS PLANS

The Access plan selected should provide a cost effective method of serving the total requirements of the project, including construction schedule, provide a facility that can serve the ultimate recreational uses following construction, provide for maintance of the facilities, and control or minimize the impact on the environment.

10.1 - Supply Sources and Shipping Options

Nearly all material supplies and equipment that will be required for construction of the Susitna project will have to be brought in from outside Alaska. The major exception to this is fuel which is available from two separate in state sources.

For this reason an assumption has been made that all such items other than explosives will be shipped from Seattle, Washington. Explosive will be shipped through Prince Rupert B.C. It is felt that this is reasonable in that sources of supply and transportation within the Continental United States will be identical for all alternatives and that differences in shipping costs will result from Port of Entry in to Alaska and differences in modal split and route traveled within the state.

Sources of fuel within the state are the refineries at Kenai and at North Pole, Alaska. Transport from Kenai would be via product pipe line to Anchorage and rail or truck from Anchorage. Transport from North Pole would be via rail or truck.

Shipping options include a variety of transportation modes. There is no direct rail connection to Alaska therefore all items brought in from elsewhere must come by sea or air. Air Transport will not be adressed because of the costs involved and the limitation on quantities. Ships and barges will be most likely be used to bring most items to Alaska. Trucks could be used, however the rate disparity between sea and trucking makes trucking very unattractive. The barges offer some options with regard to connecting land transportation modes.

- Roll-on Roll-off Rail Cars
- Roll-on Roll-off Trucks
- Containers
- Pallatized Cargo
- Bulk Cargo

The type and quantities of materials and supplies required by the project are such that the roll-on roll-off modes and containers are the obvious choice because of the reduced need for storage and handling.

Once the materials are in Alaska the shipping options are reduced to rail or truck. Rail can offer bulk car load transport or piggy back from the dock to the project rail head. Trucks are capable of moving everything from either the dock or the project railhead.

10.2 - Alaska Ports

The sea ports within Alaska that could serve the project are:

- Anchorage
- Seward
- Whitter
- Valdez

(a) Anchorage

(i) Facilities

- Petroleum Terminal - 612 feet long with multiple manifolds and electric hose handling hoists.

- General Cargo Terminal #1 - 600 feet long - 47 feet wide. Live load 600 pounds per square inch, Containers.

- General Cargo Terminal #2 - 610 feet long - 69 feet wide containers and Bulk Cement.

- General Cargo Terminals #3 - 898 feet long - Roll-on Roll-off trucks and containers

- 35 feet of water MLLW at the dock face.

- Cranes

  - 2 - 40 Ton Level Luffing Gantry
  - 1 - 7½ Ton Level Luffing Gantry
  - 2 - 27½ Ton Container Cranes

- Transit Shed - 52,950 square feet - 22-foot ceiling - heated - Rail and truck access.

- Staging and Storage Areas

  A - 4.6 acres
  B - 6.4 acres
  C - 6.7 acres

(ii) Limitations

- Cook Inlet does form heavy ice floes during the winter months. Tidal fluctuations keep the ice broken up, however there are periodic problems for shipping due to winter ice.

- There is no provision for roll-on roll-off rail.

(b) Seward

(i) Facilities

- One general cargo dock capable of handling a single ship.

- A single 40 ton level luffing gantry.

- Truck and rail service to the dock.

- 20 acres open storage.

(ii) Limitations

- No covered storage
- Limited capacity
- No movement of explosive allowed

(c) Whittier

(i) Facilities

- Single dock with roll-on roll-off rail capacity

- Rail switchyard for storing cars from barge and making up train.

(ii) Limitation

- No truck access

(d) Valdez

(i) Facilities

- 600' x 60' wooden dock
- 33-foot of water MLLW at the dock face
- 1 - 150 ton crawler crane
- 1 - 100 ton fork lift
- 2 - 30 ton fork lifts
- 3 - 9 ton fork lifts
- 5 - 3 ton fork lifts
- 200 acre open storage area four miles from dock
- 12,000 square foot warehouse at dock
- Two private barge docks having 0- to 1-foot of water at MLLW. Both were used during the Trans-Alaska pipe line construction.

- New dock under construction is a floating dock 700' x 100' with live load capacity of 1,000 lb./sq.ft. and served by two 150 ton crawler cranes. Work should be completed in 1982.

(ii) Limitations

- No railroad access

(e) Comparisons

Anchorage is closest to the project and has the greatest flexbility. Winter ice and the lack of roll-on roll-off rail capability not withstanding Anchorage is a viable sea port for the project.

Seward is a longer haul than Anchorage and does not have the capacity of Anchorage however it is an ice free port and could be used nicely as an alternate should ice conditions or volume of traffic become such that there would be delays in reaching Anchorage. For this reason Sewared is not considered further except as an alternate if needed. It must be noted that explosives cannot flow through Seward.

Whitter is a viable port for all items that can be shipped via rail car load lots. The roll-on roll-off rail barge capability is very attractive for bulk items and heavy equipment. Whitter is an ice free port so that material can flow year round.

Valdez apparently will have the capacity to handle the material flow however this is the longest truck haul and there is no rail access to Valdez. The lack of rail acess and the length of truck haul combine to effectively eliminate Valdez from consideration as a viable sea port to serve the Susitna Project.

TABLE 10.1
Mileage from Ports to Rail Head or Project

	Anchorage	Seward	Whitter	Valdez*
Rail Haul to				
Gold Creek	149 mi	262	211	NA
Devil Canyon	165 mi	278	227	-
Cantwell	205 mi	318	267	NA
Watana via Devil Canyon	207 mi	320	269	-
Truck Haul to				
Gold Creek, via B-1	180	307	NA	
Devil Canyon	193	320	NA	393 mi
Cantwell	212	339	NA	
Watana via Devil Canyon, B-3	229	356	NA	
Watana via Denali Highway	277	404	NA	349 mi
Watana via Devil Canyon, A-2	234	361	NA	

* The road milage from Valdez is shown via Denali Highway and Richardson Highway and Corridor 3.

The access plans must include the ports through which materials should flow. For comparison purposes shipping rates through the possible ports were requested. Table 10.2 below includes "across the dock" costs including handling as derived from the data supplied by port offices and shippers.

TABLE 10.2
ACROSS THE DOCK HANDLING COSTS

Material From Seattle (6)	Cost in $/Ton (1) To Anchorage	(2) To Seward	(4) To Whittier	(1) To Valdez
Reinforcing Steel	72.00	72.00	55.00	86.00
Structural Steel	85.40	85.40	55.00	125.00
Cement	66.00	66.00	(3) 55.00	80.00
General Cargo	80.00	80.00	55.00	110.00
Equipment	160.00	160.00	120.00	191.00
Explosives	89.00	Not Allowed	55.00	115.00

1 Quoted by Pacific Western.

2 Information not received - Estimated equal to Anchorge.

3 Rate for 140,000 lb Hopper Cars - Rates for Bags 100.00/ton as per ARR.

4 Rates derived from quotion by ARR.

5 Includes Stevedoring at all ports.

6 Explosives must flow through Prince Rupert, B.C.

10.3 - Surface Transportation Modal Options

There are two obvious modes of transportation available to serve the project, Truck and Rail. The project may be served by either one or a combination of both. In order to compare the two modes the respective rates are presented in ton-mile figures. In this way length of haul may be considered in the analysis.

TABLE 10.3
LINE HAUL RATES IN $/TON-MILE

Item	Rail*	Truck**
Equipment	0.1878	0.2069
Steel	0.2577	0.2069
Cement	0.1565	0.2069
Fuel	0.1450	0.2069
General Cargo	0.1262	0.2069
Explosives	0.6267	0.2069

* From price per 100 Lb. rates quoted by ARR.
** One rate for all quoted by three separate truck lines. The cost shown is an average of three rates.

The modal alternates that seem most probable include the following:

- Truck from port to the site.
- Rail from port to the site.
- Rail to Gold Creek or Cantwell and truck from the rail head to the site.

10.4 - Access Plans

To this point three alternative Corridors have been defined, Corridors A, B and C. Estimates have been made of the amounts of materials required at each site and freight handling costs have been identified for the available transportation modes and ports. The three major costs pertaining to access are logistics, construction and maintenance. Estimated construction costs are outlined.

Maintenance costs will not be estimated in detail. Instead, an estimate of the relative difference in difficulty of maintenance will be applied to an average maintenance figure of $10,000 per mile per year. Alaska Department of Transportation and Public Facilities records show an average annual maintenance cost of $10,000 per mile for primary highways.

The alternate corridors identified herein are split into sections for further analysis. Those sections are as follows:

TABLE 10.4
BASIC CORRIDOR SEGMENTS

Section	Description
A-1	Parks Highway to Devil Canyon (north side)
A-2	Devil Canyon to Watana (north side)
B-1	Parks Highway to Gold Creek
B-2	Gold Creek to Devil Canyon (south side)
B-3	Devil Canyon to Watana (south side)
C	Denali Highway to Watana
D	Devil Canyon Trans-Dam Crossing
H	Devil Canyon Low Level Crossing
R-1	Gold Creek to Devil Canyon
R-2	Devil Canyon to Watana

The access plans outlined on the following pages are made of combinations of the above listed corridor segments.

TABLE 10.5
MAINTENANCE FACTORS

	Section	Maintenance Factor*
A-1	Parks Highway to Portage Creek	1.0
	Portage Creek - Devil Canyon	1.4
A-2	Devil Canyon - Watana	1.0
B-1	Parks Highway to Gold Creek	1.0
B-2	Gold Creek to Devil Canyon	1.2
B-3	Gold Creek to Stephan Lake	1.3
	Stephan Lake to Watana	1.0
C	Denali Highway to Watana	0.8
D	Devil Canyon Trans-Dam Crossing	1.0
H	Devil Canyon Low Level Crossing	1.3
R-1	Gold Creek to Devil Canyon	0.5
R-2	Devil Canyon to Stephan Lake	0.7
	Stephan Lake to Fog Creek	0.6

* Based an author's past experience.

Potential borrow pit areas are listed in the discussion of each access plan. The locations of the pits were determined by calculating the earthwork and locating areas along each corridor that would need borrow. The terrain unit maps were then used to determine potential pit sites. Environmental comment was provided by TES and is shown in Appendix G. The pit sites are shown on the segment maps in Appendix B. The entire area in which favorable material may be taken is shown, however, the actual pit will encompass a much smaller space. The pits are as follows:

TABLE 10.6
BORROW PITS

Pit	Corridor	Map	Comments
1	B-1, B-2, R-1	6	Private land - Indian River Disposal area, relatively high value wildlife habitat
2	B-2, R-1	6	Creek banks have relatively high value wildlife habitat and high erosion potential
3	B-2, R-1	6	Creek bank erosion potential
4	B-2, R-1	7	Partly wetlands (wet sedge grass habitat) Native Claim - Knik
5	B-2, R-2	7	Medium - High value. Wildlife habitat, Native claim - CIRI
6	B-3, R-2	7	Will be submerged
7	A-2	2	Moose browse near lake
8	A-2	2,3	Moose browse. Avoid creek on west edge.
9-10	A-1	2	Not investigated because segment was dropped from consideration

No potential borrow pits were investigated for section C because this segment had very minimal borrow needs (20,000 c.y., partly for the Denali Highway).

Section B-2 has by far the highest borrow needs - 445,200 c.y. - and any plan that uses B-2 may have a higher impact on wildlife habitat, erosion, and visual esthetics. Railroad section R-1 parallels Section B-2, but because of the narrower typical section, only one fourth of the borrow needed in B-2 will be needed in

R-1. In the discussion of each plan, all the potential borrow areas for R-1/B-2 are listed (numbers 1 through 5) but not all of the areas will be developed for R-1.

The alternate corridors identified herein are split into sections for further analysis. Those sections are as follows:

(a) Plan I

(i) Description

Access Plan I is a basic roadway plan beginning at the Parks Highway and serving both Devil Cayon and Watana dams from the south side of the river. See Figure 10.1.

(ii) Sea Ports

There are two sea ports that appear logical for serving the project. Anchorage and Whittier. These are common to all access plans. Seward is available as an emergency backup to Anchorage. All items that can be shipped in carload lots should enter the State through Whittier because of the rail barge facility. Information provided by railroad officials indicates that this facility can handle any rail load that can be shipped on main line trackage in the continental United States and fit on the barge. Other cargo should be containerized for shipment through Anchorage because of port capacity and available area for short term storage.

(iii) Modal Split

The split in transportation modes is consistant through all plans. Based on ton mile freight costs, the railroad should be used to as near the project as practical for all items except explosives. Therefore the rail mode should be used for all items to a rail head at Gold Creek. For Plan I, a rail head should be provided at Gold Creek with truck haul from Gold Creek to the work site.

(iv) Sections Included

The corridor sections included in Plan I include B-1, B-2, and B-3.

(v) Borrow Pits

This plan uses borrow areas 1 through 6

(vi) Cost Estimates

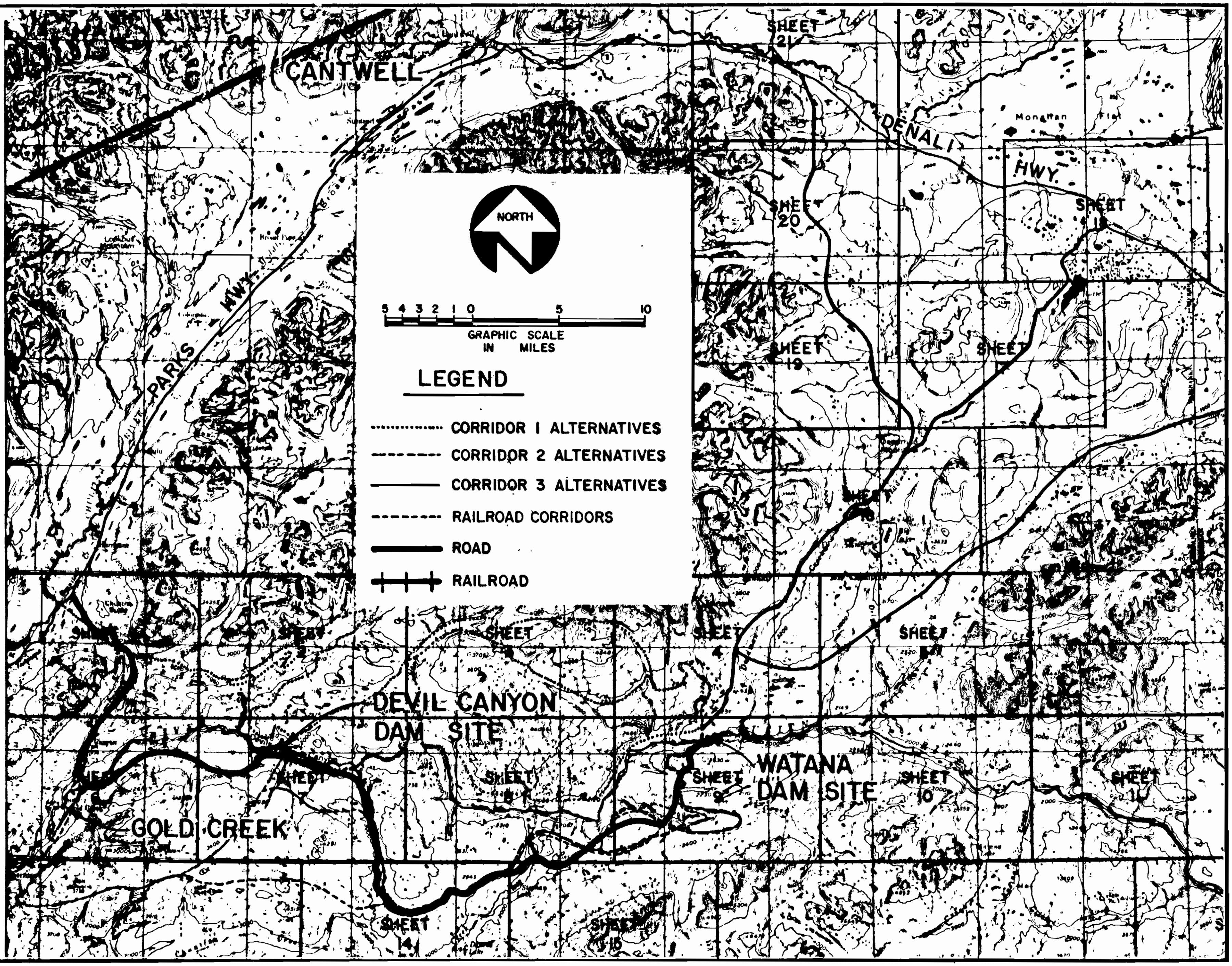
The estimated cost of Plan I in 1982 dollars is outlined below:

Construction	$119,072,148
Camp Facilities	12,645,460
Maintanance	7,426,900
Logistics	214,438,356
TOTAL	$353,582,864

(vii) Advantages/Disadvantages

The Advantages of the plan are:

- The shortest haul to serve the project.
- Only one rail head at Gold Creek
- Utilizes the same section from Gold Creek to Devil Canyon throughout the construction of both dams.
- Second to lowest logistics cost.



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ACCESS PLAN #1

ALL ROADS

FIGURE 10.1

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The Disadvantages of the plan are:

- The plan includes a major bridge above Cheechako Creek that will take 18-24 months to construct with about twelve miles of heavy rock construction immediately beyond. The rock work will be slow work and there is no easy access around Cheechako Creek to allow the rock work to proceed coincident with the bridge.

- A similar but shorter bridge is required at Fog Creek. The Fog Creek bridge will require approximately 18 months to construct. These time constraints combined with the length of facility to be constructed will require an overall construction period of nearly four years. The terrain is such that construction of multiple sections simultaneously would not be practical.

- Recent soils investigations have revealed massive ice at or near the surface with up to 20 feet of organic soils in the area north of Stephan Lake.

- Third highest borrow volume of all plans - 672,000 cy - with associated environmental and esthetic impacts.

(b) <u>Plan 2</u>

(i) <u>Description</u>

This plan is the railroad alternative to serve both dams. A spur track would be constructed beginning at Gold Creek and following the south side of the river to Watana Dam. There would be no roadway involved with this plan. See Figure 10.2.

(ii) Sea Ports

Anchorage and Whittier would be the obvious sea ports for this plan. The rail barge capabilities of Whittier would be vital to this plan.

(iii) Modal Split

Transportation would be essentially single mode with all material being transported from the dock to the job site by rail. The movement of personnel would be by rail or by air. The volumes of personnel would probably dictate passenger train service. This service has not been included in the cost estimates.

(iv) Sections Included

This plan includes Sections R-1 and R-2.

(v) Borrow Pits

Plan 2 uses borrow areas 1 through 6 for borrow, but with smaller pits than Plan 1. Some areas may not need to be developed.

(vi) Cost Estimates

The estimated cost of Plan 2 in 1982 dollars is outlined below:

Construction	102,964,049
Camp Facilities	10,294,280
Maintanance	3,624,000
Logistics	213,620,024
TOTAL	330,502,353

(vii) Advantages/Disadvantages

- This plan essentially eliminates concern about the impact of public access to the project area.

- The rail line could be used as a transportation facility to aid in potential mineral resources along part of the route.

- Least cost to maintain

- Least Logistics cost

- A significant disadvantage is that the line must be built lineally rather than in simultaneous sections.

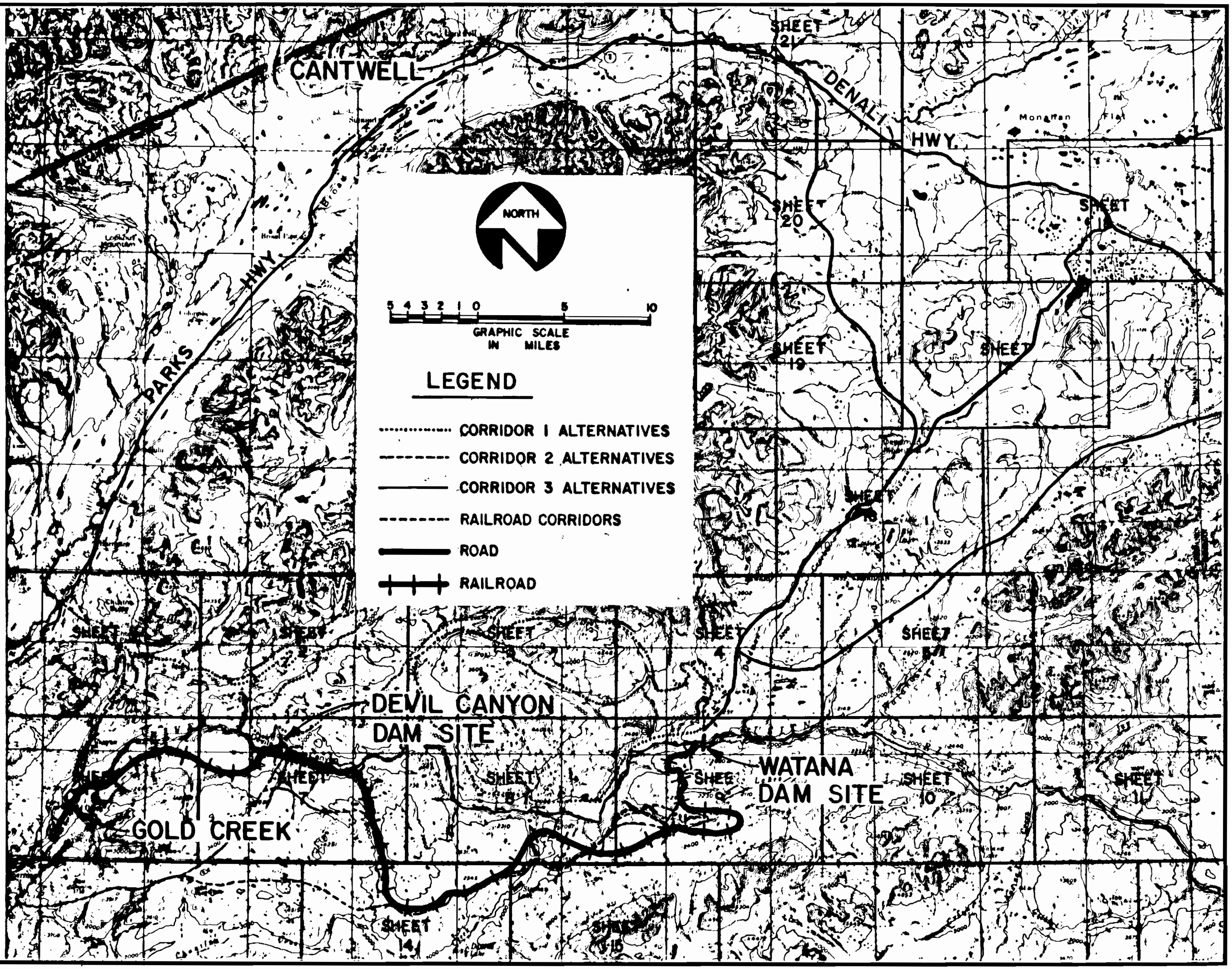
- Another disadvantage is the major bridge at Cheechako Creek. This also is an 18-24 month construction project.

- The section of heavy rock construction is even more severe than for Plan I because grades hold the line down further on the slope in the critical section.

- The ice and organic soils problems near Stephan Lake would have more impact on the railroad than on a roadway.

- As with Plan I, construction time would be three to four years.

- Second lowest borrow quantities of all plans (137,500 c.y.)



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ACCESS PLAN #2

ALL RAILROAD

FIGURE 10.2

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(c) Plan 3

(i) Description

This plan uses a combination of rail and truck. Construction of Watana Dam would be served from a rail head at Cantwell by truck across the Denali highway and along Alternate C. Construction of Devil Canyon dam would be served by truck from a rail head at Gold Creek with road access to Parks Highway. This plan does not include a connection between the two dams. See Figure 10.3.

(ii) Sea Ports

Common to all plans are Anchorage and Whittier.

(iii) Modal Split

This plan requires rail heads at Gold Creek and at Cantwell. Materials would move from port to rail head via railroad, be transfered to trucks at the rail head and be hauled to the work site by truck. The movements of construction workers would be via private auto direct to the construction camp.

(iv) Section Included

This plan includes Sections B-1, B-2 and C

(v) Borrow Pits

Plan 3 uses borrow areas 1 through 5.

(vi) Cost Estimates

This plan is estimated to cost as follows:

Construction	115,915,734
Camp Facilities	11,593,479
Maintanance	6,225,000
Logistics	228,050,617
TOTAL	361,784,830

(vii) Advantages/Disadvantages

The advantages of the plan are:

- It utilizes Section C which is the only approach to Watana that could be completed sufficiently in one season to allow resupply of construction activities at Watana.
- Personnel access via private auto.
- No major bridges necessary for movement of construction materials.
- Segments B-1 and B-2 including the Susitna River Bridge could be built during the period of construction for Watana thereby eliminating the time constraints.

The disadvantages of the plan are:

- Potential environmental impacts resulting from public access to additional portions of the Nelchina Caribou Range.

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ACCESS PLAN #3

ROAD—PARKS HWY. TO DEVIL CANYON ROAD
ROAD—DENALI HWY. TO WATANA

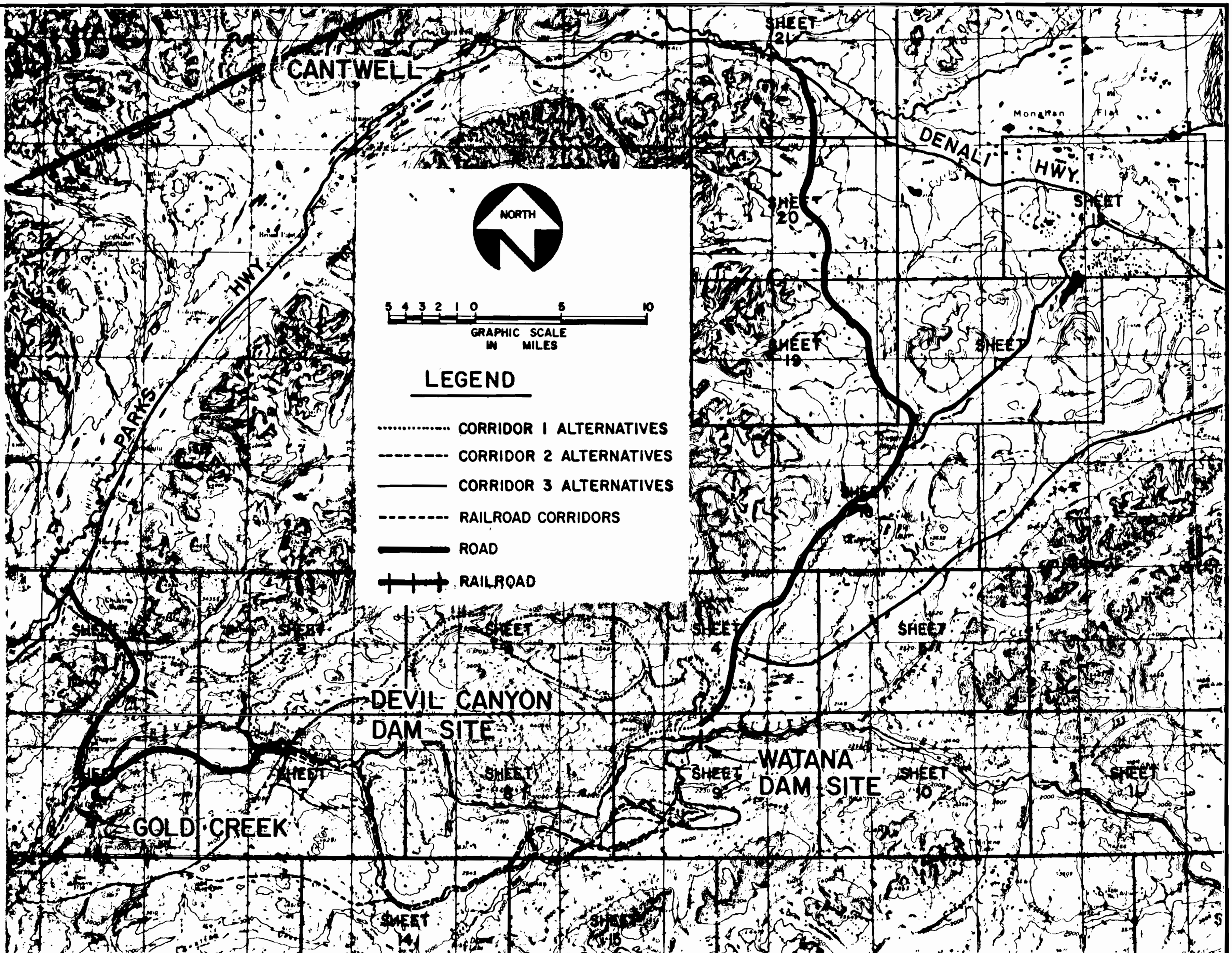

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FIGURE 10.3

- Second to highest logistics cost.

- Lack of direct access between dams for maintenance and operations staff.

(d) Plan 4

(i) Description

This plan serves Watana by truck from a rail head at Cantwell and Devils Canyon by rail from Gold Creek. In the plan there is no connection between dams.

(ii) Sea Ports

The same sea ports are common to all plans. They are Anchorage and Whittier.

(iii) Modal Split

This plan would require rail service to Cantwell via existing trackage with construction of a rail head at Cantwell and truck service from Cantwell to Watana.

Devil Canyon would be served by rail only from Gold Creek with the second rail head at the Devil Canyon dam site.

All material would flow by rail to the rail head. Personnel access for Watana would be via private vehicle while a shuttle service would be required for Devil Canyon.

(iv) Section Included

This plan would require construction of Sections C and R-1

(vi) Borrow Pits

Plan 4 will select from borrow areas 1 through 5, but the pits will be small and not all areas will be developed.

(vi) Cost Estimates

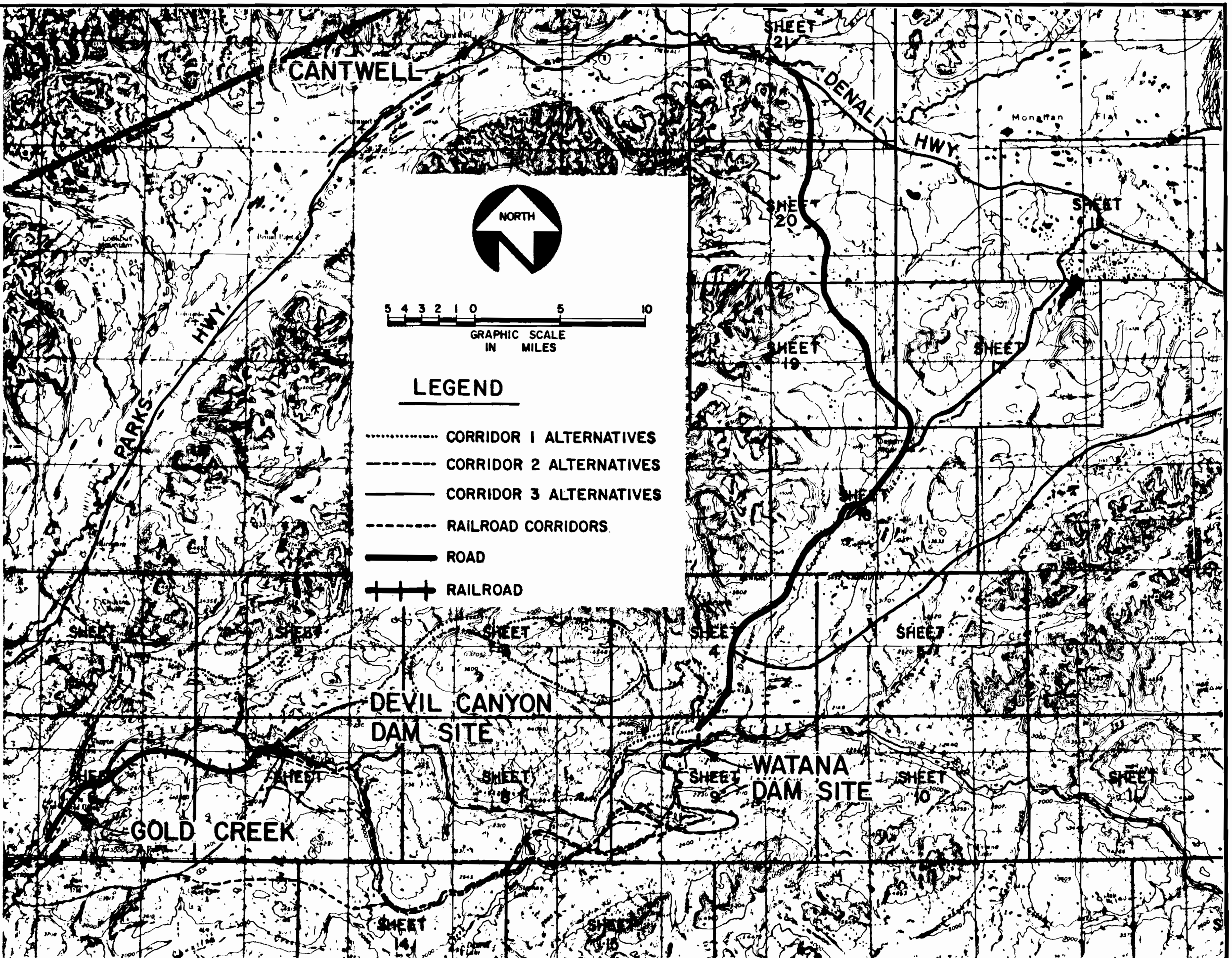
The estimated cost of Plan 4 in 1982 dollars is outlined below:

Construction	89,737,347
Camp Facilities	8,977,811
Maintanance	5,118,000
Logistics	228,004,352
TOTAL	331,837,510

(vii) Advantages/Disadvantages

The advantages of this plan include:

- Good compliance with required project schedule.
- Section C to serve Watana can be constructed sufficiently to allow resupply in one season using multiple simultaneous contracts for shortened sections with primary mobilization via winter snow road.
- No major bridges.
- Smallest borrow quantity of all plans (128,500 c.y., partly on the Denali Highway).
- Lowest construction cost.



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ACCESS PLAN #4

RAIL TO DEVIL CANYON ROAD TO WATANA

PREPARED FOR:

ACRES

FIGURE 10.4

The disadvantages include:

- Potential impact from public access.

- Need for rail shuttle to move personnel into Devil Canyon.

- No direct connection between dams for maintenance and operations staff.

(e) Plan 5

(i) Description

This plan serves both dams by truck from a rail head at Gold Creek. The south side of the river is used to Devil Canyon with low level crossing upstream from the damsite, then the north side is used to Watana. A road way connection to the Parks Highway is included.

(ii) Sea Ports

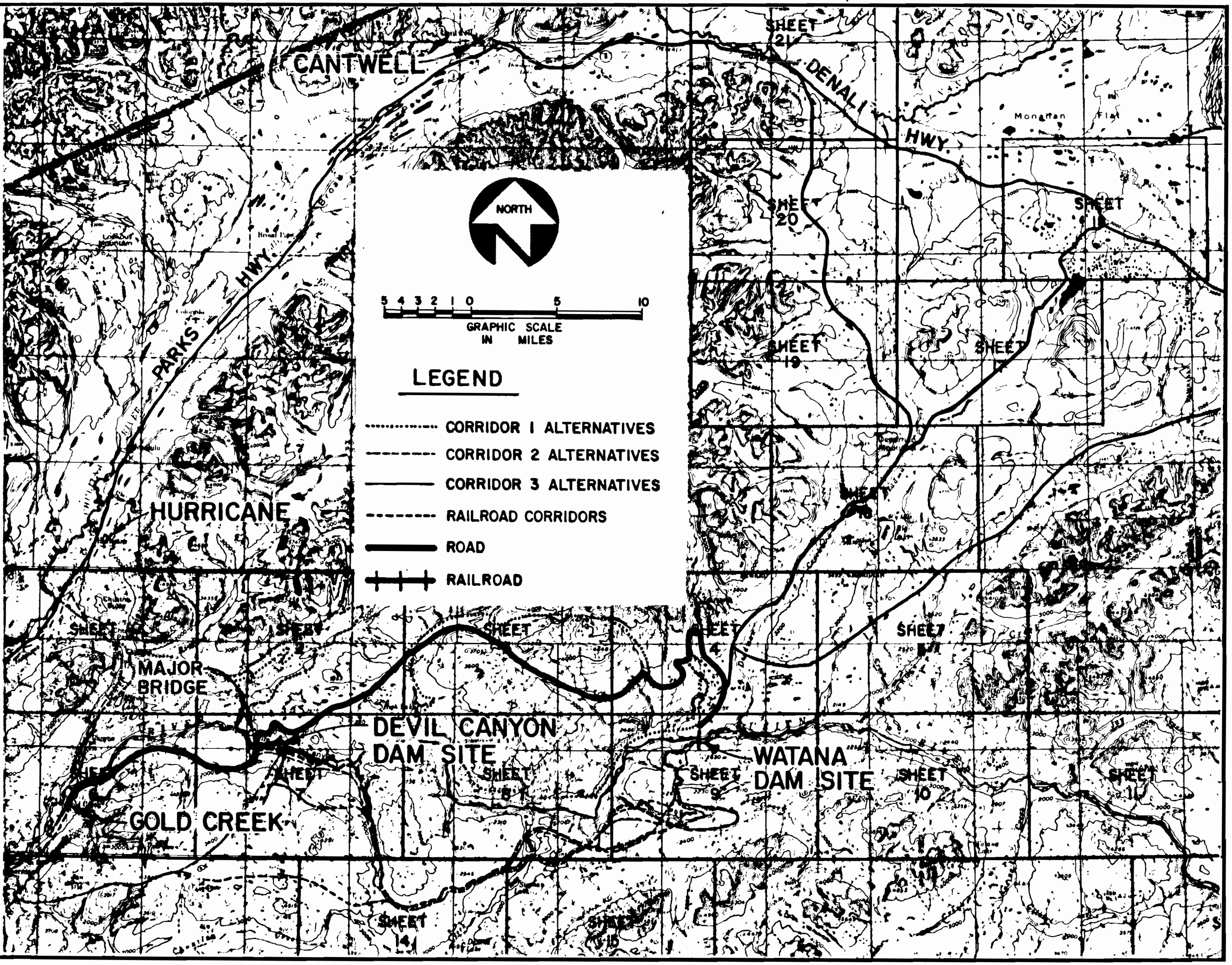
This plan utilized Anchorage and Whittier as do the other plans presented.

(iii) Modal Split

Rail haul to Gold Creek with a subsequent truck haul to the work site. Personnel would access the camps via private auto.

(iv) Sections Included

The Sections that would be included in this plan are B-1, B-2, and A-2. Devil Canyon is crossed during dam construction via H and after dam completion via D.



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ACCESS PLAN #5

ALL ROAD

DEVIL CANYON BRIDGE

PREPARED FOR:

ACRES

FIGURE 10.5

(v) Borrow Pits

Plan 5 uses Borrow areas 1 through 5, 7 and 8.

(vi) Cost Estimates

The estimated costs of this plan are outlined below:

Construction	122,279,828
Camp Facilities	12,215,529
Maintanance	7,780,900
Logistics	215,571,651
TOTAL	357,847,908

(vii) Advantages/Disadvantages

The advantages of this plan are:

- The segments involved encounter the apparent minimum of environmental conflicts.
- Personnel access is via private auto.

The disadvantages include:

- A requirement for total construction of the access prior to being able to resupply construction at Watana.
- Second highest borrow quantity of all plans, with associated negative impacts of borrow pit development (728,500 cy).

- The low level crossing at Devil Canyon has 3 miles of 30 mph design criteria including 10% grades, sharp curves, a narrow bridge, and associated hazards.

(f) Plan 6

(i) Description

This plan is essentially the same as Plan 4 except that a secondary road is provided along the north side between the dams for use by the maintenance and operations staff. This plan would use the top of Devil Canyon Dam for a crossing rather than constructing a bridge.

(ii) Sea Port

As with all plans, the sea ports will be Anchorage and Whittier.

(iii) Modal Split

This plan contemplates rail haul to Cantwell with truck haul from Cantwell to Watana and direct rail haul to Devil Canyon via Gold Creek. Personnel access to Watana by private auto and Devil Canyon by shuttle.

(iv) Section Included

The Sections included are A-2, R-1 and C

(v) Borrow Pits

Plan 6 plans use borrow areas 1 through 5, 7 and 8 but not every area will be developed.

(vi) Cost Estimates

The estimated cost of the plan is outlined below:

Construction	130,224,947
Camp Facilities	13,119,200
Maintanance	8,008,000
Logistics	228,004,352
TOTAL	379,356,499

(vii) Advantages/Disadvantages

The advantages of the plan include:

- Good compliance with the required project schedule.
- Section C to serve Watana can be constructed to a point that would allow resupply in one construction season using multiple simultaneous contracts over short sections with primary mobilization over winter snow roads.
- No major bridges involved.
- Direct access between dams for maintenance and operations staff.

The disadvantages of the plan include:

- The potential impact from increased public access.
- Second to highest construction cost.

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ACCESS PLAN #8

RAIL TO DEVIL CANYON
ROAD FROM DENALI HWY. TO
WATANA

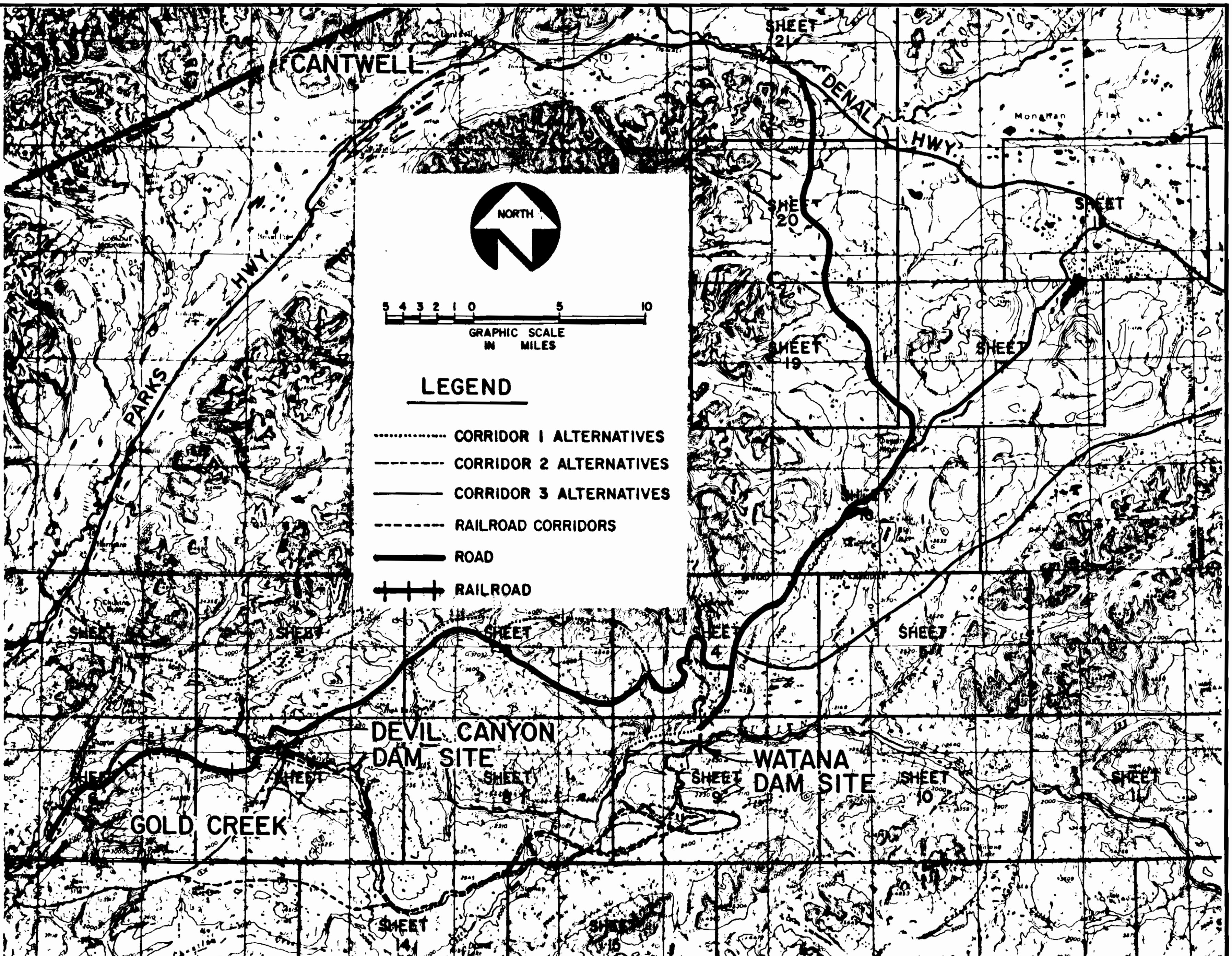

FIGURE 10.6

PREPARED FOR:

ACRES

DEVIL CANYON BRIDGE

- The need for a rail shuttle to bring personnel to the Devil Canyon site.

(g) Plan 7

(i) Description

This plan serves Watana by truck from a rail head at Cantwell, Devil Canyon by truck from a rail head at Gold Creek with a road connection to the Parks Highway and a maintenance road connection between dams north of the river. This plan would use the crest of Devil Canyon Dam for a crossing rather than constructing a bridge.

(ii) Sea Ports

Anchorage and Whittier are the logical sea ports for this plan.

(iii) Modal Split

All freight would travel by rail to the appropriate rail head then by truck to the work sites. Personnel travel would be by private vehicle.

(iv) Section Included

The Sections include B-1, B-2, A-2, C with rail head construction at Gold Creek and Cantwell.

(v) Borrow Pits

Plan 7 uses borrow areas 1 through 5, 7 and 8.

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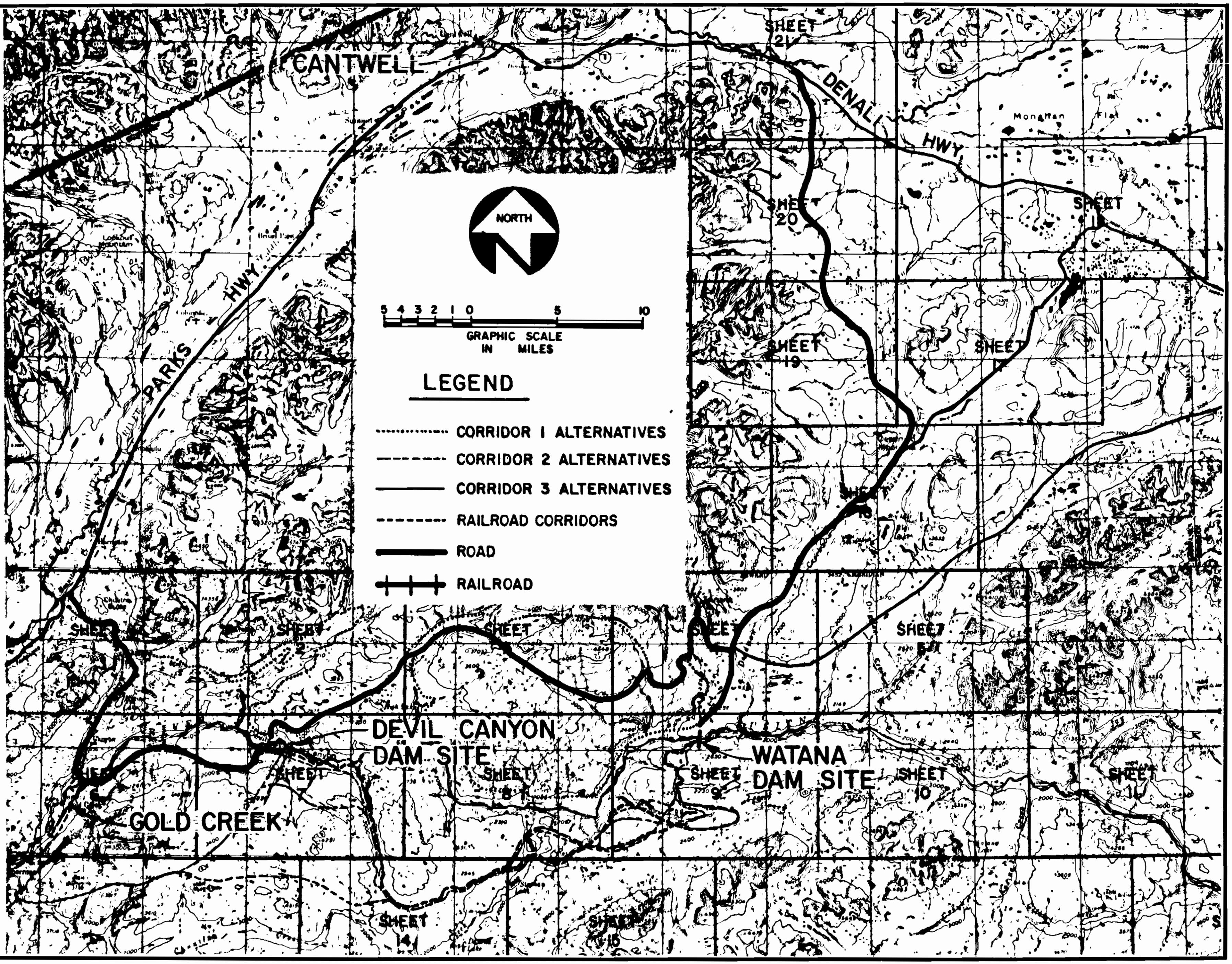

ACCESS PLAN #7

ALL ROADS

FIGURE 10.7

PREPARED FOR:

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(vi) Cost Estimates

The estimated cost of this plan is outlined below:

Construction	157,403,334
Camp Facilities	15,734,868
Maintanance	9,115,000
Logistics	228,050,617
TOTAL	410,303,819

(vii) Advantages/Disadvantages

The advantages of this plan include:

- Good compliance with the required project schedule.
- Section C to serve Watana can be constructed in one season sufficient to allow resupply.
- The only major bridge is over the Susitna River at Gold Creek and is not on the project critical path.
- Direct access between dams for the maintenance and operations staff.
- All personnel access via private auto.

The disadvantages of this plan include:

- The potential impacts from public access.
- Highest construction cost of all plans

- Second to highest maintenance cost

- Second to highest logistics cost

- Highest total cost of all plans

- Highest borrow quantities of all plans (748,500 c.y.) with associated negative impacts of pit development.

(h) Plan 8

(i) Description

This plan is esssentially the same as Plan 5, except that there is no road connection between the Parks Highway and Gold Creek. The plan serves both dams by truck from a rail head at Gold Creek. The south side of the river is used to Devil Canyon with a low level crossing upstream from the damsite, then the north side is used to Watana. All truck tractors will initially have to be ferried to Gold Creek by train, than they will be able to shuttle between Gold Creek and the damsites.

(ii) Sea Ports

This plan utilized Anchorage and Whittier as do the other plans presented.

(iii) Modal Split

Rail haul to Gold Creek with a subsequent truck haul to the work site. Personnel would access the camps via train to Gold Creek, than bus shuttle on the road, or by air.

(iv) Sections Included

The Sections that would be included in this plan are B-2 and A-2. Devil Canyon is crossed during dam construction via H and after dam completion via D.

(v) Borrow Pits

Plan 8 uses borrow areas 1 through 5, 7 and 8.

(vi) Cost Estimates

The estimated costs of this plan are outlined below:

Construction	89,910,524
Camp Facilities	8,980,995
Maintanance	5,942,000
Logistics	215,571,651
TOTAL	320,405,170

(vii) Advantages/Disadvantages

The advantages of this plan are:

- The segments involved encounter the apparent minimum of environmental conflicts.
- Public access is restricted.
- Second to lowest construction cost
- Lowest overall costs.

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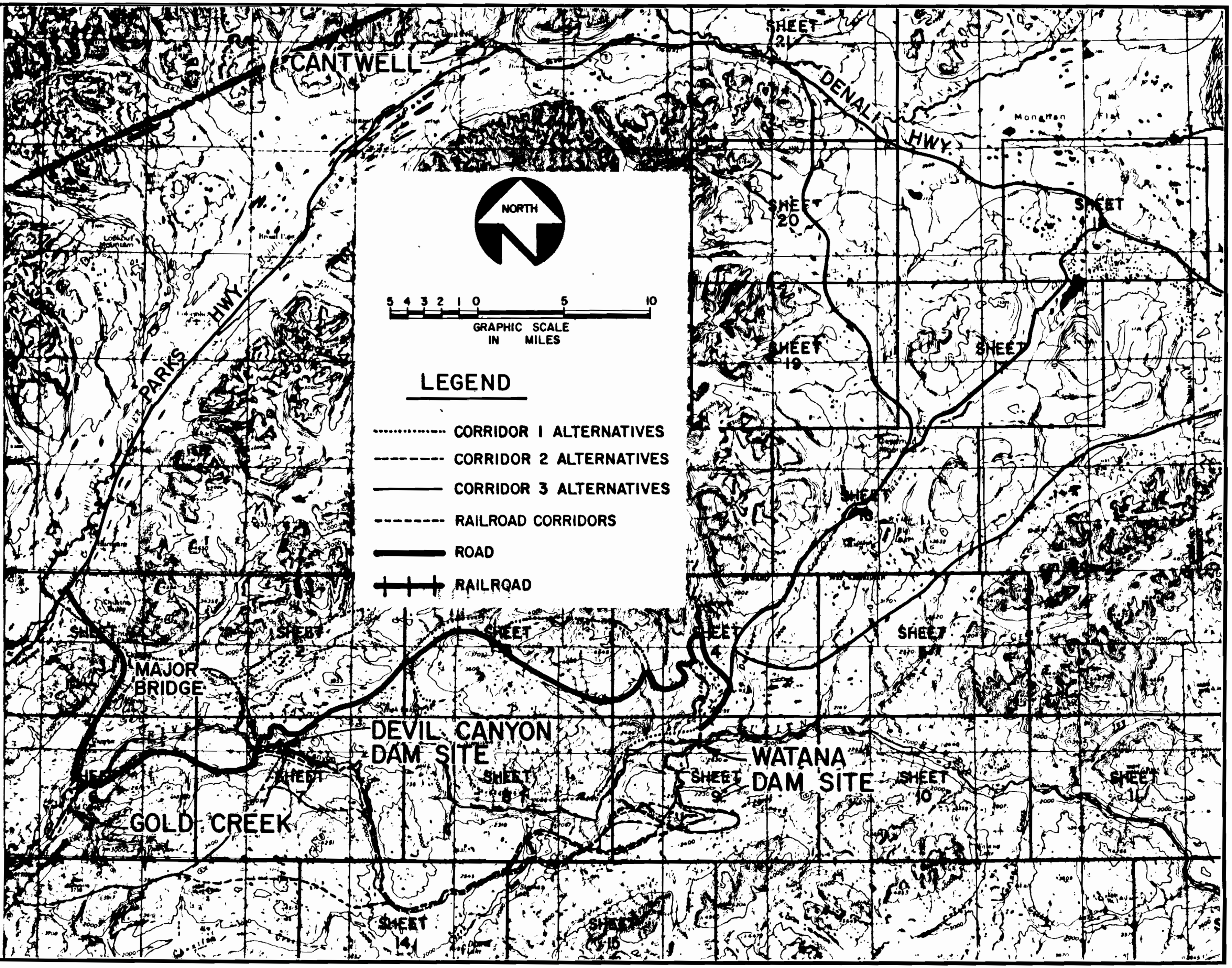
ACCESS PLAN #8

ALL ROAD

NO PUBLIC HIGHWAY ACCESS



PREPARED FOR:

ACRES

FIGURE 10.8

The disadvantages include:

- A requirement for total construction of the access prior to being able to resupply construction at Watana.
- Need to provide transportation for personnel access.
- The low level crossing at Devil Canyon has 3 miles of 30 mph design criteria including 10% grades, sharp curves, a narrow bridge, and associated hazards.

(i) <u>Plan 9</u>

(i) <u>Description</u>

This plan uses a combination of rail and truck. Construction of Devil Canyon dam would be served by rail from Gold Creek. Watana would be served by road from a rail head at Devil Canyon, across a low level crossing at Devil Canyon, and along the north side.

(ii) <u>Sea Ports</u>

Common to all plans are Anchorage and Whittier.

(iii) <u>Modal Split</u>

This plan requires a rail head at Devil Canyon. Materials would move from port to Devil Canyon via railroad, then be transfered to storage for Devil Canyon or to trucks for Watana. Movement of construction workers would be via a combination of rail passenger shuttle, bus shuttle and/or air.

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ACCESS PLAN #9

RAIL TO DEVIL CANYON
ROAD TO WATANA
DEVIL CANYON BRIDGE

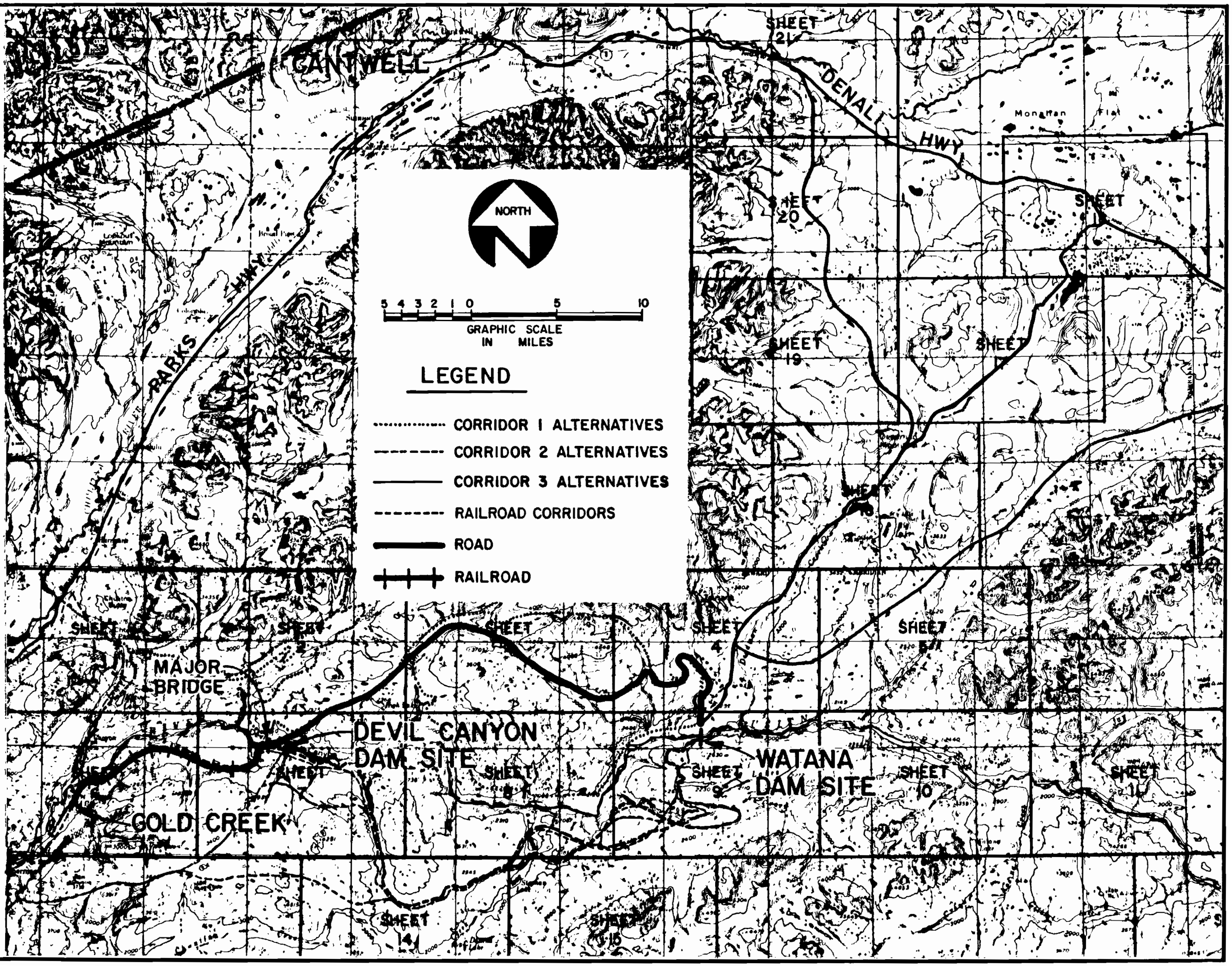

FIGURE 10.9

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Personnel transportation costs are not included in the estimates.

(iv) Sections Included

This plan includes Sections R-1, A-2, H (during construction) and D (after construction)

(v) Borrow Pits

Plan 9 may include borrow areas 1 through 5, 7 and 8, but it is unlikely that all areas will actually be developed.

(vi) Cost Estimates

The estimated cost of Plan 9 in 1982 dollars is outlined below:

Construction	95,101,441
Camp Facilities	9,601,689
Maintenance	4,128,000
Logistics	215,594,496
Total	$324,425,626

(vii) Advantages/Disadvantages

The advantages of this plan are:

- This plan essentially eliminates concern about the impact of public access to the project area.
- The segments involved encounter the apparent minimum of environmental conflicts.

- Second to lowest maintenance cost.

This disadvantages of this plan are:

- The first portion of the line must be built linearly, rather than in simultaneous sections.
- The road beyond Devil Canyon, while it can be built in a relatively short time, cannot be started until the railroad is completed, hence delaying resupply of Watana by one to two year.
- The need for rail/bus/air shuttles to bring personnel to both damsites.
- The substandard design criteria at the low level crossing of Devil Canyon, as described in Plan 8.

(j) Plan 10

(i) Description

This plan is similar to Plan 9 except that the road between Devil Canyon and Watana is on the south side. As with Plan 9, Devil Canyon is served by rail from Gold Creek to the damsite.

(ii) Sea Ports

Common to all plans are Anchorage and Whittier.

(iii) Modal Split

Materials for each dam would travel by rail to the rail head at Devil Canyon. Watana supplies would then travel by road along the south side to the damsite. As with Plan 9, a system of rail, bus and/or air shuttles will be needed to transport personnel, and this cost is not included in the estimate.

(iv) Sections Included

This plan includes Sections R-1 and B-3.

(v) Borrow Pits

This plan may utilize any or all of the following: borrow areas 1 through 6.

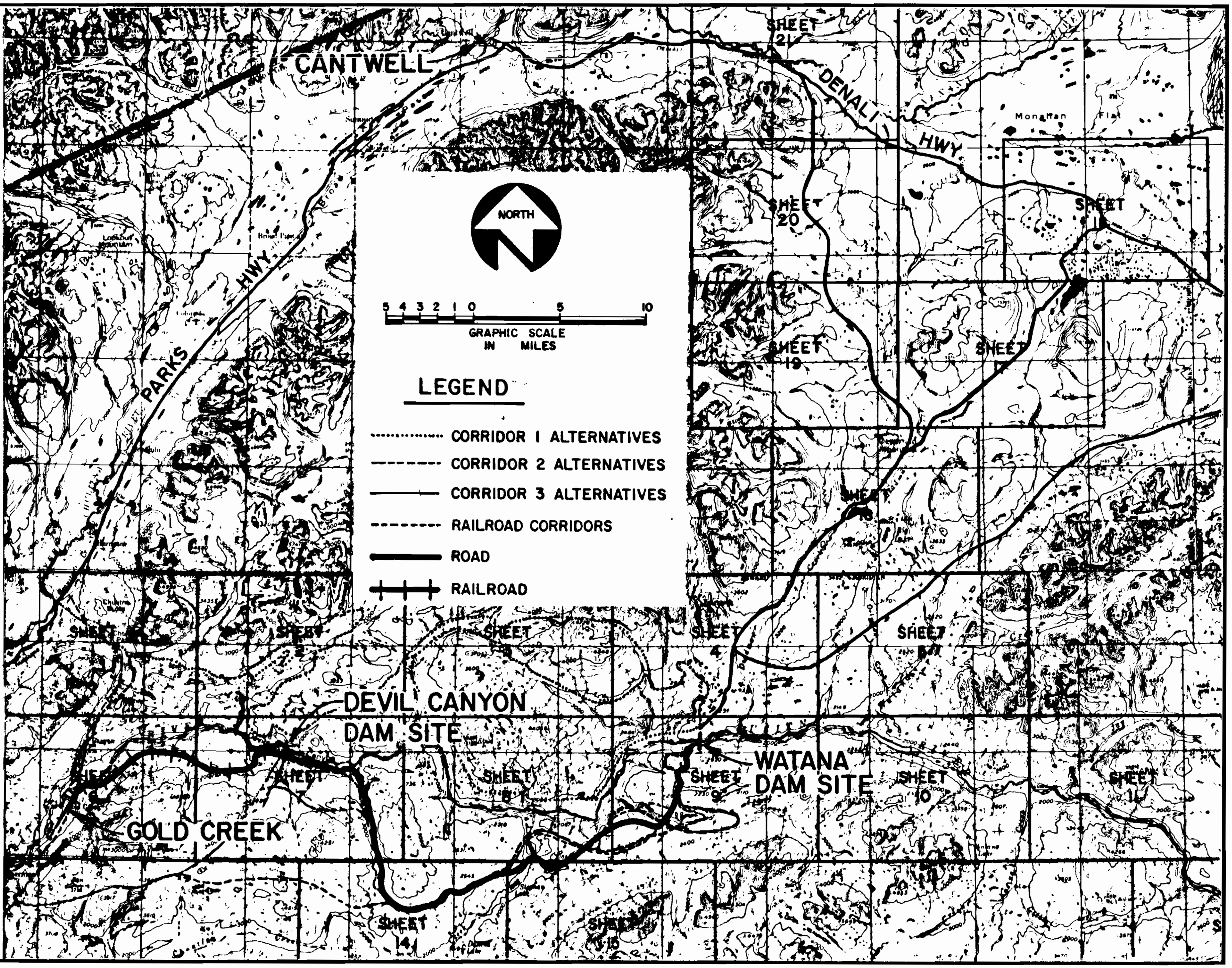
(vi) Cost Estimates

The estimated cost of this plan is outlined below:

Construction	$ 92,893,762
Camp Facilities	9,294,053
Maintenance	4,728,000
Logistics	214,461,201
Total	$321,377,016

(vii) Advantages/Disadvantages

- Second to lowest total cost
- This plan eliminates public access impact, but requires a system of shuttles for construction personnel.
- The scheduling constraints and environmental impact are as discussed in Plan 1. Construction of a major bridge at Cheechako Creek, heavy road work beyond, and a major bridge at Fog Creek combine to stretch the overall construction time to four years. Massive ice at



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ACCESS PLAN #10

RAIL TO DEVIL CANYON
ROAD TO WATANA

FIGURE 10.10

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Stephen Lake and environmental concerns at Stephan and Fog Lakes are also disadvantageous.

(k) Plan 11

(i) Description

This plan serves the entire project by road, from a rail head at Cantwell. Material is hauled to Watana via the Denali Highway, then to Devil Canyon along the north side.

(ii) Sea Ports

Common to all plans are Anchorage and Whittier.

(iii) Modal Split

Material would travel by rail to a rail head at Cantwell, then be transfered to trucks and driven to Watana. Material for Devil Canyon would continue along the north side to the damsite. Personnel access would be via private car.

(iv) Sections Included

This plan includes Sections A-2 and C.

(v) Borrow Pits

Plan 11 uses borrow areas 7 and 8.

(vi) Cost Estimates

The estimated cost of this plan is outlined below:

Construction	$108,260,024
Camp Facilities	10,821,920
Maintenance	10,661,000
Logistics	257,903,604
Total	$387,646,548

(vii) Advantages/Disadvantages

The advantages of this plan are:

- No time constraint, as the portion of the road to Watana can be completed in one year. The portion from Watana to Devil Canyon can be completed during construction of Watana.

- Personnel access via private vehicle.

- No major bridges.

- Lowest borrow quantity of the all road only plans (176,700 cy).

The disadvantages of this plan are:

- Longest haul of all plans, resulting in highest logistics cost and highest maintenance cost.

- Potential environmental impacts resulting from public access to additional portions of the Nelchina Caribou Range.

- Second to highest total cost

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ACCESS PLAN #11

ROAD VIA WATANA

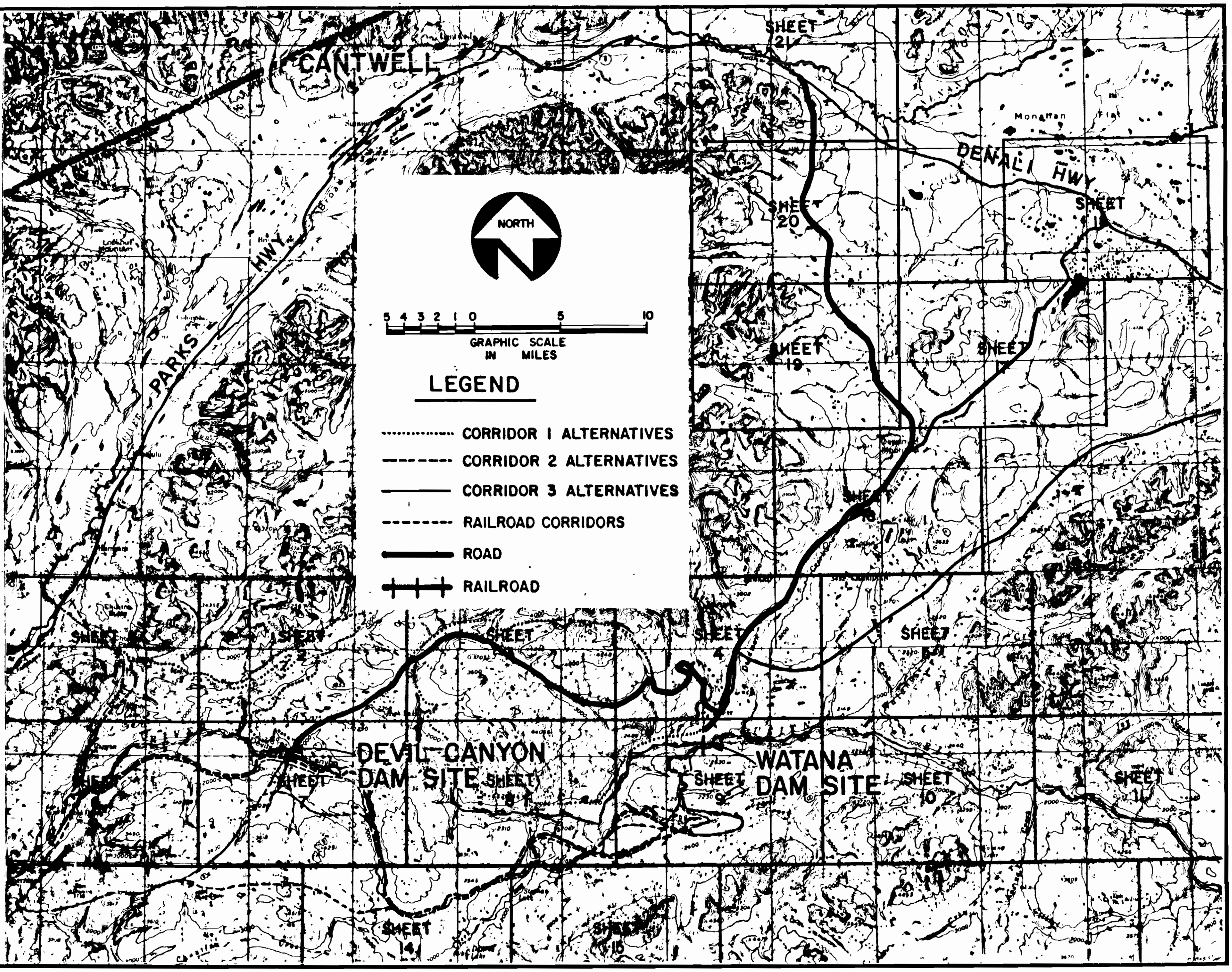

FIGURE 10.11

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CONCLUSIONS AND RECOMMENDATIONS

11 - Conclusions and Recommendations

No final conclusions or recommendations are made at this time. Additional input is required from other project team members before a final plan selection can be made.

APPENDIX A

PRELIMINARY DESIGN DEVELOPMENT

Appendix A - Preliminary Design Development

The Susitna Hydrolelectric project includes two large dams. These structures are located in remote wilderness however the size of the structures are such that major transportation facilities are required to serve the project and small communities are needed to house the construction crews.

In order to demonstrate the magnitude of the planned development plan views of the dams are included as are the projected construction schedules. Correspondence is included that identifies the major quantity requirements and crew requirements. This data has been used in the development and analysis of the various access plans.

August 20, 1981
P5700.11.10
T.1078

R&M Consultants Inc.
P.O. Box 6087
5024 Cordova Street
Anchorage, Alaska 99503

Attention: Mr. N. Gutcher

Dear Mr. Gutcher:

Susitna Hydroelectric Project
Estimate of Total Weights

As discussed with you on August 10, we have made an initial estimate of the total weights of various major items needed for construction of the Susitna development. These quantities should be used in completing the logistics portion of your access road report and are as follows:

	Watana	Devil Canyon
Installed Mechanical, Structural & Electrical Equipment	15,000 ton	13,500 ton
Construction Equipment	16,000 ton	5,000 ton
Explosives	20,000 ton	3,000 ton
Cement	350,000 ton	650,000 ton
Reinforcing Steel	33,000 ton	22,000 ton
Rock Bolts	12,500 ton	3,000 ton
Steel Support & Liners	3,600 ton	2,200 ton
Fuel	75 million gallons	17 million gallons

ACRES AMERICAN INCORPORATED
Consulting Engineers
The Liberty Bank Building, Main at Court
Buffalo, New York 14202

Telephone 716-853-7525   Telex 91-6423 ACRES BUF

Other Offices: Columbia, MD   Pittsburgh, PA   Raleigh, NC   Washington, DC

Please forward your completed report to us by September 15. If you have any questions or need further information please contact either Tom Gwozdek or myself at this office.

Sincerely,

Dennis Meilhede

D. Meilhede

DM/ljr

cc: J. Lawrence
J. Hayden
J. Gill
F. Toth

September 4, 1981
P5700.11.10
T.1132

R&M Consultants
P.O. Box 6037
5024 Cordova Street
Anchorage, AK 99503

Attention: Mr. N. Gutcher

Dear Mr. Gutcher:

Susitna Hydroelectric Project
Project Schedule

As you requested, enclosed please find the following:

1. Preliminary Schedule Watana - July 1981
2. Preliminary Schedule Devil Canyon - July 1981
3. Most Recent Layout-Watana (reduced Dylar)
4. Most Recent Layout-Devil Canyon (reduced Dylar)

As we discussed, these items reflect the present level of development of the Susitna Project and can be used in completion of your access road logistics study. Finalized layouts and schedules are, of course, impossible to provide at this time. Similarly, our present estimate for peak camp size is 4,500 units at Watana and 3,100 units at Devil Canyon.

If you have any further questions, please call.

Sincerely,

Dennis Meilhede

Dennis Meilhede

DM:db

Enclosures

cc: J. Lawrence
J. Hayden
T. Gwozdek

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The Liberty Bank Building, Main at Court
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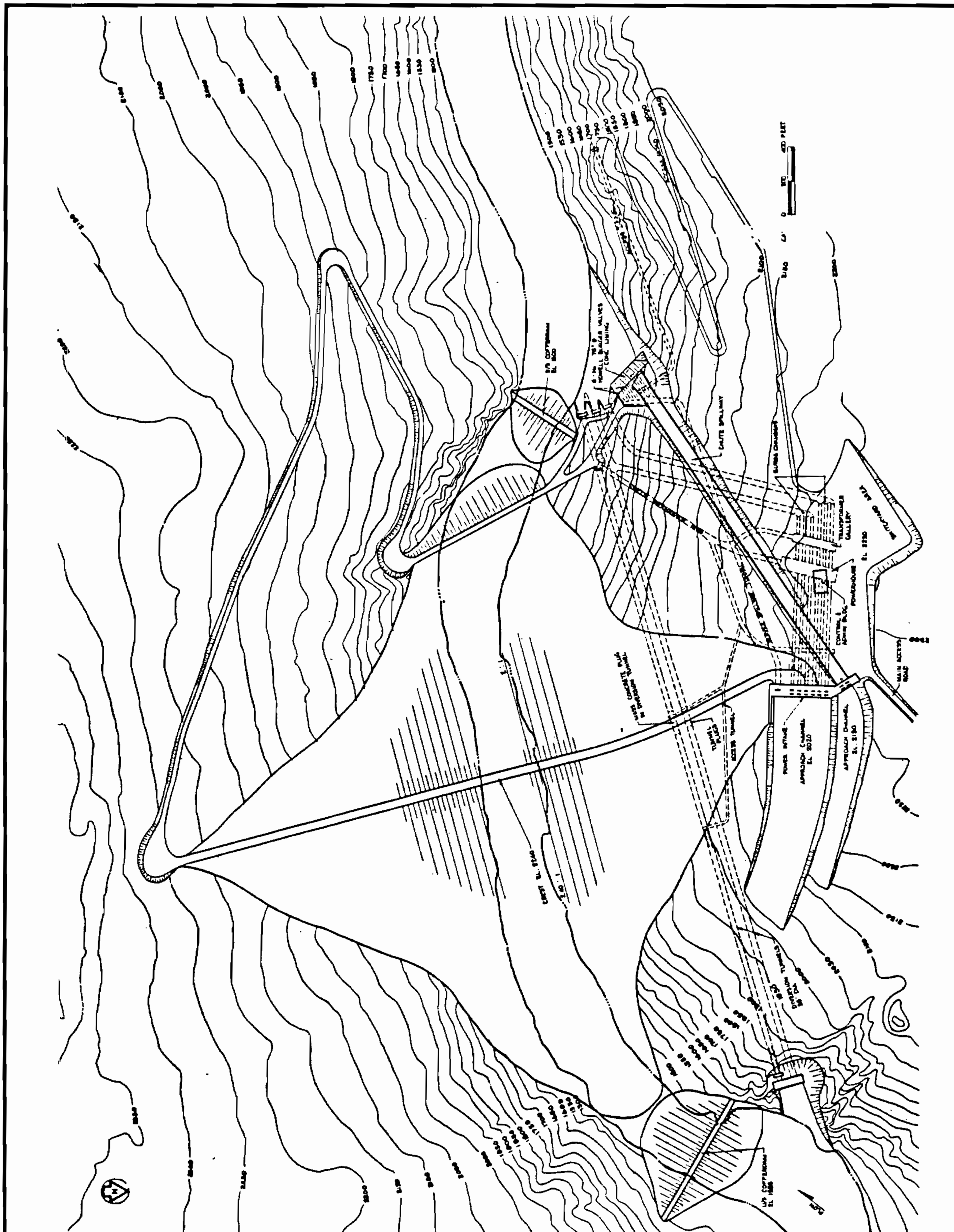

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WATANA DAM PLAN

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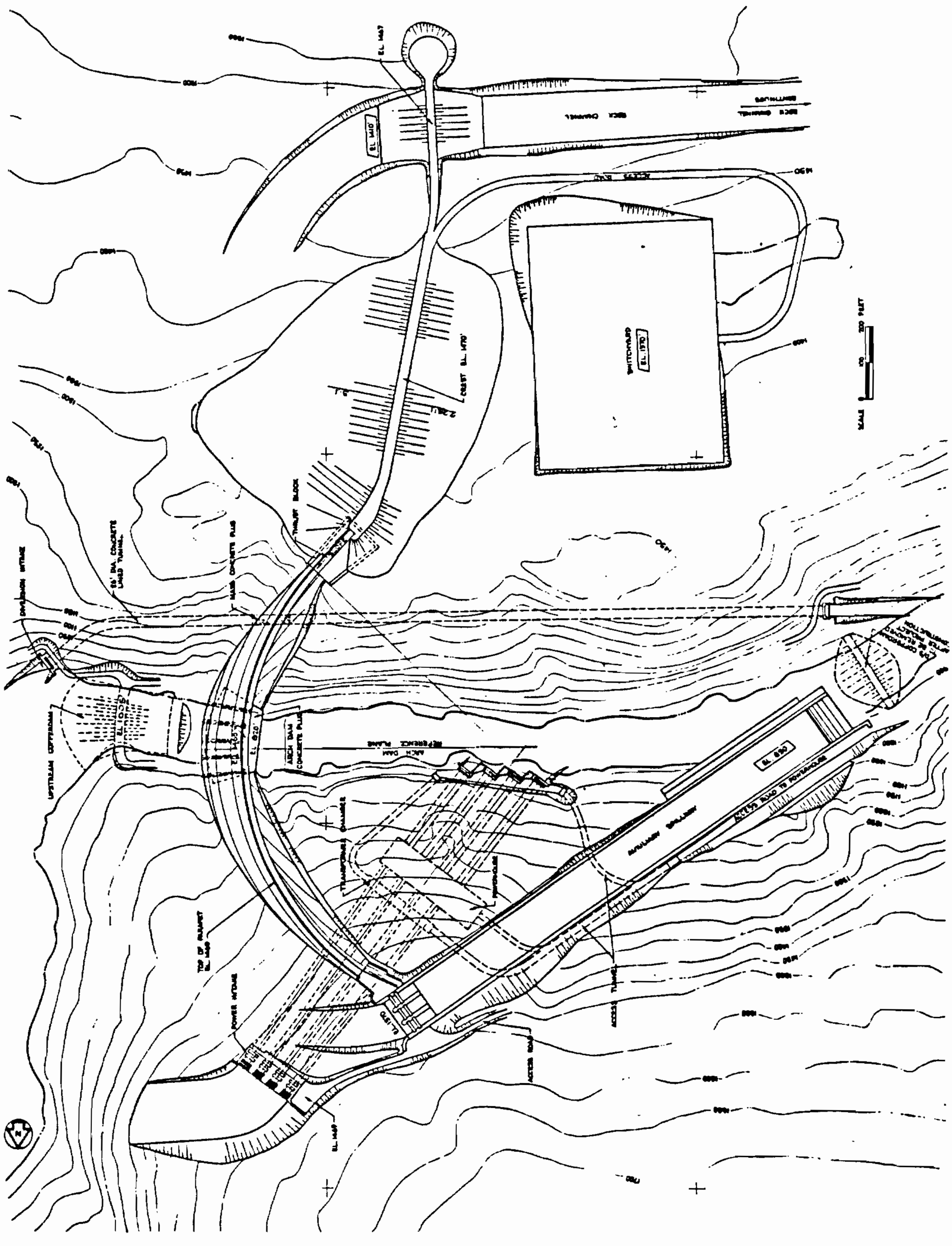
FIGURE A.1



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DEVIL CANYON DAM PLAN

FIGURE A.2

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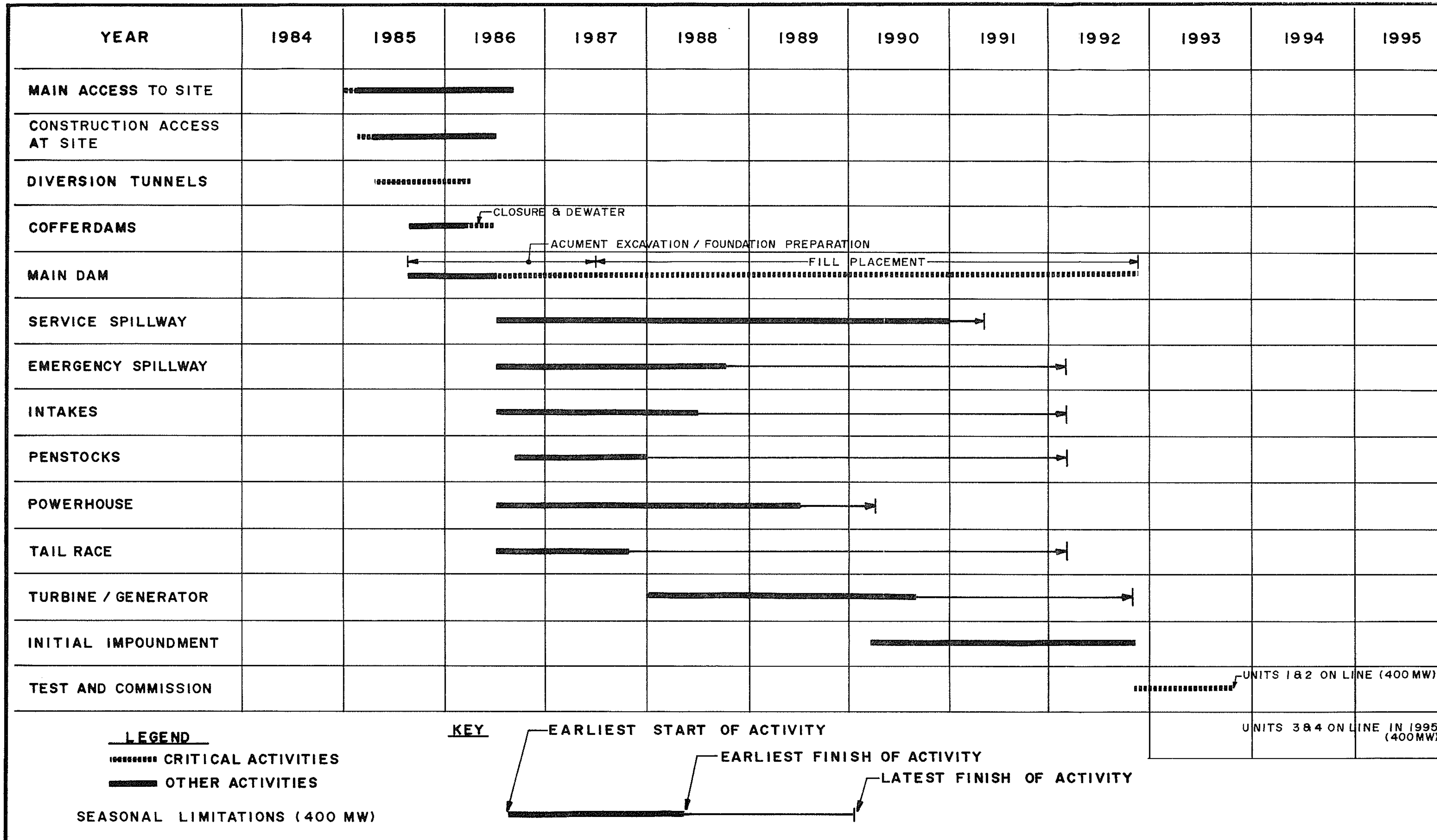

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PRELIMINARY WATANA SCHEDULE

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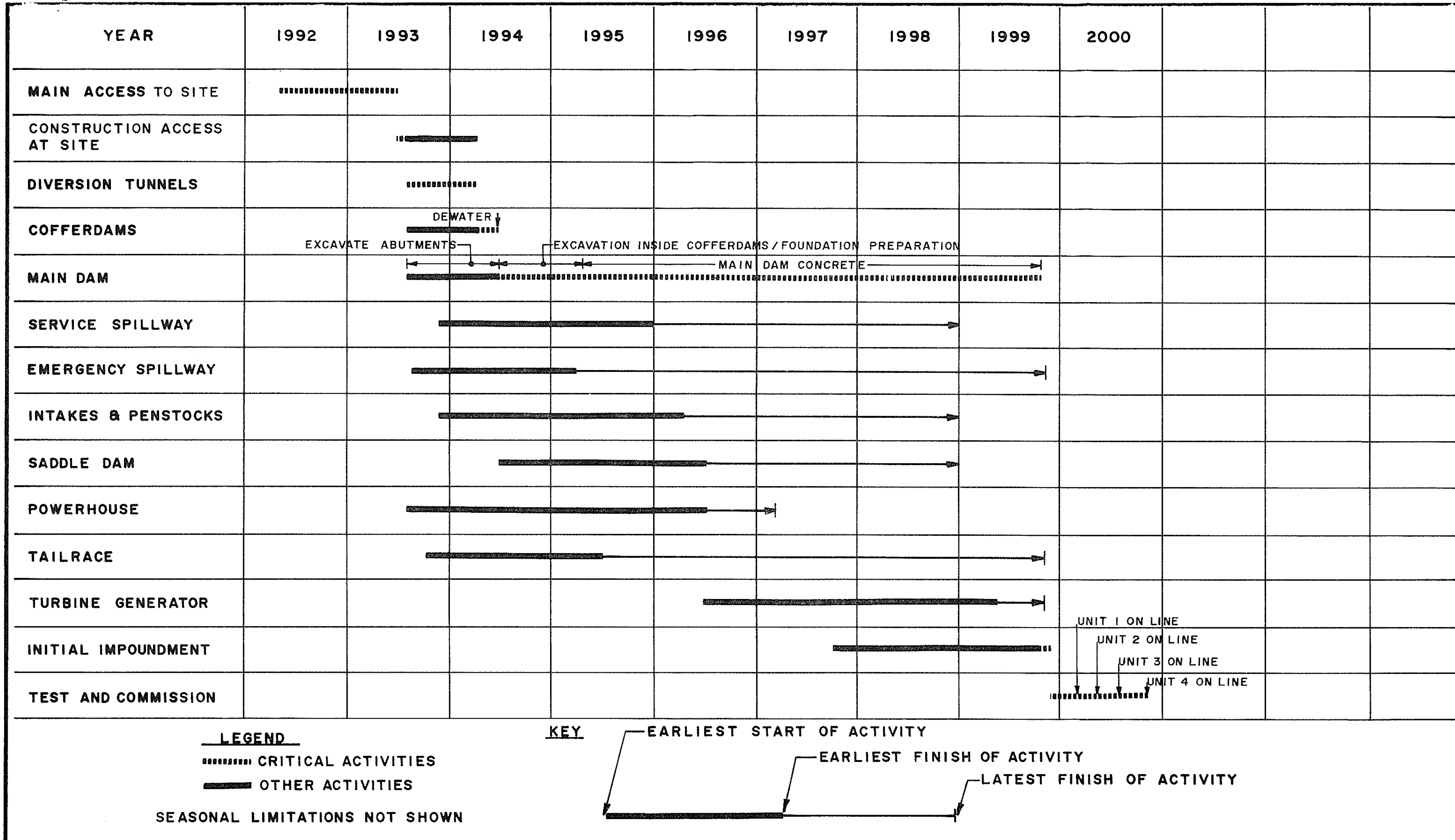
FIGURE A.3



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PRELIMINARY DEVIL CANYON SCHEDULE

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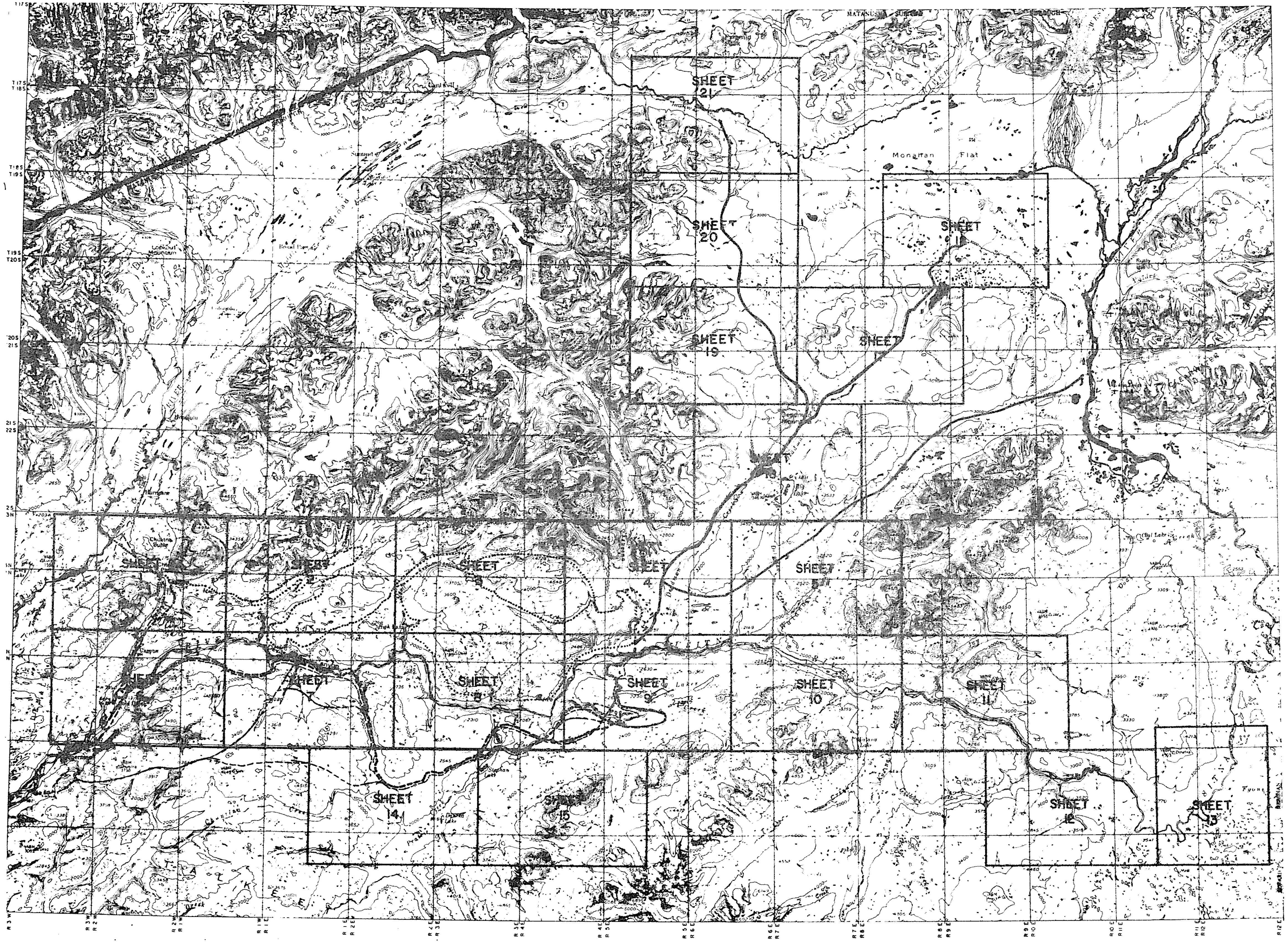
FIGURE A.4

APPENDIX B

PROPOSED ALTERNATIVES SEGMENTS

Appendix B Proposed Alternative Segements

Appendix B consist of a set of map showing each of the alternatives alignment segments studied during the course of the work.



NORTH

5 4 3 2 1 0 5 10

GRAPHIC SCALE IN MILES

LEGEND

....	CORRIDOR 1 ALTERNATIVES
– – – – – –	CORRIDOR 2 ALTERNATIVES
————	CORRIDOR 3 ALTERNATIVES
– – – – – –	RAILROAD CORRIDOR

NOTE

SHEETS NO.: 5, 10, 11, 12, & 13 ARE OMITTED. NO ACCESS CORRIDORS ARE CONTAINED THEREIN.

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ACCESS CORRIDORS INDEX MAP

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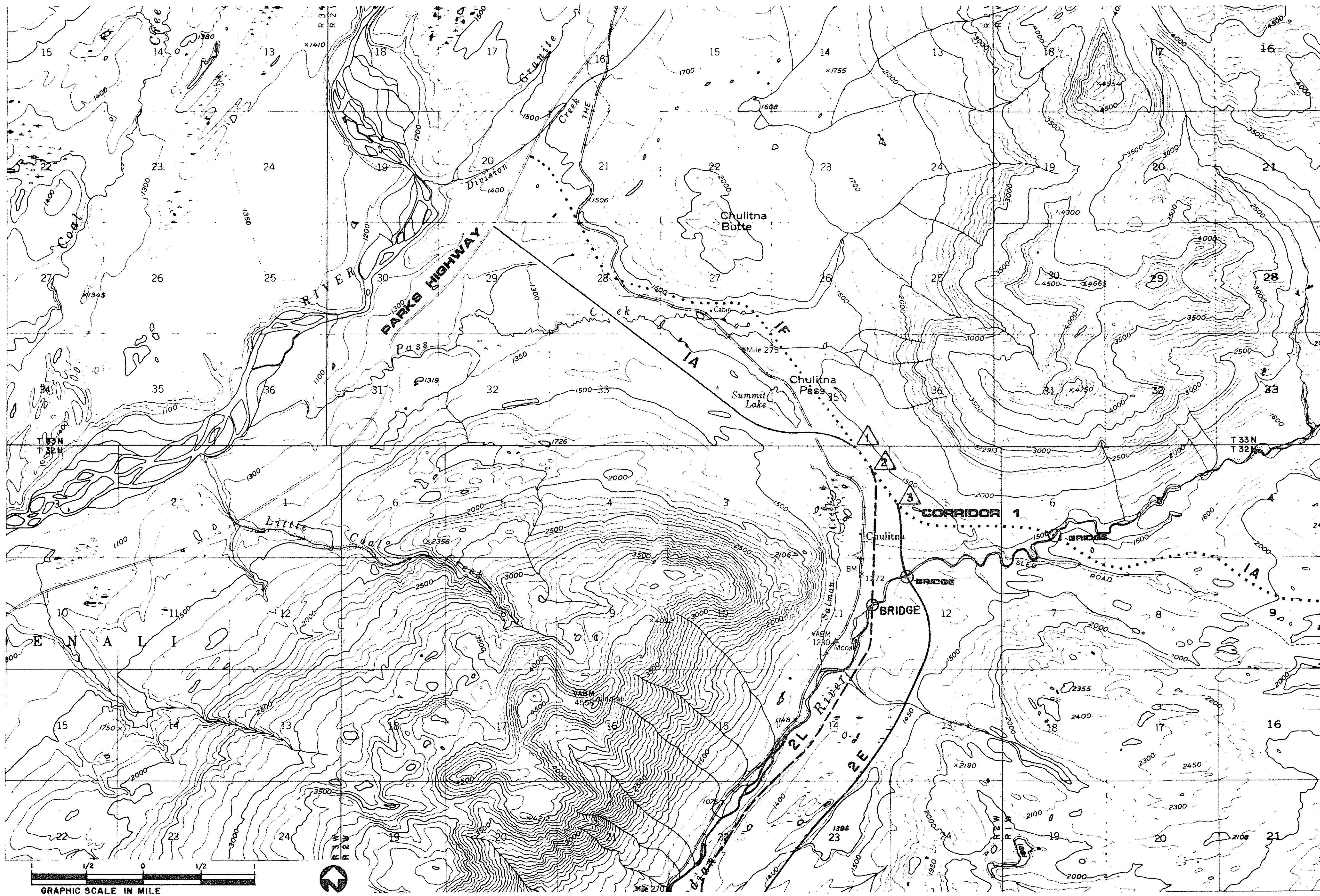
FIGURE B.0



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ACCESS CORRIDOR ALIGNMENTS

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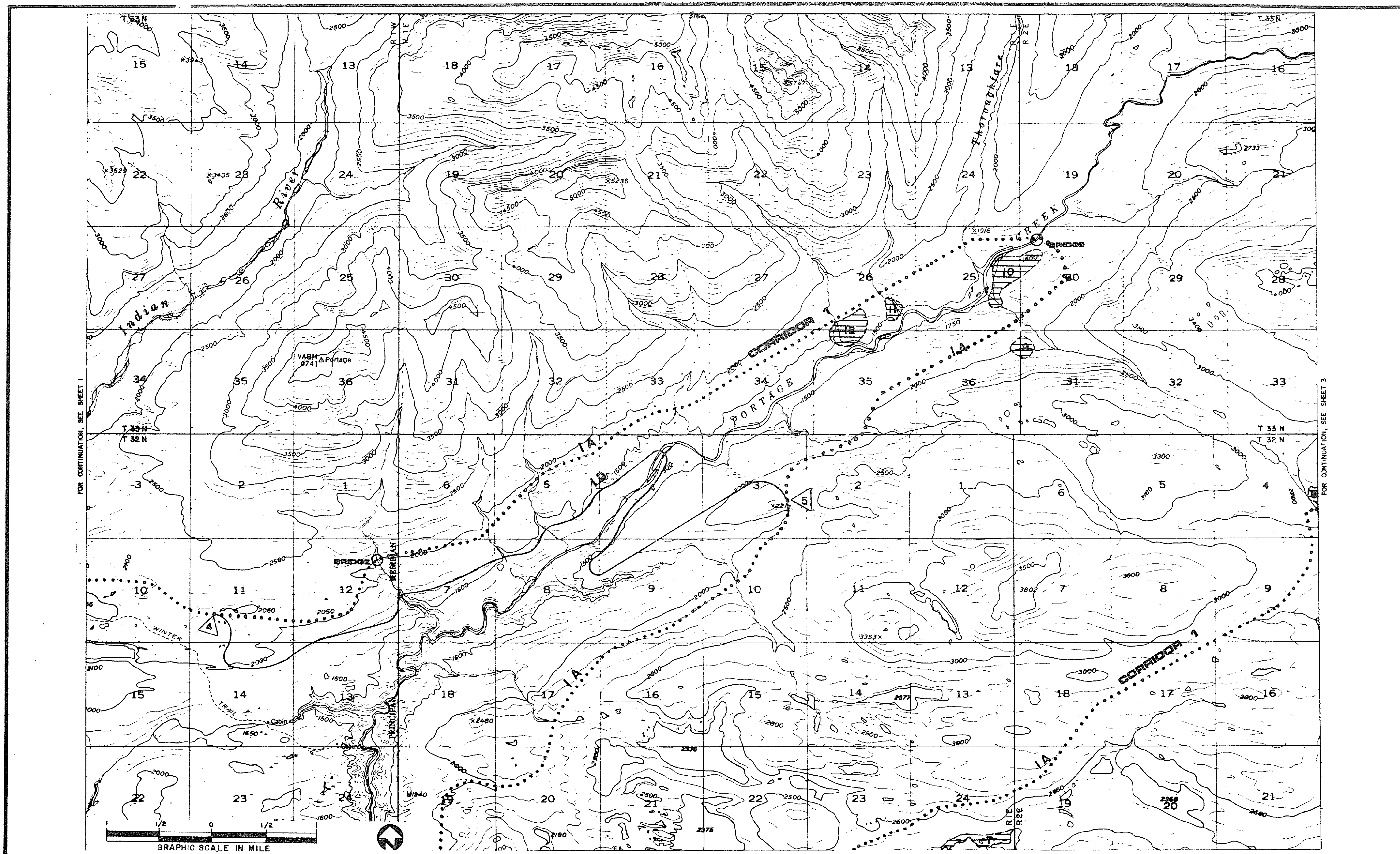
FIGURE B.1



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ACCESS CORRIDOR ALIGNMENTS

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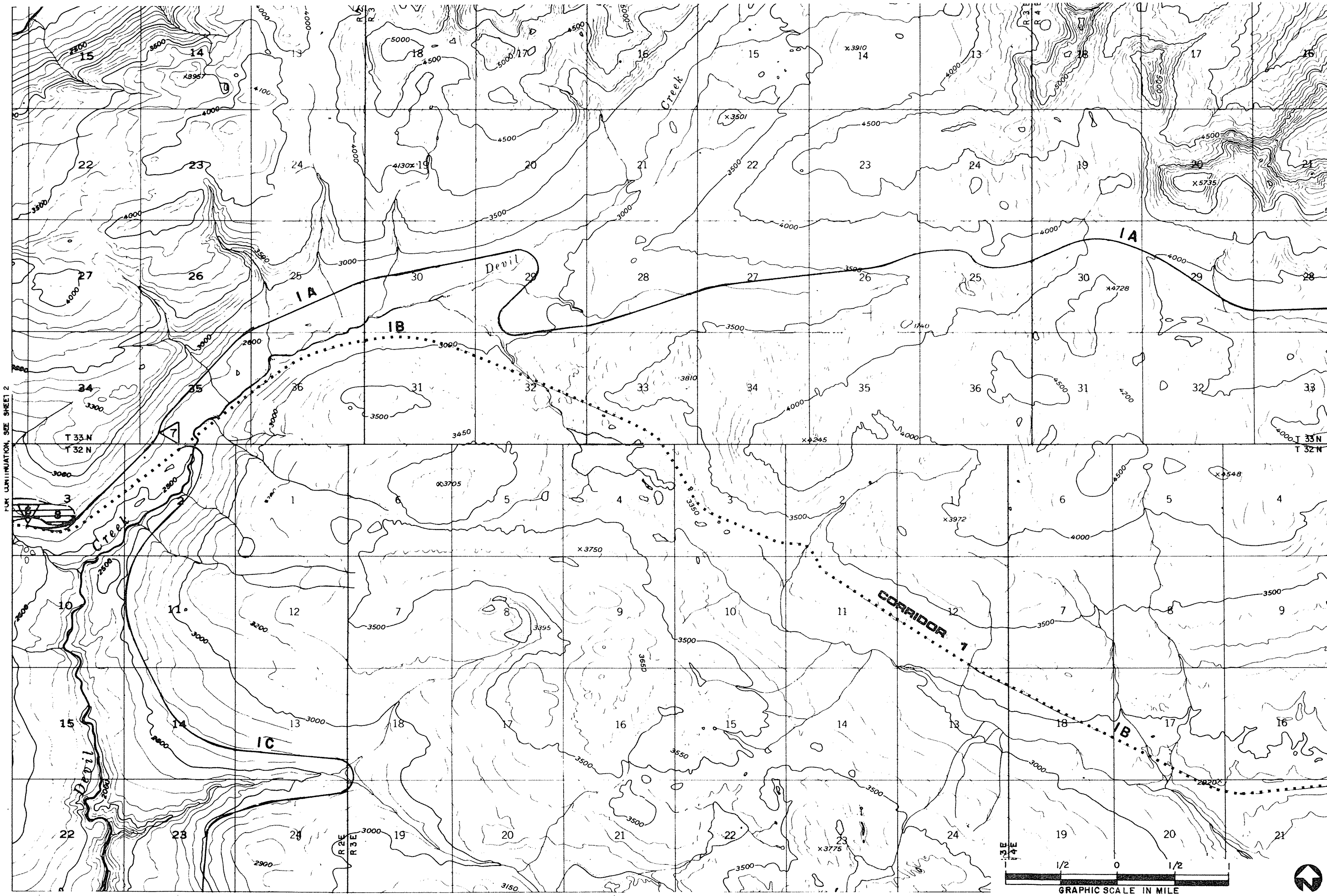
FIGURE B.2



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ACCESS CORRIDORS ALIGNMENTS

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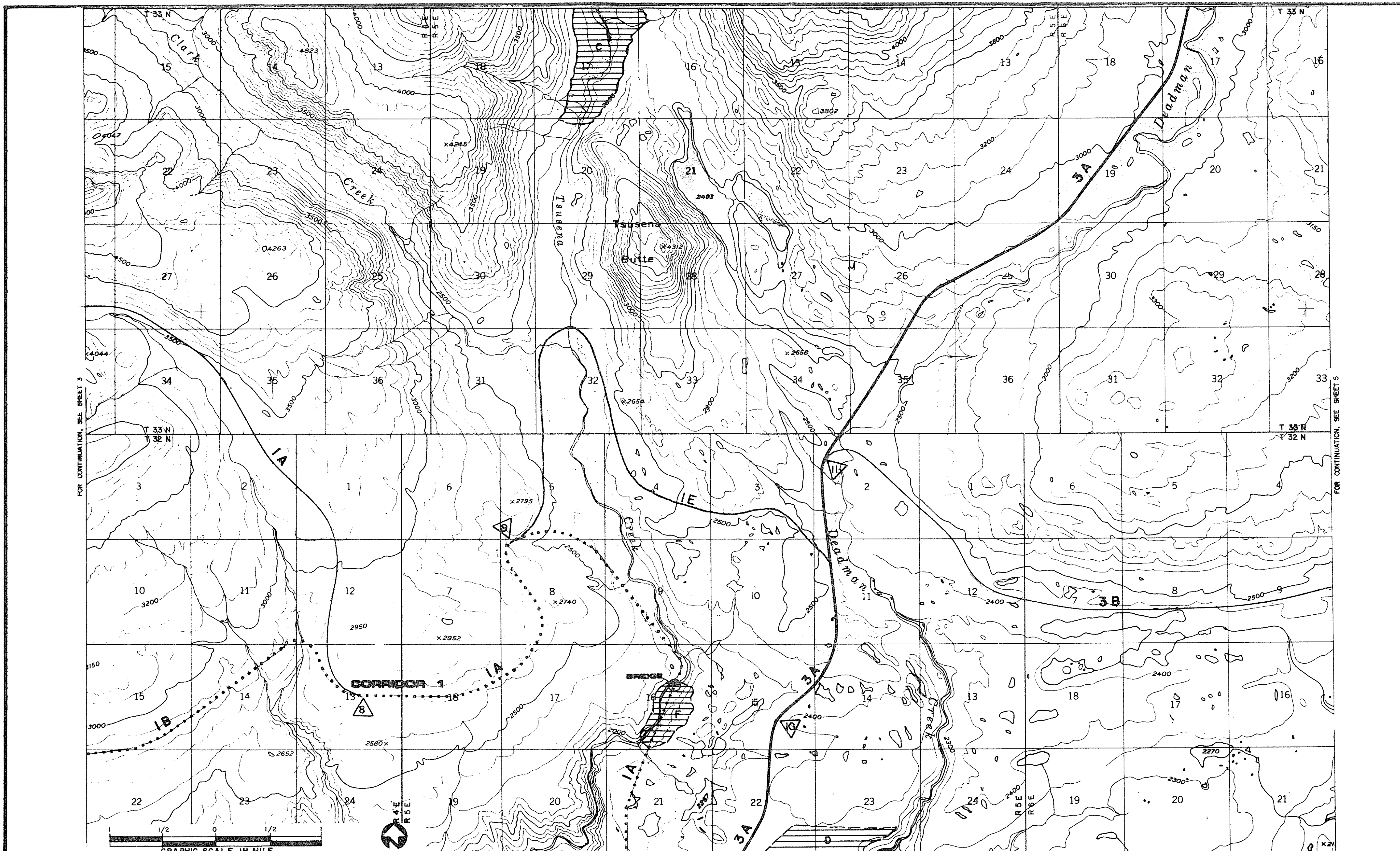
FIGURE B.3



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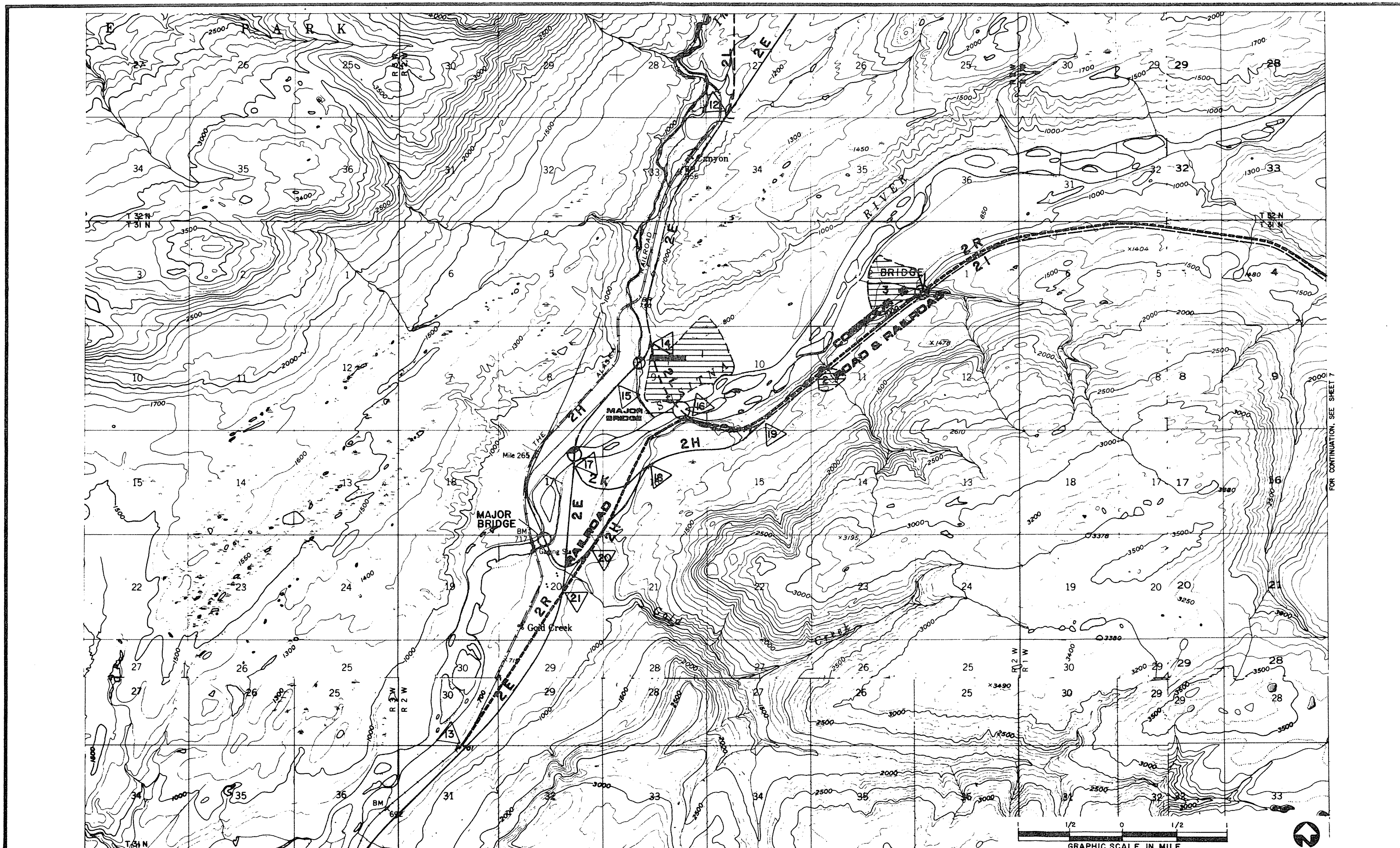
ACCESS CORRIDORS ALIGNMENTS

FIGURE B.4



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ACCESS CORRIDORS ALIGNMENTS

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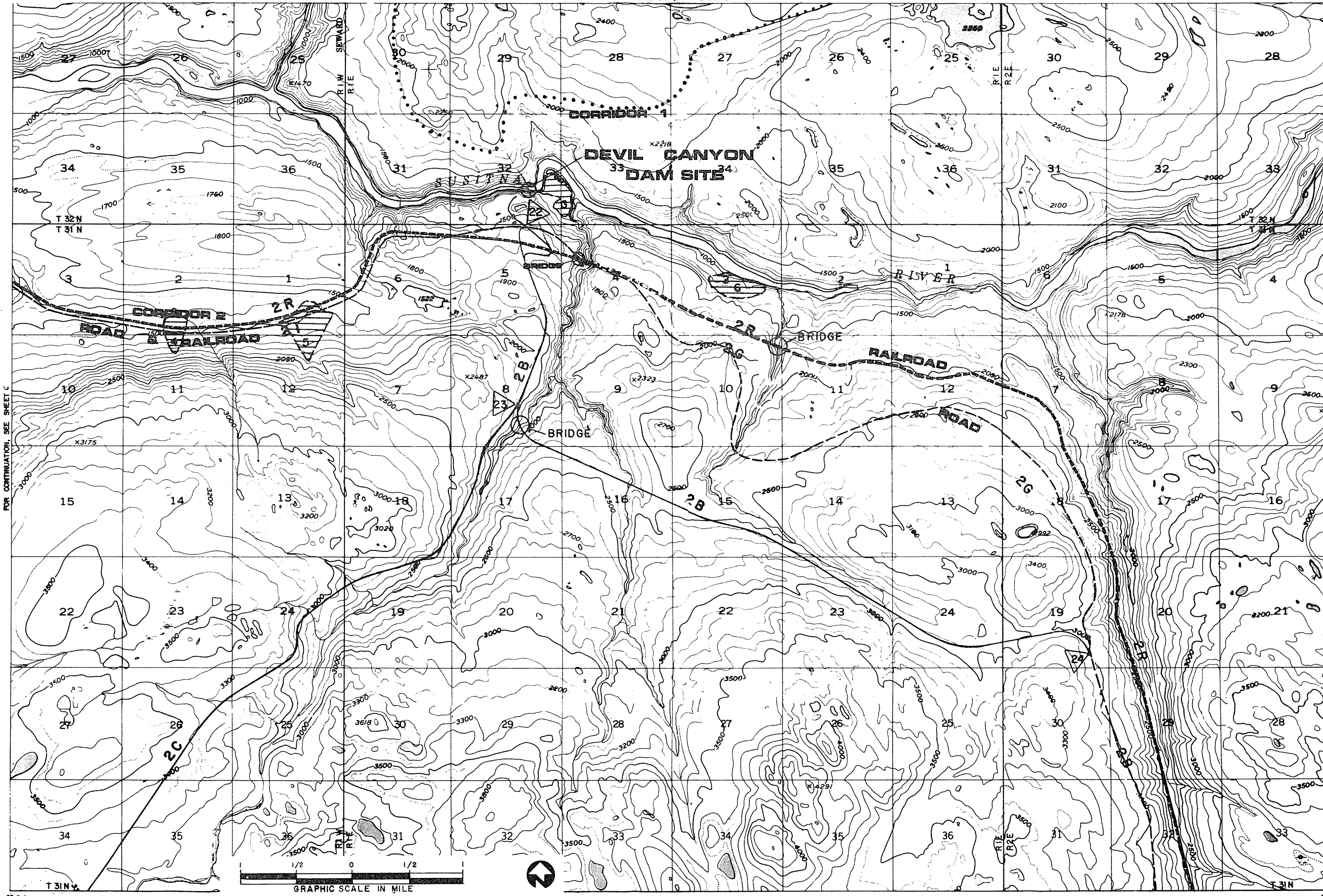
FIGURE B.6

FOR CONTINUATION, SEE SHEET 2



FOR CONTINUATION, SEE SHEET 6
FOR CONTINUATION, SEE SHEET 8

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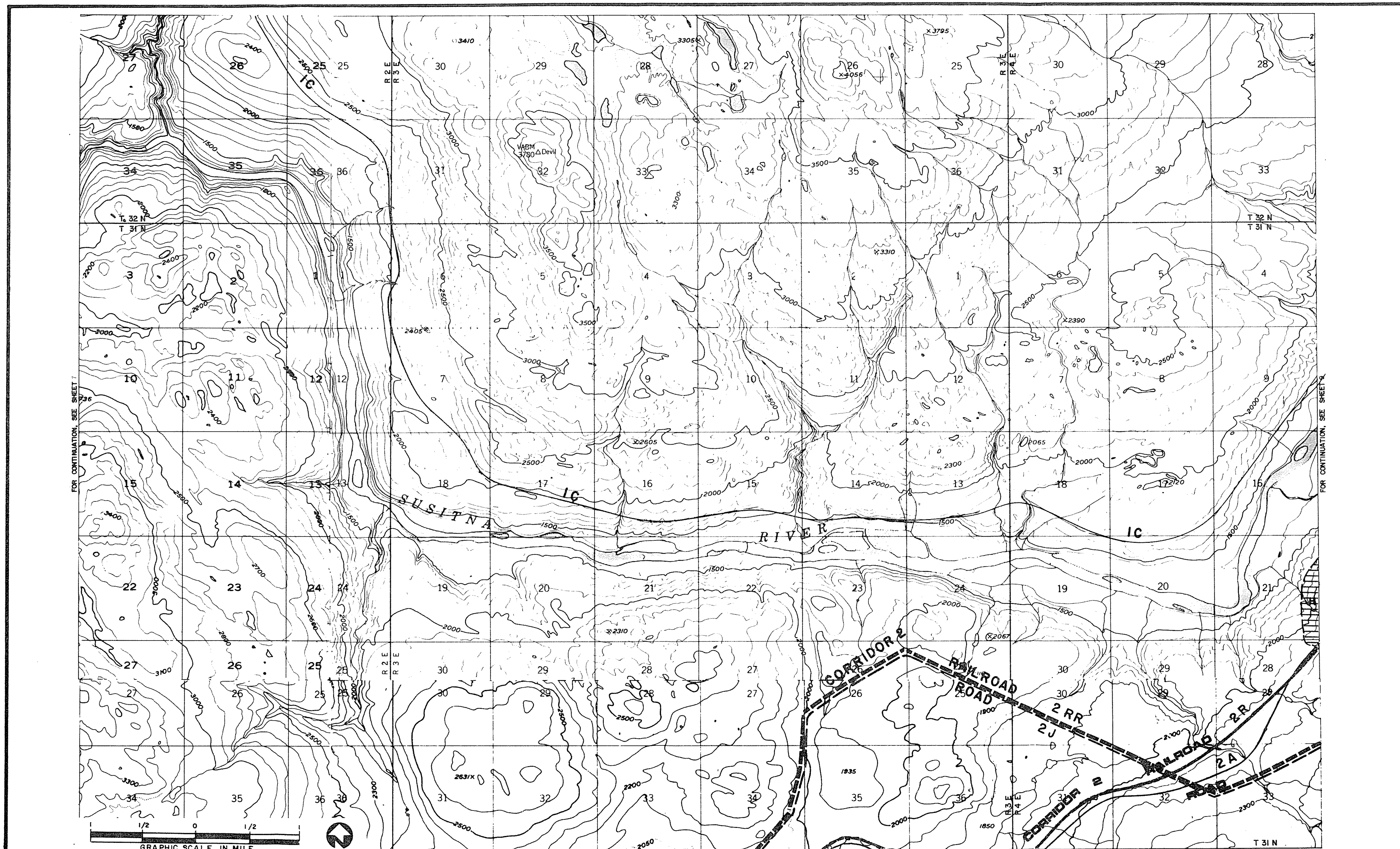
FIGURE B.7



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ACCESS CORRIDORS ALIGNMENTS

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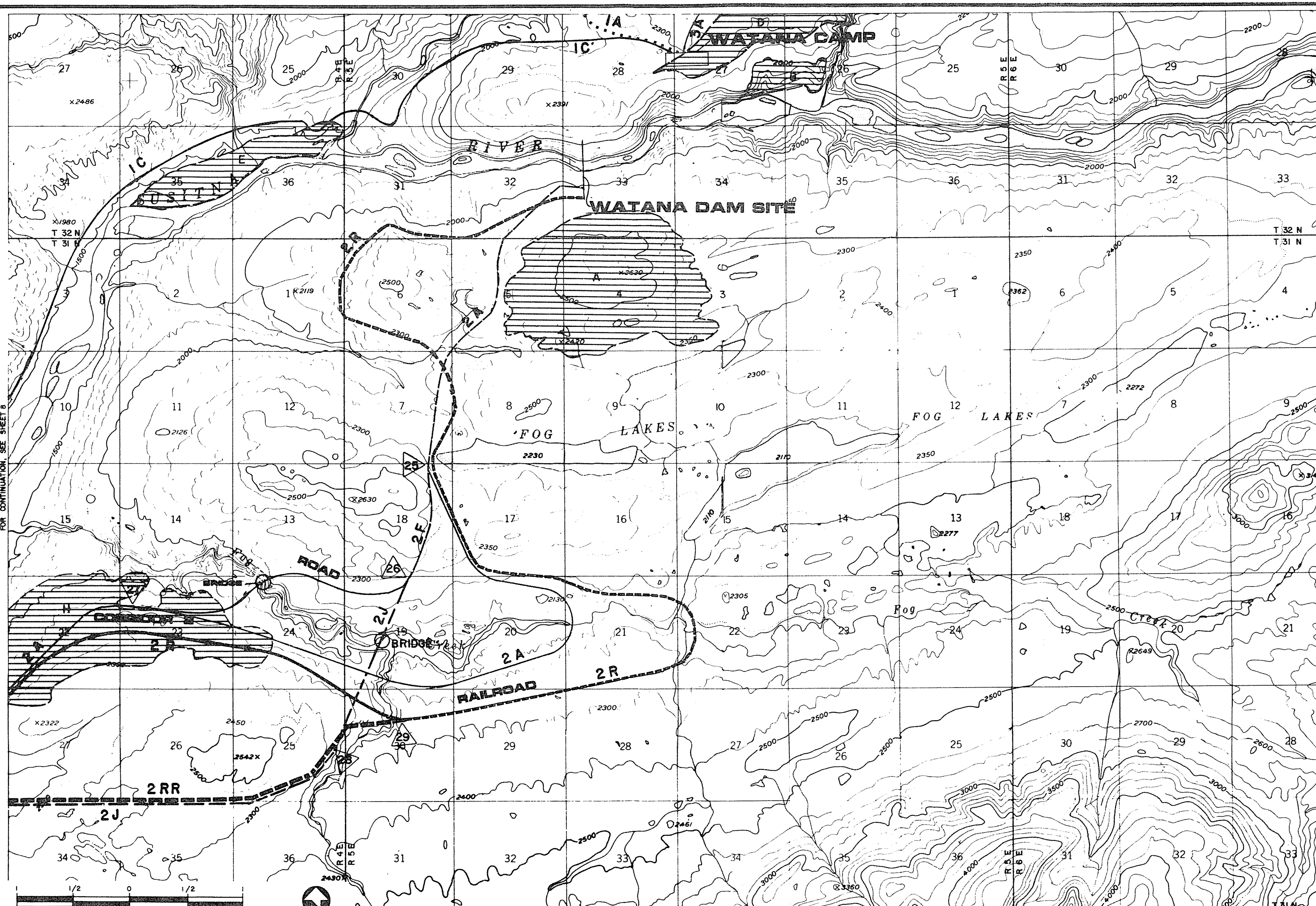
FIGURE B.8



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ACCESS CORRIDORS ALIGNMENTS

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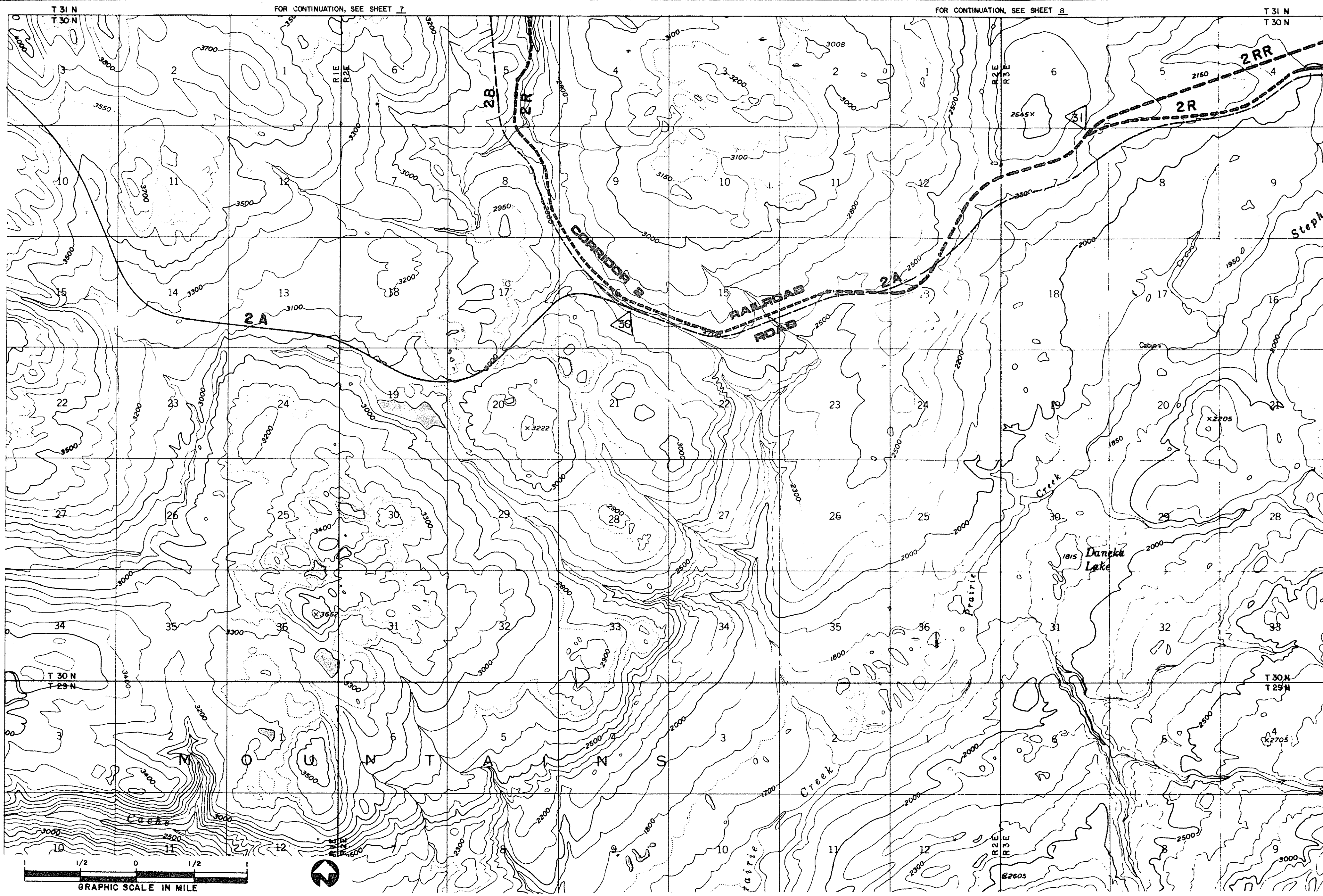
FIGURE B.9



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ACCESS CORRIDORS ALIGNMENTS

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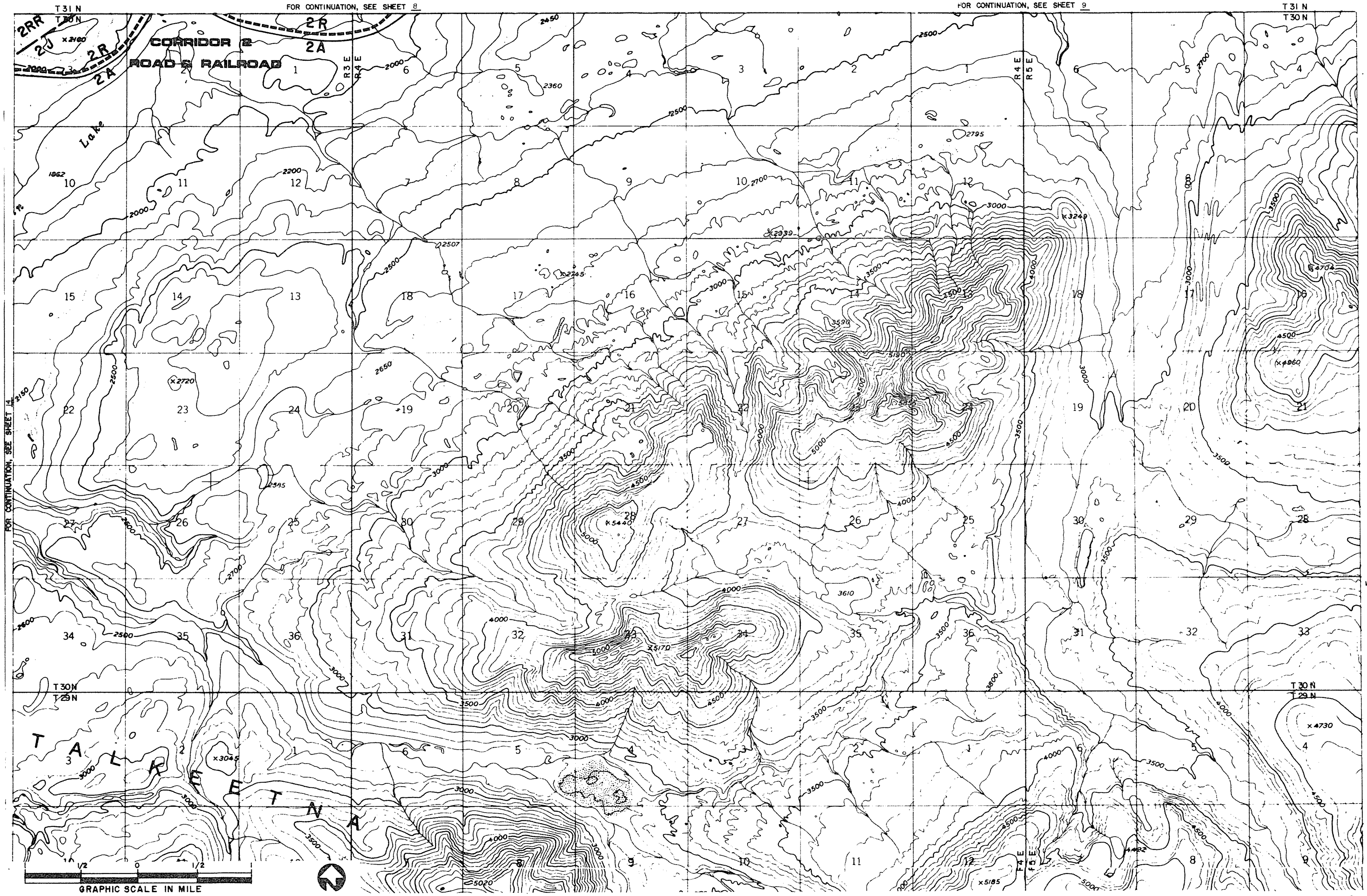
FIGURE B.14



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ACCESS CORRIDORS ALIGNMENTS

FIGURE B.15

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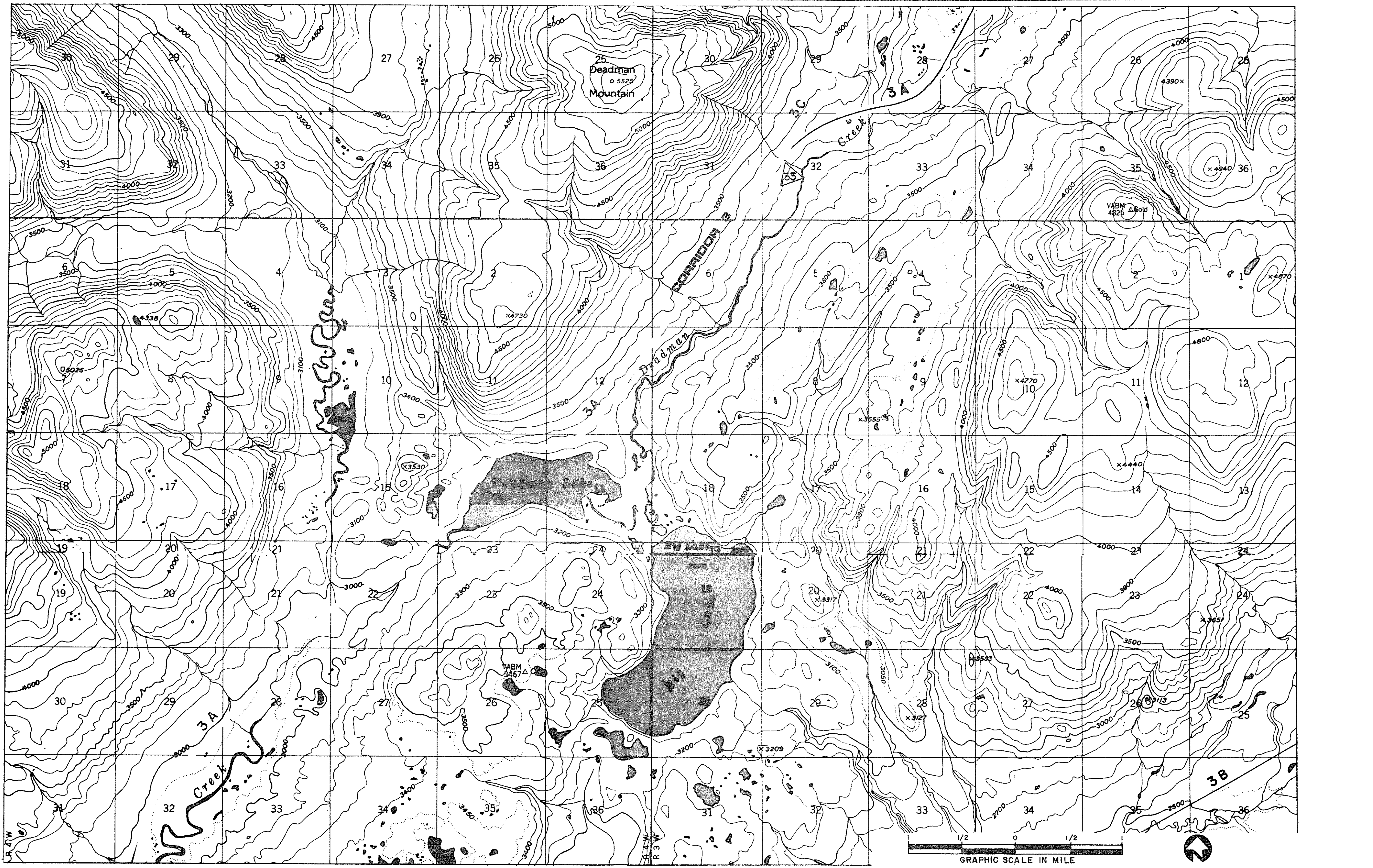

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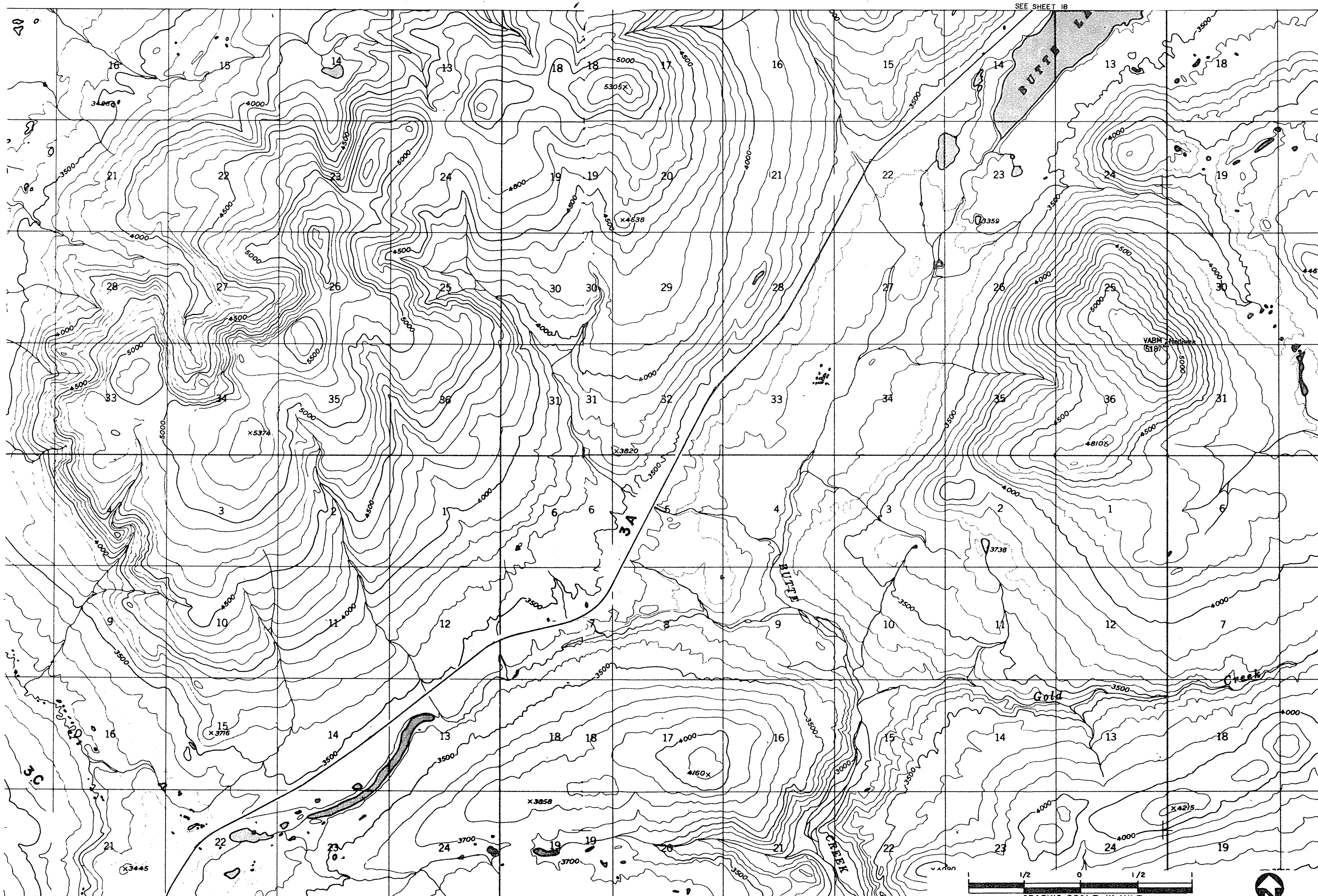
ACRES

ACCESS CORRIDORS ALIGNMENTS

FIGURE B.16



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PREPARED FOR:

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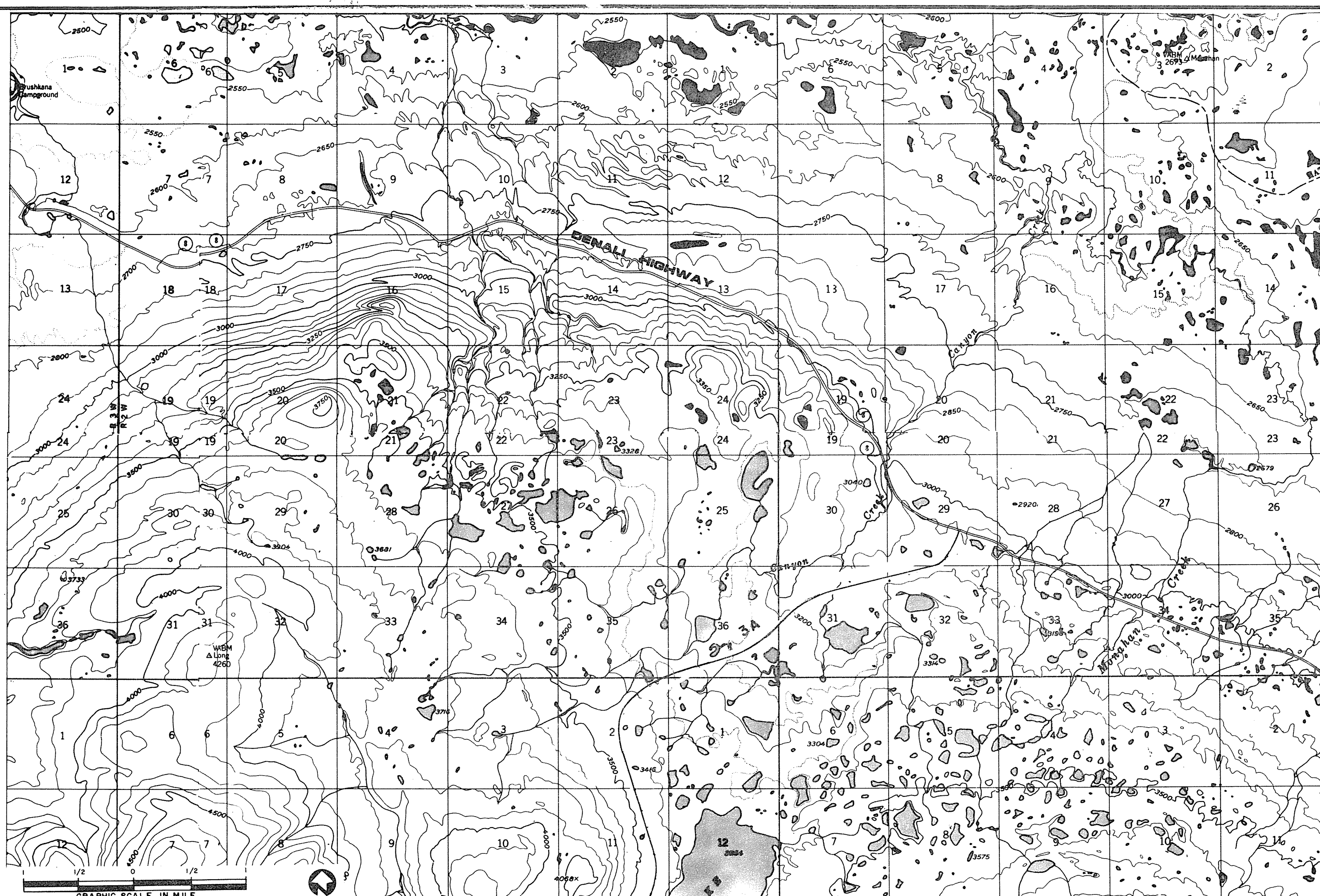
FIGURE B.17



SEE SHEET 17

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ACCESS CORRIDORS ALIGNMENTS

PREPARED FOR:

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FIGURE B.18

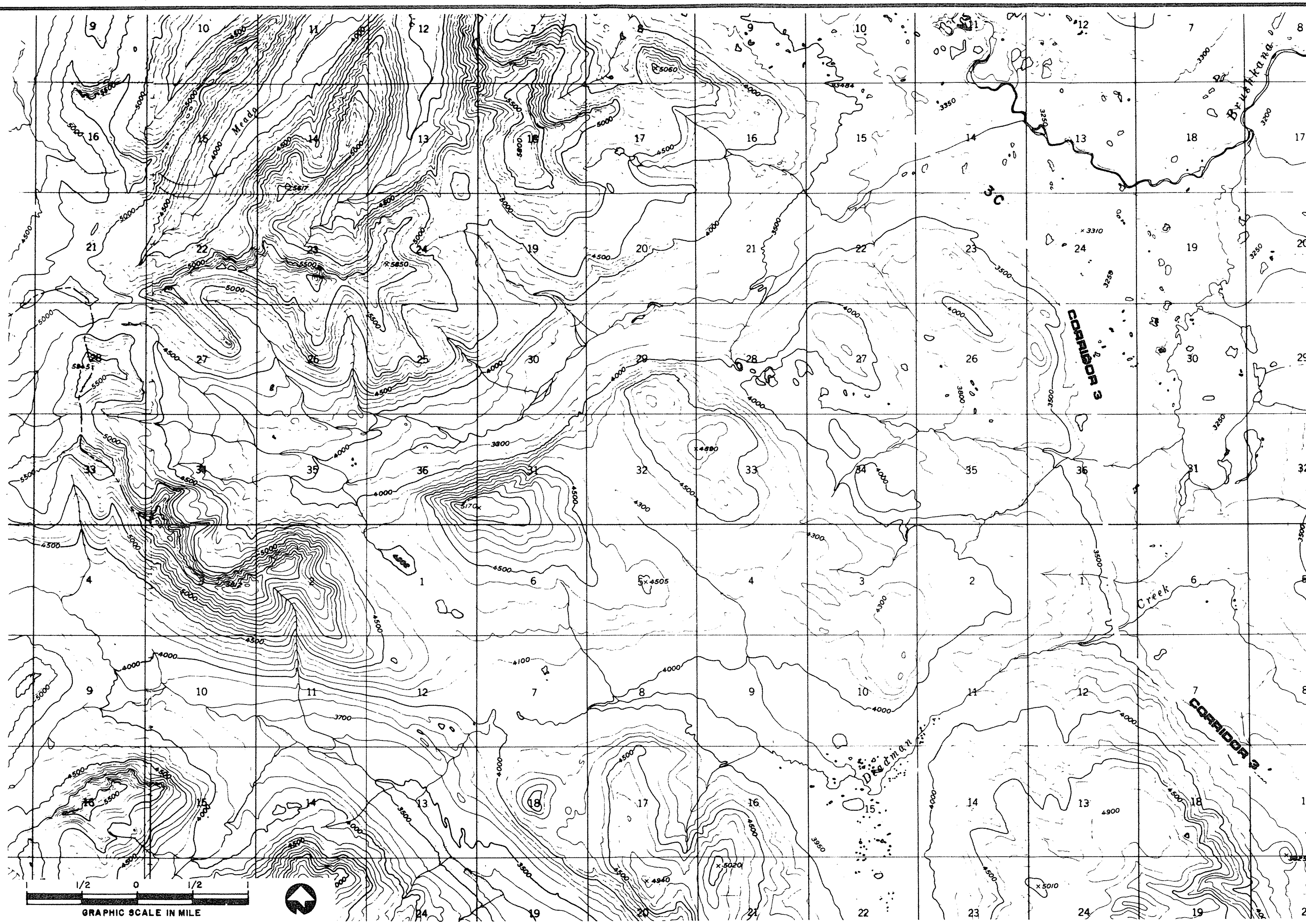

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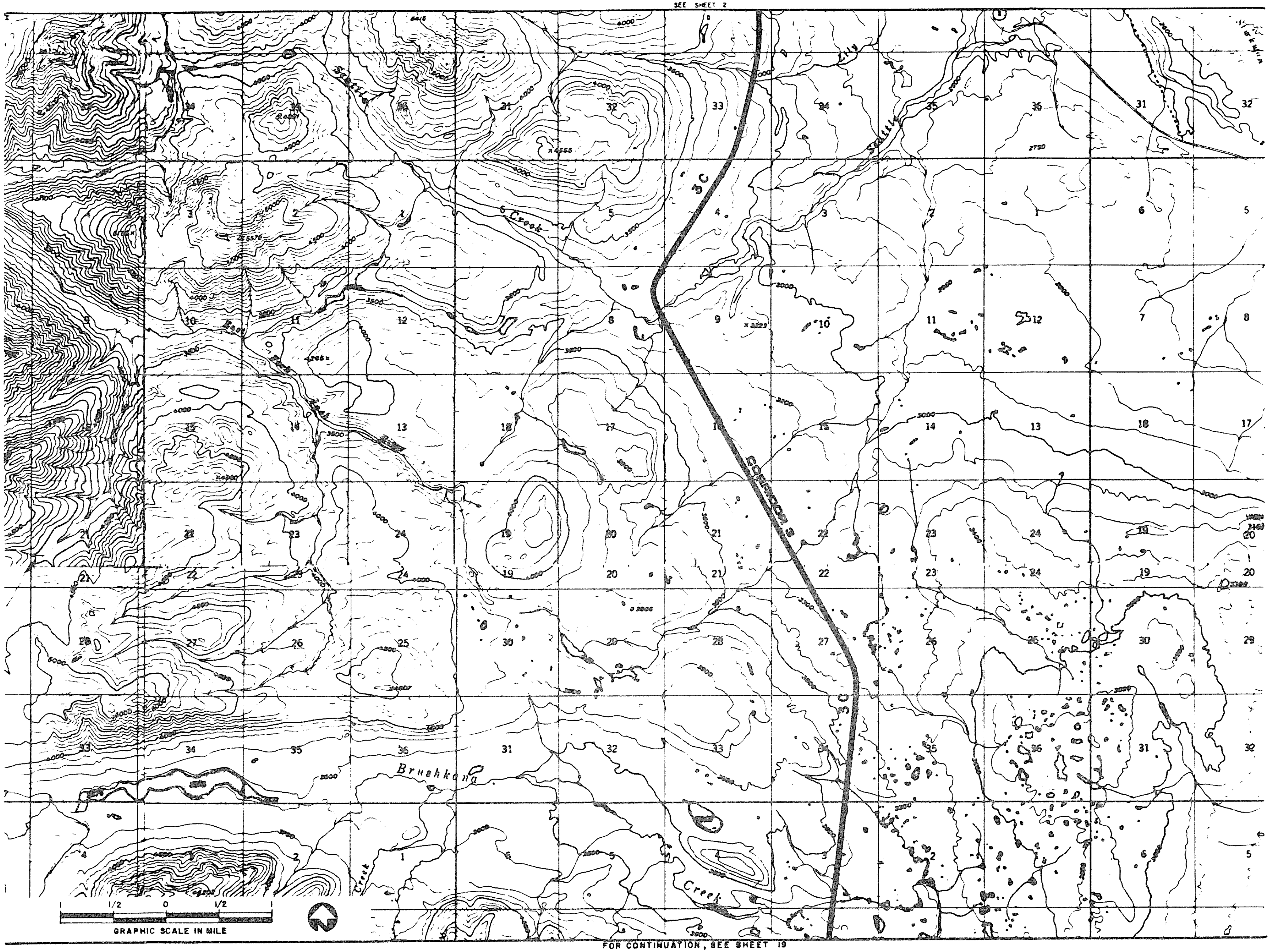
FIGURE B.19



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ACCESS CORRIDORS ALIGNMENTS

FIGURE B-20

ACRES

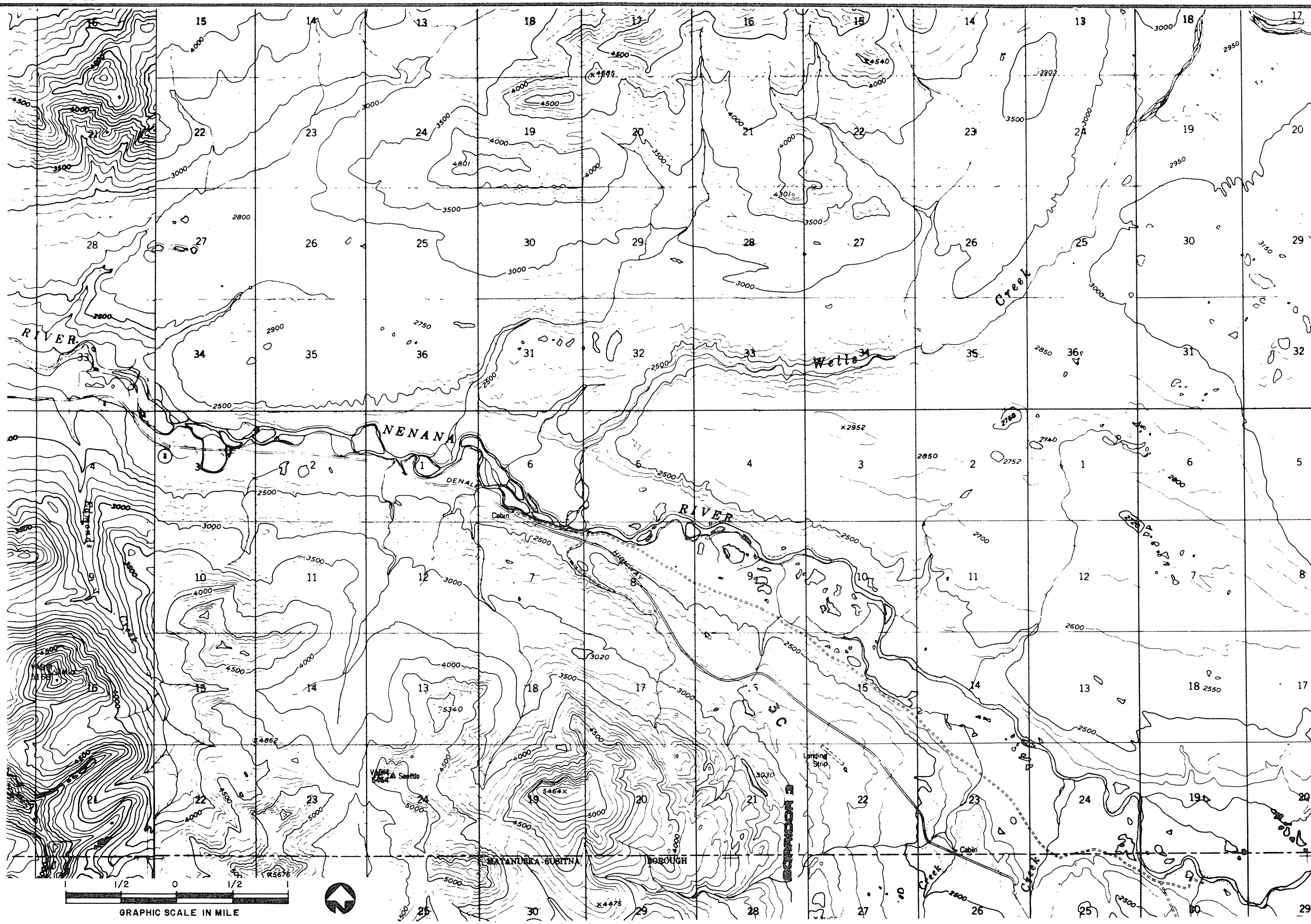

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FIGURE B.21

APPENDIX C

ALTERNATIVE COMPARISON

APPENDIX C
COMPARISON OF ALTERNATIVE SEGMENTS
GRADE, CURVATURE AND DISTANCE

Appendix C lists the length, average grade and sum of defection angles for each segment studied and each potential combination of segments. This tabulation was used to select the combination that make up the prefered alignment within each corridor. Several segments studied have been omitted due to grade, curvature or environmental limitations. The reason for the exclusion of a segment can be found in the text discussion of that segment.

TABLE C.1
SUMMARY OF SEGMENTS USED

Segment	Limits
1-A	All but Chulitna Pass (Parks Hwy to node 1)
1-B	All
1-E	All
1-F	All
2-A	From junction with 2-B (node 30) to Watana
2-B	From south junction with 2-G (node 21) to junction with 2-A (node 30)
2-E	From Gold Creek railhead north to 2-H (node 20)
2-F	From 2J (node 26) to 2A (node 25)
2-G	All
2-H	From 2-E (node 20) to 2-I (node 19)
2-I	All
2-J	All
2-L	All
2-M	All - Pioneer Road only
2-P	All - only after Devil Canyon Dam is built
2-R	All
2-RR	All
3-A	All
3-B	All
3-C	All
4-A	Existing Denali Highway: Cantwell siding to north end of 3-A
4-B	Existing Denali Highway: Cantwell siding to north end of 3-B
4-C	Existing Denali Highway: Cantwell siding to north end of 3-C

TABLE C.2

SUMMARY OF ALIGNMENT PARAMETERS

Segment	Nodes	Distance Miles	Average Grade %	Sum of Defl. Angles
1-A	1-2	0.3	0%	0°
	2-Devil	25.3	2.88	2034°
	Devil-6	9.5	2.40	1139°
	6-8	18.9	2.49	1223°
	8-9	2.6	1.89	460°
	9-Watana	3.9	3.28	354°
1-B	6-8	16.2	1.91	707°
1-E	All	7.5	1.96	436°
1-F	All	4.1	1.85	204°
2-A	30-31	7.6	1.60	297°
	31-25	16.3	1.16	779°
	25-Watana	3.9	2.52	218°
2-B	24-30	6.0	2.42	689°
2-E	13-20	0.9	0	0°
2-F	26-25	1.5	2.17	44°
2-G	22-24	5.3	5.21	724°
2-H	20-19	2.4	2.11	189°
2-I	16-19	0.6	3.42	52°
	19-22	11.4	2.10	285°
2-J	31-26	12.2	1.40	453°
2-L	2-16	8.7	3.05	270°
2-M	All	7.9	7.37	1113°
2-P	All	7.3	5.10	899°
2-R	13-22	15.9	1.78	446°
	22-31	20.2	1.67	2067°
	31-29	11.3	1.18	462°
	29-Watana	10.3	1.09	927°
2-RR	All	10.5	1.01	414°
3-A	Watana-10.5	1.9	1.96	63°
	10.5-11	3.2	1.70	159°
	11-33	14.1	1.39	276°
	33-Denali	19.2	1.15	659°
3-B	All	37.2	1.10	1736°
3-C	All	22.6	1.30	365°
4-A	All	41.7	2.37	2590°
4-B	All	54.9	2.16	3230°
4-C	All	21.0	2.50	1302°

TALBE C.3

COMBINATIONS OF SEGMENTS INTO CORRIDORS

Corridors	Segments	Distance Miles	% Av. Grade	Defl./ Miles	Access Plan
A1-A2	1-F, 1-A	64.6	2.60	83.8	
	1-F, 1-A, 1-B	61.9	2.45	79.1	
	1-F, 1-A, 1-E, 3-A	70.1	2.48	79.3	
	1-F, 1-A, 1-B, 1-E, 3-A	67.4	2.34	74.8	
A1-B3	1-F, 1-A, 2-M, 2-G, 2-B, 2-A	76.7	2.89	79.0	
	1-F, 1-A, 2-M, 2-G, 2-B, 2-A, 2-J, 2-F	74.1	3.01	77.9	
A1-C	1-F, 1-A, 3-C, 3-A, 4-C	92.5	2.07	47.6	
	1-F, 1-A, 3-A, 4-A	109.8	2.10	54.5	
	1-F, 1-A, 3-B, 3-A, 4-B	126.9	1.96	58.5	
B1-B2-B3	1-F, 1-A, 2-L, 2-I, 2-M, 2-G, 2-B, 2-A	67.9	3.03	75.2	
	1-F, 1-A, 2-L, 2-I, 2-G, 2-B, 2-A, 2-J, 2-F	61.6	2.35	52.5	1
B2-B3	2-E, 2-H, 2-I, 2-G, 2-B, 2-A	53.8	2.08	59.1	
	2-E, 2-H, 2-I, 2-G, 2-B, 2-A 2-J, 2-F	51.2	2.22	56.6	
B1-B2-A2	1-F, 1-A, 2-L, 2-I, 2-M, 1-A	67.9	3.03	75.2	
	1-F, 1-A, 2-L, 2-I, 2-M, 1-A, 1-B	65.2	2.91	70.3	
	1-F, 1-A, 2-L, 2-I, 2-M, 1-A, 1-E, 3-A	73.4	2.88	71.5	
	1-F, 1-A, 2-L, 2-I, 2-M, 1-A, 1-B, 1-E, 3-A	70.7	2.76	66.9	5
B2-A2	2-E, 2-H, 2-I, 2-M, 1-A	57.5	3.04	82.8	
	2-E, 2-H, 2-I, 2-M, 1-A, 1-B	54.8	2.89	77.5	
	2-E, 2-H, 2-I, 2-M, 1-A, 1-E, 3-A	63.0	2.87	77.9	
	2-E, 2-H, 2-I, 2-M, 1-A, 1-B 1-E, 3-A	60.3	2.72	70.2	8
B1-B2-C	1-F, 1-A, 2-L, 2-I, 3-C, 3-A 4-C	87.9	1.94	33.9	3 (7)
	1-F, 1-A, 2-L, 2-I, 3-A, 4-A	105.2	1.99	43.3	
	1-F, 1-A, 2-L, 2-I, 3-B, 3-A, 4-B	122.3	1.87	49.1	

TABLE C.3 (Continued)

COMBINATIONS OF SEGMENTS INTO CORRIDORS

Corridors	Segments	Distance Miles	% Av. Grade	Defl./ Miles	Access Plan
B2-C	2-E, 2-H, 2-I, 3-C, 3-A, 4-C	77.5	1.80	34.1	
	2-E, 2-H, 2-I, 3-A, 4-A	94.8	1.88	44.5	
	2-E, 2-H, 2-I, 3-B, 3-A, 4-B	111.9	1.77	50.1	
R1-A2	2-R, 2-M, 1-A	58.7	2.97	80.7	
	2-R, 2-M, 1-A, 1-B	56.9	2.77	74.2	
	2-R, 2-M, 1-A, 1-E, 3-A	48.3	3.14	91.8	
	2-R, 2-M, 1-A, 1-B, 1-E, 3-A	45.6	2.72	85.9	9
R1-B3	2-R, 2-G, 2-B, 2-A	55.0	2.02	57.3	10
	2-R, 2-G, 2-B, 2-A, 2-J, 2-F	52.4	2.15	54.8	
R1-C	2-R, 3-C, 3-A, 4-C	78.7	1.77	33.2	4 (6)
	2-R, 3-A, 4-A	96.0	1.85	43.7	
	2-R, 3-B, 3-A, 4-B	113.1	1.74	49.8	
R1-R2	2-R	57.7	1.50	67.6	
	2-R, 2-RR	56.9	1.47	67.7	2
C-A2	1-A, 3-A, 4-A	115.0	2.06	60.2	
	1-A, 3-A, 3-B, 4-B	132.1	1.94	63.3	
	1-A, 3-A, 3-C, 4-C	97.7	2.03	54.7	
	1-A, 1-B, 3-A, 4-A	112.3	1.97	57.1	
	1-A, 1-B, 3-A, 3-B, 4-B	129.4	1.86	60.6	
	1-A, 1-B, 3-A, 3-C, 4-C	95.0	1.92	50.8	
	1-A, 1-E, 3-A, 4-A	120.5	2.02	58.7	
	1-A, 1-E, 3-A, 3-B, 4-B	137.6	1.90	61.8	
	1-A, 1-E, 3-A, 3-C, 4-C	103.2	1.98	53.2	
	1-A, 1-B, 1-E, 3-A, 4-A	117.8	1.92	55.6	
	1-A, 1-B, 1-E, 3-A, 3-B, 4-B	134.9	1.82	59.3	
	1-A, 1-B, 1-E, 3-A, 3-C, 4-C	100.5	1.87	49.5	11

APPENDIX D

TERRAIN UNIT MAPPING

Appendix D - Terrain Unit Maps

This appendix describes the terrain unit analysis for the access alternatives.

This data identifies the surface geology and qualitatively discusses the engineering characteristics of the various soils. The alternative segments studied are plotted on the Terrain Unit Maps. The soil types and characteristics have been taken into account in developing the construction cost estimates for the alternate plans.

The text that follows is a general report, applicable to more than just access road selection.

D.1 INTRODUCTION

The feasibility study for the Susitna Hydroelectric Project includes geological and geotechnical investigation of the area extending from the Parks Highway 80 miles east to the mouth of the Tyone River and from the Denali Highway 50 miles south to Stephan Lake. The most cost effective method of generating and compiling baseline geologic information about this large, little-investigated region is through the methods of photointerpretation and terrain unit mapping.

This text and the accompanying terrain unit maps present the results of aerial photograph interpretation and terrain unit analysis for the area including the proposed Watana and Devil Canyon damsite areas, the Susitna River reservoir areas, construction material borrow areas, and access and transmission line corridors. The task was performed for the Alaska Power Authority by R&M Consultants, Inc., working under the direction of Acres American, Inc.

Scope of Work and Methods of Analysis

Work on the air photo interpretation subtask consisted of several activities culminating in a set of Terrain Unit Maps delineating surface materials and geologic features and conditions in the project area.

The general objective of the exercise was to document geological features and geotechnical conditions that would significantly affect the design and construction of the project features. More specifically the task objectives included the delineation of terrain units of various origins on aerial photographs noting the occurrence and distribution of geologic factors such as permafrost, potentially unstable slopes, potentially erodible soils, possible buried channels, potential construction materials, active flood plains and organic materials. Engineering characteristics listed for the delineated areas allows assessment of each terrain unit's influence on project features. The terrain unit analysis serves as a data bank upon which interpretations concerning geomorphologic development, glacial geology, and geologic history could be based. Additionally, this subtask provides base maps for the compilation and presentation of various other Susitna Hydroelectric project activities.

The area of photo coverage was divided into units of workable size, resulting in 21 map sheets. Base maps were prepared from photo mosaics and the terrain units were delineated on overlay sheets.

Physical characteristics and typical engineering properties were developed for each terrain unit and are displayed on a single table.

The execution of this project progressed through a number of steps that ensured the accuracy and quality of the product. The first step consisted of a review of the literature concerning the geology of the Upper Susitna River Basin and transfer of the information gained to high-level, photographs at a scale of 1: 125,000. Interpretation of the high-level photos created a regional terrain framework which would help in the interpretation of the low-level 1:24,000 project photos. Major terrain divisions identified on the high-level photos were then used as an areal guide for delineation of more detailed terrain units on the low-level photos. The primary effort of the subtask was the interpretation of 300-plus photos covering about 800 square miles of varied terrain. The land area covered in the mapping exercise is shown on the index map sheet and displayed in detail on the 21 photo mosaics.

During the low altitude photo interpretation a preliminary work review and field check was undertaken by R&M and L.A. Rivard, terrain analysis consultant. A draft edition of the Terrain Unit maps and report was completed and submitted for review to ACRES and L.A. Rivard. Comments and questions generated in the review of the draft report were analyzed by R&M and a second field check, a test hole boring program, and peat probe study was undertaken. The final revised maps are included herein.

Terrain units composed of or including bedrock are shown on the interpretation. However, these divisions are interpreted only as weathered or unweathered bedrock. Detailed petrologic designations and age relations of the rock units have been synthesized from U.S. Geological Survey sources (Csejtey, 1978) and project field mapping accomplished to date. Rock unit designations from these sources are included on the maps. Lineaments, features-of-interest, and potential faults have not been shown as their delineation is outside the scope of R&M's work.

Limitations of Study

This is a generalized study which is intended to collect geologic and geotechnical materials data for a relatively large area. Toward this goal, the work has been successful, however, there are certain limitations to the data and interpretations which should be considered by the user. The engineering characteristics of the terrain units have been generalized and described qualitatively. When evaluating the suitability of a terrain unit for a specific use, the actual properties of that unit should be verified by on-site subsurface investigation, sampling, and laboratory testing.

An important factor in evaluating the engineering properties, composition and geologic characteristics of each terrain unit is extensive field checking and subsurface investigation. The scope of the current project allowed only limited field checking and subsurface investigations to date have been restricted to a few test holes in terrain units located along the access corridors. This lack of detailed ground-truth data further restricts the use of the terrain unit maps and engineering interpretation chart for site specific applications.

D.2 TERRAIN UNIT ANALYSIS

A landform is defined (Kreig and Reger, 1976) as any element of the landscape which has a defineable composition and range of physical and visual characteristics. Such characteristics can include topographic form, drainage pattern, and gully morphology. Landforms classified into groups based on common modes of origin are most useful because similar geologic processes usually produce similar topography, soil properties, and engineering characteristics. The terrain unit is defined as a special purpose term comprising the landforms expected to occur from the ground surface to a depth of about 25 feet. It has the capability to describe not only the most surficial landform, but also, an underlying landform when the underlying material is within about 25 feet of the surface (i.e. a compound terrain unit), and areas where the surficial exposure pattern of two landforms are so intimately or complexly related that they must be mapped as a terrain unit complex. The terrain unit is used in mapping landforms on an areal basis.

The terrain unit maps for the proposed Susitna Hydroelectric Project area show the areal extent of the specific terrain units which were identified during the airphoto investigation and were corroborated in part by a limited on-site surface investigation. The terrain units, as shown on the following sheets and described in this text, document the general geology and geotechnical characteristics of the Susitna Hydroelectric Project area.

On the maps each terrain unit is identified by letter symbols, the first of which is capitalized and indicates the genetic origin of the deposit. Subsequent letters differentiate specific terrain units in each group and when separated by a dash, identify the presence of permafrost.

During terrain unit mapping bedrock was identified, as per established techniques, only as weathered bedrock or unweathered bedrock. Details of bedrock geology shown on the mosaic maps is derived from Csejtey's USGS open file report on The Geology of the Talkeetna Mts. (1979) and from Acres American (unpublished data, 1981). The letter designations are used here as those authors defined them and the rock units are shown only where the photointerpretation located bedrock on the maps. There has been no attempt to correlate units across areas of limited exposure or to modify the outcrop pattern. Bedrock symbols are shown in slanted letters with the capital letters defining the age of the unit and following lower case letters describing the rock type.

D.3 TERRAIN UNIT DESCRIPTIONS

For this photo interpretation exercise, the soil types, engineering properties and geological conditions have been developed for the 14 landforms or individual terrain units briefly described below. Several of the landforms have not been mapped independently but rather as compound or complex terrain units. Compound terrain units result when one landform overlies a second recognized unit at a shallow depth (less than 25 feet), such as a thin sheet of glacial till overlying bedrock or a mantle of lacustrine sediments overlying till. Complex terrain units have been mapped were the surficial exposure pattern of two landforms are so intricatly related that they must be mapped as a terrain unit complex, such as some areas of bedrock and colluvium. The compound and complex terrain units behave and are described as a composite of individual landforms comprising them. The stratigraphy, topographic position and areal extent of all units are summarized on the terrain unit properties and engineering interpretations chart.

Bx - BEDROCK: In place rock that is overlain by a very thin mantle of unconsolidated material or exposed at the surface. Two modifiers have been used for all types of bedrock whether igneous, sedimentary or metamorphic. Weathered, highly fractured, or poorly consolidated bedrock is indicated by the modifiers "w" (as in Bxw); unweathered, consolidated bedrock is indicated by the modifier "u" (as in Bxu). A modifier or special symbol for frozen bedrock has not been used, although bedrock at higher elevations may be frozen.

C - <u>COLLUVIAL DEPOSITS</u>: Deposits of widely varying composition that have been moved downslope chiefly by gravity. Fluvial slopewash deposits are usually intermixed with colluvial deposits.

Cl - <u>Landslide</u>: A lobe- or tongue-shaped deposit of rock rubble or unconsolidated debris that has moved downslope. Includes rock and debris slides, slump blocks, earth flows and debris flows. Young slides are generally unfrozen while older slides may be frozen.

Cs-f - <u>Solifluction Deposits</u>: Solifluction deposits are formed by frost creep and the slow down-slope, viscous flow of saturated soil material and rock debris in the active layer. This unit is generally used only where obvious solifluction lobes are identifiable. Includes fine-grained colluvial fans formed where solifluction deposits emerge from confined channel on a hillside onto a level plain or valley. These landforms are often frozen as denoted by "-f".

Ffg - Granular Alluvial Fan: A gently sloping cone generally composed of granular material with varying amounts of silt deposited upon a plain by a stream where it issues from a narrow valley. The primary depositional agent is running water (for solifluction fans, see Colluvial Landforms). Can include varying proportions of avalanche or mudflow deposits, especially in mountainous regions. Fans are generally unfrozen.

Fp - Floodplain: Deposits laid down by a river or stream and flooded during periods of highest water in the present stream regimen. Floodplains are composed of two major types of alluvium. Generally granular riverbed (lateral accretion) deposits and generally fine-grained cover (vertical accretion) deposits laid down above the riverbed deposits by streams at bank overflow (flood) stages.

Fpt - Old Terrace: An old, elevated floodplain surface no longer subject to frequent flooding. Occurs as horizontal benches above present floodplains, and generaly composed of materials very similar to active floodplains.

Gta - Ablation Till: Relatively younger ablation till sheets with more pronounced hummocky moraine topography and less dissected than older till sheets. These deposits are predominently of the Naptowne Glaciation, contain abundent cobbles and boulders, and consist of water-worked till. The ablation till may be sporadically frozen in the Denali Highway access corridors.

Gtb-f - Basal Till: Basal glacial till sheets, with subdued moraine morphology, which in the Watana Creek-Stephan Lake area are relatively older (probably deposited during Eklutna and older glaciations) and elsewhere are as young as Naptowne age. Often frozen in the Watana - Stephan Lake area with a higher silt and ground ice content as denoted by modifier "-f"; generally unfrozen in the Gold Creek - Indian River area; and possibly frozen between Watana Camp and the Denali Highway.

GFo - Outwash: Coarse, granular relatively level floodplain formed by a braided stream flowing from a glacier.

GFe - Esker Deposits: Long ridges of granular ice-contact deposits formed by streams as they flow in or under a glacier.

GFk - Kame Deposits: Hills, crescents and cones of granular ice-contact deposits formed by streams as they flow on or through a glacier.

L-f - LACUSTRINE DEPOSITS: Generally fine-grained materials laid down in the Copper River proglacial Lake and gravelly sands deposited in the Watana Creek - Stephen Lake proglacial lake. Often frozen as denoted by modifier "-f".

O - ORGANIC DEPOSITS: Deposits of humus, muck and peat generally occurring in bogs, fens and muskegs. Frequently overlies frozen material.

Special Symbols and Landforms

In addition to the terrain unit symbols, several special symbols are used on the Terrain Unit maps to denote landslide scars, terrace scarps, frozen soils, buried channels and trails.

Well defined landslide scarps, which indicate relatively recent failure, are shown as lines following the scarp trace with arrows indicating the direction of movement. Visible on the aerial photos within many of the terraces and outwash deposits are several different surfaces which may be related to sedimentation at a temporary base level which was followed by renewed incision. The various outwash and stream terraces are noted by lines following the scarps separating the different elevation surfaces, with tick marks on the side of the lower surface. Permafrost soils have been delineated on the terrain unit maps through the use of an -f following the terrain unit letter designation. By convention the symbol -f is used where the permafrost is thought to occur at least discontinously. Sporadically frozen areas have not been defined on the maps, however, the possible occurrance of frozen material within a terrain unit is described in the preceeding section on definitions and on the engineering interpretation chart.

Buried channels along the Susitna River have been delineated by the use of opposing parallel rows of triangular teeth. Most of these features are minor and should have no impact on the present studies, however three buried channels south of the southern abutment at the Devil Canyon damsite, should be investigated to assess potential leakage around the dam. A similar but larger buried channel extends from near the mouth of Deadman Creek to Tsusena Creek. The trough is filled with quaternary sediments of several different types and ages some of which may have a high transmissibility. Because this channel bypasses the Watana damsite detailed work should be directed towards determining its width, depth, soil types, and potential for reservoir leakage.

Existing jeep and/or winter sled trails have been noted on the Terrain Unit maps by a dash-dot line.

D.4 TERRAIN UNIT PROPERTIES AND ENGINEERING INTERPRETATION CHART

In order to evaluate the impact of a terrain unit with respect to specific project features an interpretation of the engineering characteristics of each unit is provided. On the chart the terrain units are listed in horizontal rows and the engineering properties and parameters being evaluated are listed as headings for each column. Within the matrix formed are relative qualitative characterizations of each unit. Several of the engineering properties and evaluation criteria are briefly discussed below. The chart is presented for general engineering planning, and environmental assessment purposes. In this form, the data are not adequate for design purposes but when additional laboratory and field information is acquired and synthesized, site specific development work can be minimized.

Engineering Interpretation Definitions:

Slope Classification — Following guidelines established by the U.S. Forest Service, the Bureau of Land Management and the American Society of Landscape Architects, slopes in the project corridor have been divided into the following classes: Flat - 0 to 5%; Gentle - 5 to 15%, Moderate - 15 to 25% and steep - greater than 25%. References have been made to steep local slopes to account for small scarps and the similar short but steep slopes which characterize ice contact glacial drift.

Probable Unified Soil Types	Based on the laboratory test results, field observations, previous work in similar areas, and definitions of the soils, a range of unified soil types has been assigned to each terrain unit. Often several soil types are listed, some of which are much less prevelant than others. Information in the soil stratigraphy column will aid in understanding the range and distribution of soil types. Study of the borehole logs and lab test results will give site specific unified soil types.
Drainage and Permeability	How the soils comprising the terrain units handle the input of water is characterized by their drainage and premeability. Permeability (hydraulic conductivity) refers to the rate at which water can flow through a soil. Drainage describes the the wetness of the terrain unit, taking into account a combination of premeability, slope, topographic position, and the proximaty of the water table.

Erosion Potential

Erosional potential as described here, considers the materials likelyhood of being moved by eolian and fluvial processes such as sheetwash, rill and gully formation, and larger channelized flow. In general this relates to the partical size of the soil, however, the coarse sediments of floodplains have been rated as high because the surface is very active, and likewise coarse terrace deposits can have a high rating because of their proximaty (by virture of the their origin) to streams. (Mass wasting potential is considered under slope stability).

Ground Water Table

Depth to the ground water table is described in relative terms ranging from very shallow to deep. In construction involving excavation and foundation work, special techniques and planning will be required in most areas with a shallow water table and in some of the areas with a moderately deep water table. In areas of impermeable permafrost a shallow perched local water table may occur.

Probable Permafrost Distribution

The occurance of permafrost and the degree of continuity of frozen soil is described on the Engineering Interpretation Chart, by the following relative terms: Unfrozen- generally without any permafrost; Sporadic - significantly large areas are frozen. Site specific work may be required before design; Discontinous - most of the area is underlain by frozen soils - site specific work is required unless design incorporates features relating to permafrost; Continous - the entire area is frozen. All designs should be based on occurrance of permafrost.

Frost Heave Potential

Those soils which contain significant amounts of silt and fine sand have the potential to produce frost heave problems. A qualitative low, moderate, and high scale rates the various soils based on the potential severity of the problem. Where the soil stratigraphy is such that a frost susceptible soil overlies a coarse grained deposit, a dual classification is given; for these soils it may be possible to strip off the frost susceptable material.

Thaw Settlement Potential	Permafrost soils with a significant volume of ice may show some settlement of the ground surface upon thawing. In general, clays, silts and fine sands have the greatest settlement potential, forming the basis for the three fold classification presented on the chart. Unfrozen soils do not have the potential for thaw settlement, as denoted by "not applicable" (NA). Thawing problems may be initiated or accellerated by disturbance of the surficial soil layers or the organic mat.
Bearing Strength	Based on the terrain unit soil types and stratigraphy a qualitative description of bearing strength is given. In general coarse grained soils have a higher bearing strength than fine grained soils, but the presence of permafrost may significantly increase the strength of some fine grained soils (as indicated on the chart by the thermal state qualifying statement).
Slope Stability	The slope stability qualitative rating was derived through evaluation of each terrain units'

topographic position, slope, soil composition, water content, ice content, etc. The stability assessment considers all rapid mass wasting processes (slump, rock slide, debris slide, mud-flow, etc.). Several terrain units which have character-istically gentle slopes and are commonly in stable topographic positions have been oversteepened by the recent, active undercutting of streams and/or man (or by older processes not currently active such as glacial erosion and tectonic uplift and faulting). The stability of the terrain units on oversteepened slopes and natural slopes is described on the Engineering Interpretation Chart.

Suitability as a Source of Borrow

Great quanties of borrow mate-rials will be needed for all phases of construction. The rating considers suitability as pit run and processed aggragete or impervious core and takes into account the materials present as well as the problems associated with extracting material from the various terrain units.

D.5 REGIONAL QUATERNARY GEOLOGY

Quaternary glacial events throughout South-Central Alaska profoundly affected the soils, landforms, and terrain units occurring in the project area. This history has been discussed and partially deciphered in papers by Karlstrom (1964), Pewe (1965), Ferrians (1965), and Wahrhafting (1958). However, these investigations are of such scope as to make them of limited value here. The photointerpretation and resultant terrain unit mapping is the most detailed study of the Upper Susitna River Basin. The following discussion of Quaternary Geology is a synthesis of the new information, derived during the photointerpretation, supplemented by data from published sources.

The major topographic features of Southcentral Alaska were established by the end of the Tertiary Period. What is now the Susitna project area was located in the relatively low northern portion of the Talkeetna Mountains, which separated the broad ancestral Copper River Basin lying to the east from the ancestral Susitna Cook Inlet Basin lying to the west. North and south of the Talkeetna Mountains and the adjacent large river basins stood, respectivily, the great arc of the Alaska Range and Chugach Mountains. Streams draining the region that would become the project study area may have flowed into either the ancestral Copper or Susitna River systems. During the Pleistocene the entire Susitna Project study area was repeatedly glaciated. Each of the glacial events would be expected to follow the same general pattern with several advances most likely reaching the maximum event described here.

The onset of a given glacial advance in Southcentral Alaska would be marked by the lowering of the snowline on the regions numerous mountain ranges and the growth of valley glaciers, first in the higher ranges and those closer to the Gulf of Alaska. Advancing glaciers from the Chugach, Wrangell, Alaska and southern Talkeetna ranges would flow out of their valleys and coalesce to form large piedmont glaciers spreading across the basin floors, while the ice of the northern Talkeetna Mountains (in the project area) would still exist as valley glaciers. The piedmont glaciers of the Chugach and Wrangell Mountains would at some point be expected to merge, damming the ancestral Copper River and creating an extensive proglacial lake in the Copper River Basin. Alaska Range glaciers flowing southward would block possible ancestral drainage paths of the upper Susitna River creating a second lake which covered much of the project area and merged with the lake filling the Copper River basin. Glaciers flowing from the Kenai Mountains and southern Alaska Range would also merge creating another proglacial lake in Knik Arm, Cook Inlet, and the Southern Susitna Basin. Continued glacial advance would fill the basins eliminating the lakes and possibly forming an ice dome. Ice shelves may have extended many miles into the Gulf of Alaska. At this maximum stage many mountains in the project area were completely buried by ice as evidenced by their rounded summits while numerous others existed as nunataks.

The deglaciation of Southcentral Alaska would follow a similar pattern but in reverse. Wasting of the ice would uncover peaks in the project area and the thinning and retreat of the glaciers in the Copper River, Upper Susitna and Cook Inlet regions would again allow lakes to form. Continued melting of the glaciers would remove ice dams blocking the proglacial lakes possibly creating a catastrophic (trench cutting) outburst flood. Intervals between glacial advances would be characterized by the fluvial entrenching of the Susitna and Copper Rivers and their tributaries. The earlier glacial events of the Quaternary Period are poorly known in the Upper Susitna Basin due to both the erosion of the older deposits and their burial beneath younger deposits. However, from the alpine topography and minor glacial sediments left on high slopes it can be demonstrated that early Pleistocene glaciers completely covered Southcentral Alaska as in the maximal event described above. Most of the glacial deposits that remain and the terrain units used to describe them have resulted from later glacial events.

The last glaciation to completely cover the project area is of uncertain age. It has been interpreted to be of Eklutna age by Karlstrom (1964) which may be correlated with the Illinoian glaciation of the Continental United States (Pewe, 1975), however, with the limited data available an early Wisconsin (Knik) age may be just as viable. Whatever the age, ice flowing from the Alaska Range, the Talkeetna Mountains and several local highland centers spread across the project lowlands depositing a sheet of gray, gravelly, sandy and silty, basal till (Gtb-f). The till varies greatly in thickness, ranging from the 100+ feet, displayed in some river cut exposures, to a thin blanket over bedrock. This till presumably overlies older, poorly exposed Quaternary sediments. It is recognized that the basal till, mapped as Gtb-f in the Stephan Lake-Watana Creek Area may actually represent several closely related events and that basal till in valleys north of Deadman Lake and downstream of the Devil Canyon site was probably deposited during younger glacial advances. Prominent lateral moraines of the major advance occur on the flanks of mountains bordering the central Watana Creek-Stephan Lake Lowland.

Overlying the basal till unit and representing the next major depositional event is a lacustrine sequence. Presumably the lacustrine materials were deposited during the Eklutna (?) Glacial retreat and during much of the younger Knik and Naptowne glacial events. During these stadial events glaciers from the Alaska Range blocked drainage down the present Susitna channel and probably through a low divide between Watana Creek and Butte Creek; Talkeetna River Valley glaciers blocked low divides between Stephan Lake and the Talkeetna River; and the Copper River Basin was occupied by an extensive proglacial lake. The lacustrine deposits mapped within the project area as L and L/Gtb-f, cover much of the Watana Creek-Stephan Lake Lowland and extend upstream along the Susitna River to the Susitna-Copper River Lowland. In the Watana Creek-Stephan Lake Lowland the unit is generally less than 20 feet thick and composed of medium to fine sand with a significant gravel content. The lake deposits of the Copper River Lowland are thought to be much thicker and finer-grained. The coarseness of the lacustrine sediments (i.e. gravelly sands in the Watana Creek-Stephan Lake area) is not unexpected as the ancient lake was impounded behind and ringed by glaciers which were activity calving into the lake. During the late Naptowne glacial event, in the Watana Creek-Stephan Lake portion of the proglacial lake, several deltas and strandline features were formed at about the 3,000-foot elevation. This shoreline level is higher than most reported shorelines of the proglacial lake occupping the Copper River Basin. It is possible then, that during the Naptowne stadial the Watana Creek - Stephan Lake proglacial lake stood at a higher level because it was impounded behing another ice dam in the Kosina Creek - Jay Creek area. It is also possible that an outlet existed for much of the life of the lake (conceivably in Kosina - Jay Creek area). Flow from the lake would remove great quantities of fine grained suspended sediment, causing a relative increase in the coarseness of the sediment deposited in the lake.

Hummocky coarse grained deposits of ablation till (Gta) overlay lacustrine sediments between Tsusena and Deadman Creeks and basal till in the valleys north of Deadman Creek and in the Denali Highway area. These materials may be correlative with eskers and kames found along the Susitna River between the Oshetna and Tyone Rivers, and together they represent the extent of the last major advance of glacial ice into the project area. They are tentatively determined to be of Naptowne age (Late Wisconsin) (Karlstrom, 1964) suggesting that the Knik Age glaciers were less extensive and their deposits were overridden and masked by Naptowne deposits. Lacustrine sediments of the large glacial lake occupying the Stephan Lake - Watana Creek lowland have not been mapped overlying the ablation till, indicating that some of the ablation till and ancient Watana Creek-Stephan Lake lacustrine sediments were time syncronous and that the proglacial lakes were drained shortly after the Naptowne maximum. One should note that several isolated deposits of ablation till are not necessarily indicative of this late advance and ice of Naptowne age did not deposit ablation till in all localities (most importantly in the Portage-Devil Creek area and in the area between Deadman Lake and the Denali Highway); and that lacustrine sediments deposited in small isolated proglacial lakes have been found overlying ablation till.

Intervals between glacial advances would be characterized by fluvial erosion and entrenching of the project area portion of the ancestral Susitna and its tributary streams, however, the majority of the interstadial fluvial hisory has been destroyed by subsequent glacial and fluvial history. Remnants of the older entrenching events are preserved in several abandoned and buried channel sections along the modern Susitna River. One of the largest older channels found, at the Vee Canyon damsite has a bedrock floor (cut below the bedrock floor of the present Susitna channel) which is now filled with fluvial and glacio-fluvial debris. The second buried channel, between Deadman and Tsusena Creeks, just north of the Watana site is filled with outwash and lacustrine materials with intervening till layers (Corps of Engineers, 1979). Because ice of Naptowne and Knik ages presumably did not completely cover the project area, and the tills in the channel have characteristics similar to the basal till unit attributed to the Eklutna Glaciation, it appears that a portion of the ancestral Susitna River valley of similar size and depth to the present valley existed as early as the Eklutna Glacial event (Illinoian). Eklutna age till and associated lacustrine sediments also filled some of the present Susitna valley, however, most have been subsequently excavated. The Eklutna age valley may have been graded to drain east into the Copper River Basin. The fact that the present Susitna River flows in a deep canyon across mountainous terrain (in the Portage-Devil Creek and Jay-Kosina Creek areas), and not across the low Susitna-Copper River of the Stephan Lake-Talkeetna River Divides may be the result of glacial derangement and/or the rapid drainage of proglacial lakes causing a pirating of portions of the Copper and Talkeetna River drainages.

Other minor channel remnants include three buried channels above and south of the southern abutment at the Devil Canyon damsite that may be related to the drainage of a proglacial lake or an older position of the Susitna River. The channels are probably shallow but should be thoroughly investigated to assess potential leakage around the dam. A small, partially buried channel downstream of Portage Creek and another near the mouth of Devil Creek are remnants of the downcutting phase of the Susitna River. Similar channels are found near the river level just upstream of the Watana Damsite and downstream of Watana Creek.

The present course of the Susitna River was probably established during or before the Wisconsin Glacial events. Sandy glacial till observed near the river level at the Devil Canyon site may have been deposited by the glaciers forming the Naptowne Age ice dam. If this is the case, and the till is in-situ then most of the bedrock downcutting and removal of Quaternary sediment from the Susitna channel was accomplished before the end of the Wisconsin. If the till deposit near water level in Devil Canyon is older than the Naptowne event (Knik or Ekultna), it would indicate, an earlier incision date and that the river followed its present course since the Eary Wisconsin at least.

Numerous modifications of the glaciated surfaces and the development of non-glacial landforms has characterized the Sustina project area since the Pleistocene. The stream incision, as previously discussed, has produced or at least excavated the V-shaped Susitna River Valley within the wide glaciated valley floor. This has rejuvenated many tributary streams which are now down - cutting in their channels, as is evidenced by the steep gradients in the lower portions of their channels, lower gradients in the mid-channel section and frequently a waterfall niche - point separating these stream segments. Several low terraces (Fpt) have been formed above the modern floodplain (Fp) of the Susitna and its major tributaries. Terraces at several different levels were found throughout the Susitna River Valley. Some occur high on the valley walls as eroded terrace remnants (upstream of Watana Creek); while others appear as very recent, low, flat planar features. Near the mouth of Kosina Creek and in several other locations, the terrace materials overlie relatively shallow bedrock such that they may more accurately be called bedrock benches). Between the Oshetna and Tyone Rivers the thin terrace gravels overlie glacial till. The terraces are frequently modified by the deposition of alluvial fan debris (Ffg) and/or the flow of solifluction lobes and sheets (Cs) across their surfaces. Correlation of the terrace levels on the air photos is difficult because of the lack of continuity and was, therefore, not attempted. In the Gold Creek area three different, low level terraces are clearly visible and in the Tyone-Oshetna Rivers area four terrace levels can be discerned. Between these areas the terraces rarely occur in groups and are more widely spaced. Most tributary streams also show multiple terrace levels with the best example being in Tsusena Creek where five or more levels appear as steps on the valley wall.

The stream terraces are frequently modified by the deposition of alluvial fan debris (Ffg) and/or the flow of solifluction lobes and sheets (Cs) across their surfaces. Alluvial fans have also been deposited where steep small drainages debouch onto floors of wider glaciated valleys.

Frost cracking, cryoturbation and gravity have combined to form numerous colluvial deposits. Steep rubbley talus cones have accumulated below cliffs and on slightly less precipitious slopes thin deposites of frost churned soils cover bedrock terrain (C). On numerous slopes in highland areas (as long Devil Creek) and on the broad lowlands solifluction has modified the surficial glacial till and/or lacustrine deposits.

The development of a number of landslides (Cl) has occurred throughout the project area. Most landslides were found within the basal till unit (Gtb-f or L/Gtb-f) on steep slopes above actively eroding streams. The incidence of failure within this material appears to be strongly related to thawing permafrost and consequent soil saturation. The basal till unit is frequently overlain by lacustrine material and the lacustrine materials fail with the till. Most failures occur as small shallow debris slides or debris flows, however, a few large slump failures occur. The slumps and debris flows are marked with a special symbol on the Terrain Unit Maps. Steep rock slopes are assumed to be stable. However, this is undoubtedly not the case where unfavorably oriented discontinuities dip out of the rock slope. Such discontinuities must be identified and their effects assessed during on-site rock slope stability investigations.

Finally, revegetation of poorly drained portions of the landscape has produced numerous scattered deposits of organic materials (O); and permafrost has developed in many areas.

D.6 FIELD VERIFICATION PROGRAM

To verify the terrain unit maps and to more fully characterize the soils along the various Susitna access routes a field study consisting of exposure site visits, a test hole drilling program, and an organic thickness study was undertaken. Information derived from the study served to increase the reliability of the engineering interpretation chart and aid in determining the potential impacts of geotechnical factors such as: the presence of, depth to and ice content of permafrost; frost susceptability; organic material thickness; construction material suitability and depth to bedrock. This data will allow better construction cost and time estimates and a more accurate preliminary design. However, the field investigations were not of the scope to do final design work or to make site specific judgments.

Natural exposures of the terrain units were studied in two field trips. In the first trip the R&M photo interpreters, accompanied by L.A. Rivard, visted about a dozen exposures in several different terrains. This trip was carried out before the majority of interertation was completed and allowed the development of a glacial history model and an initial assessment of the soil characteristics. Some of the specific stratigraphic relationships and soil characteristics revealed in the exposure visits included: the presence of a gravelly sandy soil, interpreted to be of a highly active glacio-lacustrine origin, overlying a gray silty basal till, in the Watana Creek area; a coarse grained rubbery ablation till overlying the lacustrine sediments in the Deadman Tsusena Creek area; the existence of several deltas and kame deltas at the 3,000-foot elevation surrounding the Watana Creek - Stephan Lake lowland; massive degrading ice lenses in the basal till; solifluction features, thermo karst, and patterned ground throughout the study area and very thick lacustrine sediments in the Tyone - Oshetna River area.

The second trip was made following reviews of the draft terrain unit maps and was directed towards refining unit boundaries, selecting test boring locations, and further characterizing the soils' engineering properties. Results of the second field visit included: confirmation of the existance and extent of the Watana Creek - Stephan Lake lacutrine blanket and its gravelly sand composition; the presence of several material sources between the Watana and Devil Canyon sites; and a check of the distribution of ablation and basal tills in the Watana-Denali Highway access corridors.

The organic thickness study consisted of making multiple probes in areas identified on the terrain unit map as organics (O) which were potentially crossed by access roads. The probe instrument consisted of a modified oakfield sampler, pushed by hand into the peaty soils. A field party of a geologist and a laborer supported by a helicopter preformed hundreds of probes, providing a series of cross sections or profiles through most of the organic material deposits encountered along the access routes. The hand driven limit of sampler penetration seemed to be about 16 feet and in all cases the probe depths recorded were minimum organic thicknesses. The probing demonstrated that: 1) in general the organic deposit thicknesses are directly related to the size of deposit (i.e. the large deposits are generally deeper); 2) the thickness profiles usually appeared to be uniform with greatest organic material thickness occurring near the center of the deposits; and 3) organic deposits in bedrock dominated terrains were generally thinner than (ie. one half to one tenth the thickness of) organic deposits overlying thick deposits of unconsolidated material. The recorded organic material thicknesses ranged from less than one foot to the limit of sampler penetration, about 16 feet (several of deposits were probably significantly thicker than 16 feet) and had a median thickness of about 8 feet. All of the probed organic accumulations were completely saturated with a water table at the surface.

The test hole boring program involved drilling 26 boreholes varing in depth from 6.5 feet to over 30 feet. Individual test holes were selected to verify the presence of specific terrain units in areas of uncertainty, document adverse geotechnical conditions, and to partially characterize a variety of the terrain units that will be encountered in the access corridors. A CME 55 rig mounted on a modified helicopter transported base was used by the field party (geologist, driller and driller's helper). Split spoon hammer driven samples were taken at 2.5-foot intervals for the first 10 feet, at five-foot intervals below 10 feet and at all detected changes in strata.

Brass liner, moisture tin, and plastic bag samples collected in the field were transferred to the R&M laboratory where a few of the samples were analysed and the majority stored for later reference. Tests preformed included: sieve and hydrometer analysis; moisture content; organic content; dry density; and atterberg limit determinations. Based on these values the tested soils were classified according to the Unified, ASSHTO, and the Corps of Engineers Frost Classification systems.

In general the terrain unit maps and engineering interpretation chart were corroborated by the drilling program. The distribution of test holes provided a somewhat balanced sampling of units related to extent and significance of the soils. Accordingly most of the holes were drilled in basal till (Gtb-7 holes) and lacustrines over till (L/Gtb-6 holes). Ablation till (Gta-4 holes), Lacustrine soils (L-3 holes), and Colluvium (C-3holes) follow in importance and number of test borings. The remaining test borings were located in solifluction over till and till over bedrock terrain units. This distribution of holes within terrain units provides a basis for refining the Engineering Interpretation chart and for checking the accuracy of the mapping delineations. Of the 26 test holes, 22 were interpretated to have been drilled in the material as identified on the terrain unit maps. The correct interpretation of soil type for 22 test borings was thought to reflect an acceptable accuracy. Furthermore several of the holes were specifically located to refine our interpretation and as discussed below the conflicts were very minor in nature. Concerning the four test holes which conflicted with the terrain maps: two revealed Lacustrine sediments over 20 feet thick where Lucustrines (less than 20 feet) over till was expected; one hole was interpreted as encountering basal till (Gtb) where ablation till (Gta) was mapped; and finally one hole showed colluvial materials further downslope than expected (where basal till, Gtb, was anticipated). The terrain unit delineations where evaluated in light of the test hole data, and it was decided that significant new interpretation was not required. Instead the terrain unit boundaries in the test hole areas received minor adjustment. The existance and importance of all the terrain units was corroborated; no terrain units were eliminated or added. The regional interpretation framework (geomorphic model and glacial history) accurately accounted for the sampled soils, further verifying the model and, providing a valuable tool for interpretation in surrounding areas and the evaluation of site specific data.

The characteristics of the soils revealed during the drilling program verified and increased the reliability and accuracy of the Engineering Interpretation Chart. Permafrost proved to less widespread than the draft report indicated occurring in only nine holes. These frozen soils, according to our limited sampling, were confined to the basal till, lacustrine and lacustrine over basal till terrain units. Massive ice, forming up to 50% of the soil volume, was found in the lacustrines (overlain by organics), while the permafrost in the lacustrine over till unit appeared to be relatively dry. Although permafrost was not encountered in test borings in ablation till or colluvium it is still thought that sporadic to discontinous permafrost is characteristic of these units.

The laboratory sieve tests run on the lacustrine materials corroborated the field site visits and photo interpretation in that most of the soils are coarse grained, consisting of sands with some gravel and very little silt. An explaination of the origin of the coarse lacustrine deposits is presented in the section on Quaternary Geology. Sieve analysis also indicated that the abalation till, which the initially was thought to be very coarse grained, does have a significant silt content. Early interpretations were based on visits of surficial outcrops which must have been well washed during or following deposition.

Specific geotechnical problem areas revealed in the drilling program are limited to the organic and ice rich soils found between Stephan Lake and the Susitna River. Severe thaw settlement in the frozen sediments and an extremely low bearing strength in the organic materials will require rerouting or special design of the roads and rail lines in this area if the southern access corridor is selected.

The test holes drilled along the proposed Watana-Denali Highway access corridor revealed generally favorable geotechnical conditions. Borrow materials are abundent, the route avoids adverse grades, only limited permafrost is expected and relatively few organic deposits were mapped.

Test holes in the northern corridor between the Devil Canyon and Watana Sites also revealed generally favorable conditions. The lacustrine cover over basal till may actually decrease construction problems as there is a lower silt content (and frost susceptability) in the lacustrine material than in the tills. The till and solifluction over till terrain units adjacent to Devil Creek may be frozen but if frozen soil construction practices are employed problems can be minimized. Much of the corridor between Devil Creek and the Devil Canyon Dam site crosses bedrock dominated soils.

Between Devil Canyon and the Parks Highway (on Corridor B) test holes were drilled in basal till which is thought to be unfrozen in most places. Few construction problems are likey to be encountered in the till or terrace gravels adjacent to the Susitna River. However, problems may be encountered in crossing organic deposits, between the Parks Highway and Indian Creek, which were found to be greater than ten feet thick in many places.

D.7 REGIONAL BEDROCK GEOLOGY

The bedrock geology of the Talkeetna Mountains and Upper Susitna River Basin is examined in numerous publications varying in nature from site specific to regional. The most comprehensive report is by Bela Csejtey (1978), entitled the Geology of the Talkeetna Mountains Quadrangle. This paper and map deals with the ages, lithology, structure, and tectonics of the regions rock units. His results, supplemented by unpublished data from recent project field mapping, are the basis of this report's bedrock unit identification. Csejtey (1978) concludes that southern Alaska developed by the accretion of a number of northwestward drifting continental blocks on to the North American plate. Each of these terrains had a somewhat independent and varied geologic history, consequently, many lithologies with abrupt and complex contacts are found. Csejtey notes that "the rocks of the Talkeetna Mountains region have undergone complex and intense thrusting, folding, faulting, shearing, and differential uplifting with associated regional metamorphism, and plutonism". He recognizes at least three major periods of deformation: "a period of intense metamorphism, plutonism, and uplifting in the Late Early to Middle Jurassic, the plutonic phase of which persisted into Late Jurassic; a Middle to Late Cretaceous alpine-type orogeny, the most intense and important of the three; and a period of normal and high-angle reverse faulting and minor folding in the Middle Tertiary, possibly extending into the Quaternary". Most of the major structural features of the Talkeetna Mountains trend northeast to southwest and were produced during the Cretaceous Orogeny.

Major bedrock lithologies as mapped by Csejtey, and included on the terrain unit maps, are summarized as follows:

Tv

Tertiary volcanic rocks of subaerial and shallow intrusive origin with a total thickness of over 1,500 feet. The lower part of the sequence consists of small stocks, irregular dikes, flows and thick layers of pyroclastic rocks of quartz latite, rhyolite and latite composition. The upper part of the sequence consists of andesite and basalt flows interlayered with tuff. These rocks are mapped in Fog Creek and its major tributary.

Tsu

Tertiary nonmarine sedimentary rocks including fluviatile conglomerate, sandstone, and claystone with a few thin lignite beds. The only known exposures of this unit are in Watana Creek.

Tbgd

Tertiary biotite granodiorite forming stocks which are believed to be the plutonic equivalent of unit Tv. The most extensive exposures are found on either side of the Susitna River from just upstream of the Devil Canyon damsite to the northward bend in the river about six miles upstream of Devil Creek. An outcrop of Tertiary hornblende granodiorite (Thgd) is located just west of Stephan Lake.

Tsmg

Tertiary schist, migmatite, and granite which display gradational contacts. The schist and lit-par-lit migmatite are probably products of contact metamorphism with the entire unit possibly representing the roof of a large stock. The rocks occur in apprxoimately equal proportions with the largest exposures occurring in Tsusena Butte, west of Deadman Creek, and in the rectangular southern jog in the Susitna River.

Csejtey maps this unit at the Watana damsite, however, more recent field work (ACRES, 1981) has shown that the Watana damsite bedrock consists of diorite and andesite.

TKgr	Tertiary and/or Cretaceous granitic rocks forming small plutons the largest of which is found in the headwaters of Jay Creek.
Jam	Jurassic amphibolite with minor inclusions of greenschist and occasional interlayers of marble. The unit is probably derived from neighboring basic volcanic formations. The amphibolite extends from the Vee Canyon damsite downstream for about 12 miles. Other Jurassic rocks which occur in extremely limited exposures include Trondjemite (Jtr) and granodiorite (Jgd) lithologies.
TRv	Triassic basaltic metavolcanic rocks form in a shallow marine environment as evidenced by thin interbeds of metachert, argillite and marble. The individual flows are reported as up to 10 meters thick and displaying pillow structure and columnar jointing. This unit is mapped, in the project area, in the mountains east of Watana Creek.
Pzv	Late Paleozoic basaltic and andesitic metavolcanogenic rocks which form a broad band across the central Talkeetna Mountains from the southwest to the northeast. The 5,000+ foot sequence is dominantly marine in origin suggesting that it is part of a complex volcanic ore system. The majority of the band of this unit crosses the

project area just west of Tsisi, Kosina and Jay Creeks. Near the top of this unit several metamorphosed limestone reef deposits (Pls) have been mapped.

Kag — Cretaceous argillite and graywacke of a thick intensely deformed flyschlike turbidite sequence. Low grade dynametamorphism to the low greenschist facies has allowed several early investigators to map portions of this unit as phyllite. The graywacke beds form about 30% to 40% of the unit and tend to be clustered in zones 1 to 5 meters thick. This unit is exposed at the Devil Canyon site. It extends downstream beyond Gold Creek and forms the mountain immediately east of Gold Creek.

TRvs — Triassic metabasalt and slate in an interbedded, shallow marine sequence found in two allochthonous blocks in the upper sections of Portage Creek.

Several of the above units have been used to describe rocks mapped by Acres between the Watana and Devil Canyon damsites. Where this data was available it took precidence over Csejtey's map.

D.8 REFERENCES

Listed below are some references which may be of help in providing background information and/or details concerning the soils and bedrock of the project area.

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D.9 TERRAIN UNIT MAPS

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

ACRES

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ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

TERRAIN UNIT SYMBOL	TERRAIN UNIT NAME	TOPOGRAPHY AND AREAL DISTRIBUTION	SOIL STRATIGRAPHY	SLOPE CLASSI-FICATION	PROBABLE UNIFIED SOIL TYPES	DRAINAGE AND PERMEABILITY IN UNFROZEN SOILS	EROSION POTENTIAL	GROUND WATER TABLE	PROBABLE PERMAFROST DISTRIBUTION	FROST HEAVE POTENTIAL	THAW SETTLEMENT POTENTIAL	BEARING STRENGTH	SLOPE STABILITY	SUITABILITY AS SOURCE OF BARROW
Bxu	Unweathered, consolidated bedrock	Cliffs in river canyon rounded knobs on broad valley floor and mountain peaks.	–	Moderate to Near-Vertical	–	–	Low	Deep	–	Nil	Nil	Very High	Moderate to High	Fine - Poor Coarse - Good
C	Colluvial deposits	Predominantly found at the base of steeper bedrock slopes as coalescing cones and fans and rock glacier.	Angular frost cracked, blocks of rock, some silt and sand.	Moderate to Steep	GP, GW, GM SW, SM	Good/High	Moderate to High	Deep	Sporadic at Low Elevation. Discontinuous at High Elevations	Low to High	Low to Moderate	Low to Moderate	Low to Moderate	Fine - Poor Coarse - Variable
Cl	Landslide deposits	Hummoncky unconsolidated deposits most common along the Susitna River and its major tributaries.	Silty gravels, silty sands and sandy silts; possible crude contorted layers.	Moderate to Steep	GM, SM, ML	Poor/Low	High	Shallow (perched)	Active - Unfrozen Inactive - Sporadic	High	High where frozen	Low	Low	Poor
Cs-f	Solifluction deposits	Relatively smooth to labate topography created by the flow of materials subjected to frequent freeze/thaw cycles.	Silty sand and sandy silt showing contorted layering.	Gently to Steeping Sloping	SW, SM, ML	Frozen	High	Shallow (perched)	Discontinuous to Continuous	High	High	High	Low	Poor
Ffg	Granular alluvial fan	Low cone shaped deposits formed where high gradient streams flow onto flat surfaces.	Rounded cobbles and gravel with sand and some silt, some sorting and layering of materials.	Moderate	GW, SW	Good/High	Moderate	Shallow	Unfrozen	Low	Low	High	High	Fine - Poor Coarse - Good
Fp	Floodplain deposits	Flat plains, slightly above and adjacent to the present Susitna River and its major tributaries.	Rounded cobbles, gravel and sand sorted and layered. With or without silt cover.	Flat to Gentle	GW, GP, SW SP, SM	Good/High	High	Very Shallow	Unfrozen	Generally Low (High for surface cover)	Low	Surficial Silts Low, Sands and Gravels High	High	Fine - Poor Coarse - Good
Fpt	Terrace	Flat surface remnants of former floodplain deposits isolated above present floodplain.	Rounded cobbles, gravel and sand with some silt covered by a thin silt layers. Sorted and layered.	Flat to Gentle	GW, GP, SW, SP, SM, ML	Good/High	Low	Deep	Unfrozen	Generally Low (High for surface cover	Low	High	Low to Moderate	Fine - Poor Coarse - Good
GFo	Outwash deposits	Bottoms of U-shaped tributary valleys and adjacent to Susitna area.	Rounded & striated cobbles, gravel and sand, crudely sorted and layered.	Gentle	GW, SW	Good/High	Moderate	Shallow to Deep	Unfrozen	Low	Low	High	Low to High	Fine - Poor Coarse - Excellent
GFe	Esker deposits	Rounded to sharp crested sinuous ridges in upper Susitna area.	Rounded & striated cobbles, gravel, and sand. Crudely to well sorted and layered.	Steep Local Slopes	GW, SW	Good/High	Moderate	Deep	Unfrozen	Low	Low	High	Moderate	Fine - Poor Coarse - Excellent
GFk	Kame deposits	Rounded to sharp-crested, Hummocky hills.	Rounded & striated cobbles, gravel, and sand. Crudely sorted and layered.	Steep Local Slopes	GW, SW	Good/High	Moderate	Deep	Unfrozen	Low	Low	High	Moderate	Fine - Poor Coarse - Excellent
Gta	Ablation till	Tributary valley side walls and valley bottoms in general, between Tsusena and Deadman Creek Hummocky rolling surface, numerous channels.	Rounded and striated cobbles, gravel, and sand, no sorting or layering. Boulder-cobble lag covering surface.	Gentle to Steep	GW, GM, SW, SM	Moderate/Moderate	Moderate	Shallow to Moderately deep	Unfrozen to Sporadic	Low to Moderate	Low to Moderate	Moderate to High	Moderate	Fine - Poor Coarse - Fair
Gtb-f	Basal till (frozen)	Bottoms of larger U-shaped valleys and adjacent gentle slopes.	Gravely silty sand and gravely sandy silt; no layering or sorting; cobbles and boulders poorly rounded and striated.	Gentle to steep	GM, SM, ML	Frozen	Moderate	Shallow (perched) to Deep	Discontinuous to Continuous	High	High	Low if Thawed. High when frozen	Low	Fine - Fair Coarse - Poor
O	Organic deposits	In swales between small rises on lowlands and in high elevation bedrock areas. Flat surface to steplike terraces.	Decomposed and undecomposed organic material with some silt.	Flat	PT, OL	Poor/Moderate to High	Low	At Surface	Discontinuous	High	High	Very Low	Low	Nil
L-f	Lacustrines (frozen)	Lowlands (below 3000') flat surface in the Tyone - Oshetna River area.	Sandy silt and silty sand with occasional pebbles, to gravelly sand. Often sorted and layered.	Gentle	SP, SW, ML	Frozen	High	Shallow (perched)	Discontinuous to Continuous	High	High	Low when Thawed. High when Frozen	Low	Poor
L / Gta	Lacustrine sediments over ablation till	Gently rolling to hummocky surface surrounding Butte Lake	Stratified sandy silt and silty sand over unsorted silty sandy gravel.	Gentle to Moderate	SP, SW, ML / GW, GM, SW, SM	Poor/Moderate	Moderate	Shallow	Sporadic	Moderate to High	Moderate to High	Low it Thawed. High when Frozen	Low	Fine - Poor Coarse - Fair
L / Gtb-f	Lacustrine deposits over basal till	Lowlands, (below 3000') between Stephan Lake and Watana Creek, and extending upstream past the Tyone River.	Well sorted silty sand and sandy silt overlying basal till.	Gentle to Moderate	SP, SW, ML, / SM, SM, ML	Lacustrine-Good/Good Basal Till-Frozen	Lacustrine-High Basal Till-Moderate	Moderately deep	L - sporadic to Discontinuous Gtb-f - Discontinuous to Continous	High	High	Low if Thawed. High when frozen	Low	Poor
Cs-f / Gtb-f	Solifluction deposits (frozen) over basal till (frozen)	Smooth to lobate steplike topography on gentle slopes above the proglacial lake level, west of Tsusena Creek.	Unsorted gravels, sands & silts with thin ice layers, contorted soil layering.	Moderate to Steep	GM, SM, ML	Frozen	Moderate	Shallow (perched)	Discontinuous to Continuous	High	High	Low when Thawed. High when Frozen	Low	Poor
Cs-f / Gta	Solifluction deposits (frozen) over ablation till	Smooth to lobate and hummocky topography along Deadman Creek	Silty, sandy, gravel and silty gravely sand showing contorted layering.	Moderate to Steep	GW, SW GM, SM	Frozen	Moderate	Shallow (perched) to Deep	Discontinuous to Continuous	High	High	Low if Thawed. High when Frozen	Low	Poor
Cs-f / Fpt	Solifluction deposits (frozen) over terrace sediments	Smooth to lobate flows of frozen fine grained materials, found on terrace of the Susitna, frequent between the Tyone and Oshetna Rivers.	Silty, sand and sandy silt showing contorted layering over gentle sorted and layered rounded cobbles, gravel and sand.	Gentle	SW, SM, ML / GW, SP, SW SP, SM, ML	Frozen	Moderate	Shallow (perched) to Deep	Discontinuous	High	High	High when Frozen. Low when Thawed.	Low	Fine - Poor Coarse - Good
Cs-f / Bxu	Solifluction deposits (frozen) over bedrock	Smooth to lobate steplike topography on the flanks of some mountains, north and south of the Devil Canyon area.	Mixed gravels sands and silts with thin ice layers and faint contorted soil layering over bedrock.	Moderate to Steep	GW, GM SW, SM, ML / bedrock	Frozen	High	Shallow (perched)	Discontinuous	High	High	High	Low	Poor
Gtb-f / Bxu	Frozen basal till over bedrock	Rolling lowland areas and moderate to steeply sloping river canyon walls. Transitional to high mountains areas.	Gravels, silty sand and sandy silt with no layering or sorting, overlying bedrock.	Moderate to Steep	SP, SM, ML, / bedrock	Frozen	Moderate	Shallow (perched)	Discontinuous to Continuous	High	High	Low if Thawed. High when Frozen	Low	Poor
Gta / Bxu	Ablation till over un-weathered bedrock	Hummocky rolling surface transitional to higher mountains adjacent to Deadman Creek.	Rounded and striated cobbles, gravel and sand, no sorting or layering, over bedrock.	Gentle to Steep	GW, GM, SW, SM / bedrock	Good/ High	Moderate	Shallow to Moderately deep	Sporadic	Low to Moderate	Low to Moderate	Low if Thawed High when Frozen	Moderate	Fine - Poor Coarse - Fair
C / Bxu + Bxu	Colluvium over bedrock and bedrock exposures	Higher elevation mountain areas and steep slopes along the Susitna River and its major tributaries.	Angular blocks of rock with some sand and silt overlying bedrock.	Steep to Near Vertical	GP, GW, GM, SW, SM / Bedrock	Good/Low to High	Moderate to High	Deep	Sporadic	Low to High	Low to Moderate	Low to Very High	Moderate to High	Fine - Poor Coarse - Fair
C / Bxw + Bxw	Colluvium over weathered, poorly consolidated bedrock	Small cliffs cut into tertiary non-marine sediments along Watana Creek and tertiary volcanics in Fog Creek.	Angular rubble with silt and sand over poorly consolidated sand over poorly consolidated or highly weathered bedrock.	Steep to Near Vertical	GM, SM, ML, GW, SW	Good/Low to Moderate	Moderate	Deep	Sporadic to Discontinuous	Low to High	Low to Moderate	Low to Moderate	Moderate	Fine - Poor Coarse - Poor

TERRAIN UNIT PROPERTIES AND ENGINEERING INTERPRETATIONS

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SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

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ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

DATE APRIL 1981

DEPARTMENT

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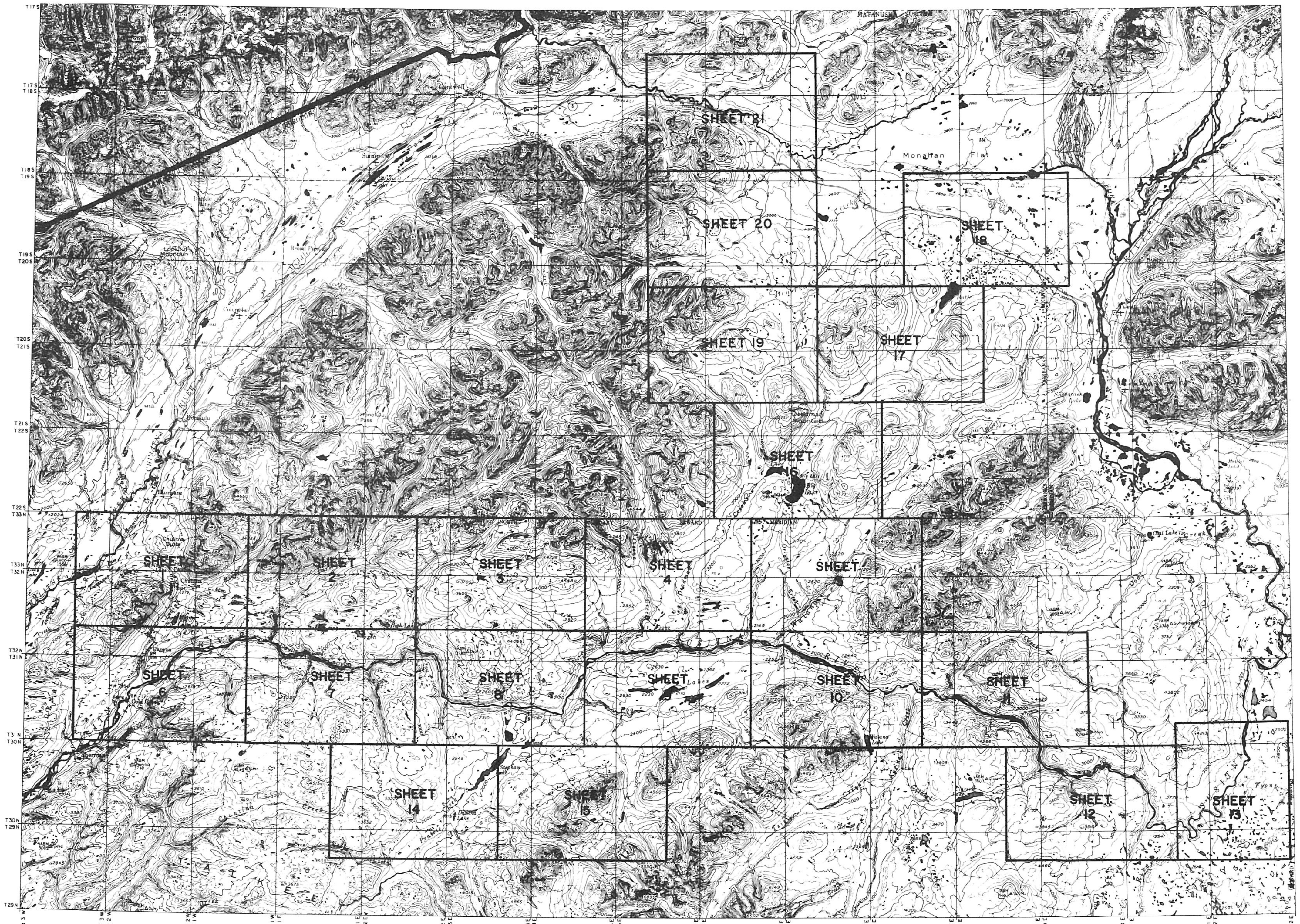

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SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT INDEX MAP

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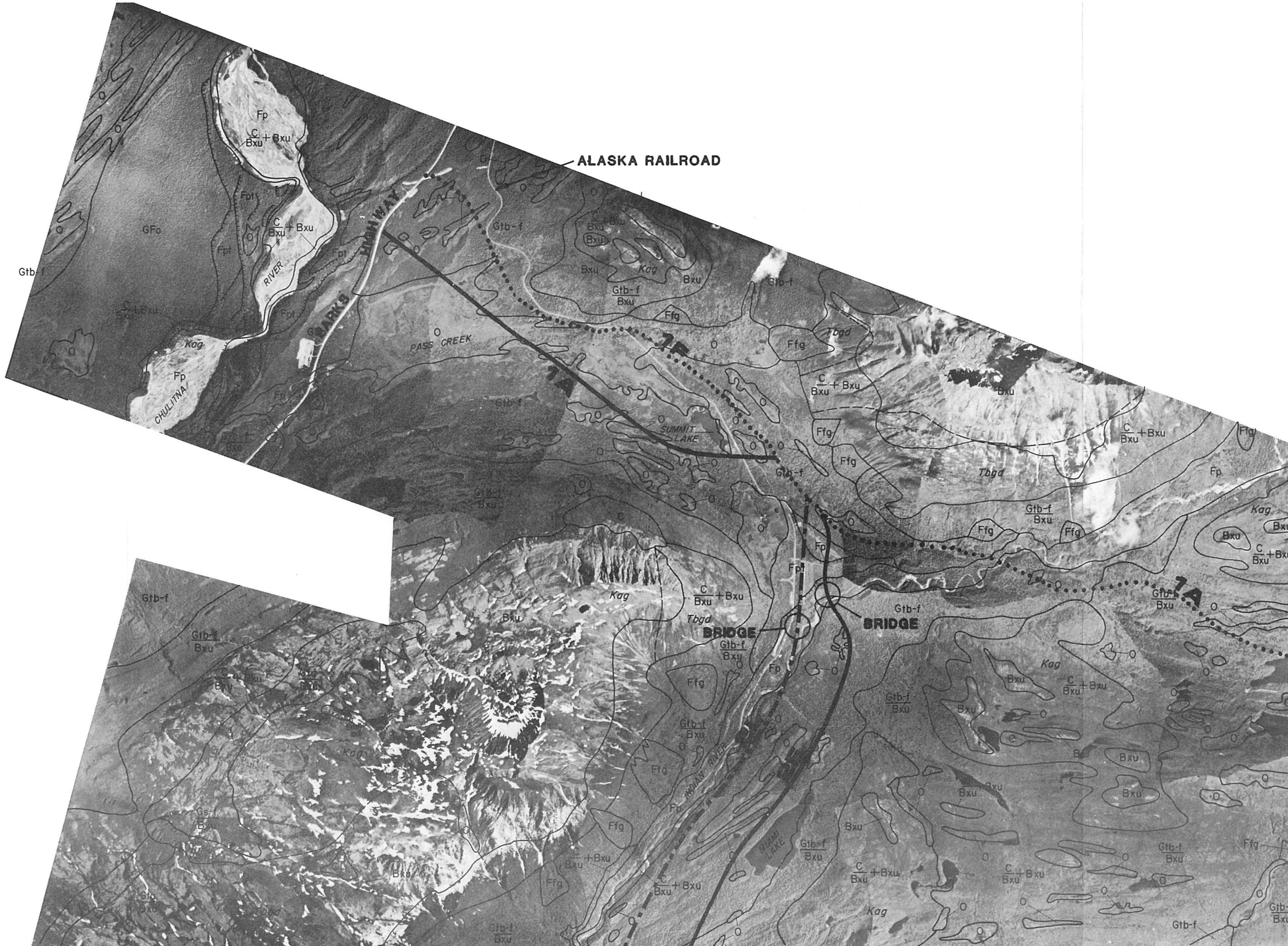

FOR CONTINUATION, SEE SHEET 2

FOR CONTINUATION, SEE SHEET 6

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over unweathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	Tv	Tsu	Tbgd	Tsmg	TKgr	Jam (Jtr)(Jgd)	₮v	Pzv (Pls)	Kag	₮vs
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.

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REV.

FOR CONTINUATION, SEE SHEET 1

FOR CONTINUATION, SEE SHEET 3

FOR CONTINUATION, SEE SHEET 7

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
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Fpt	Terrace
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TERRAIN UNIT MAPS

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DATE APRIL 1981 | SCALE

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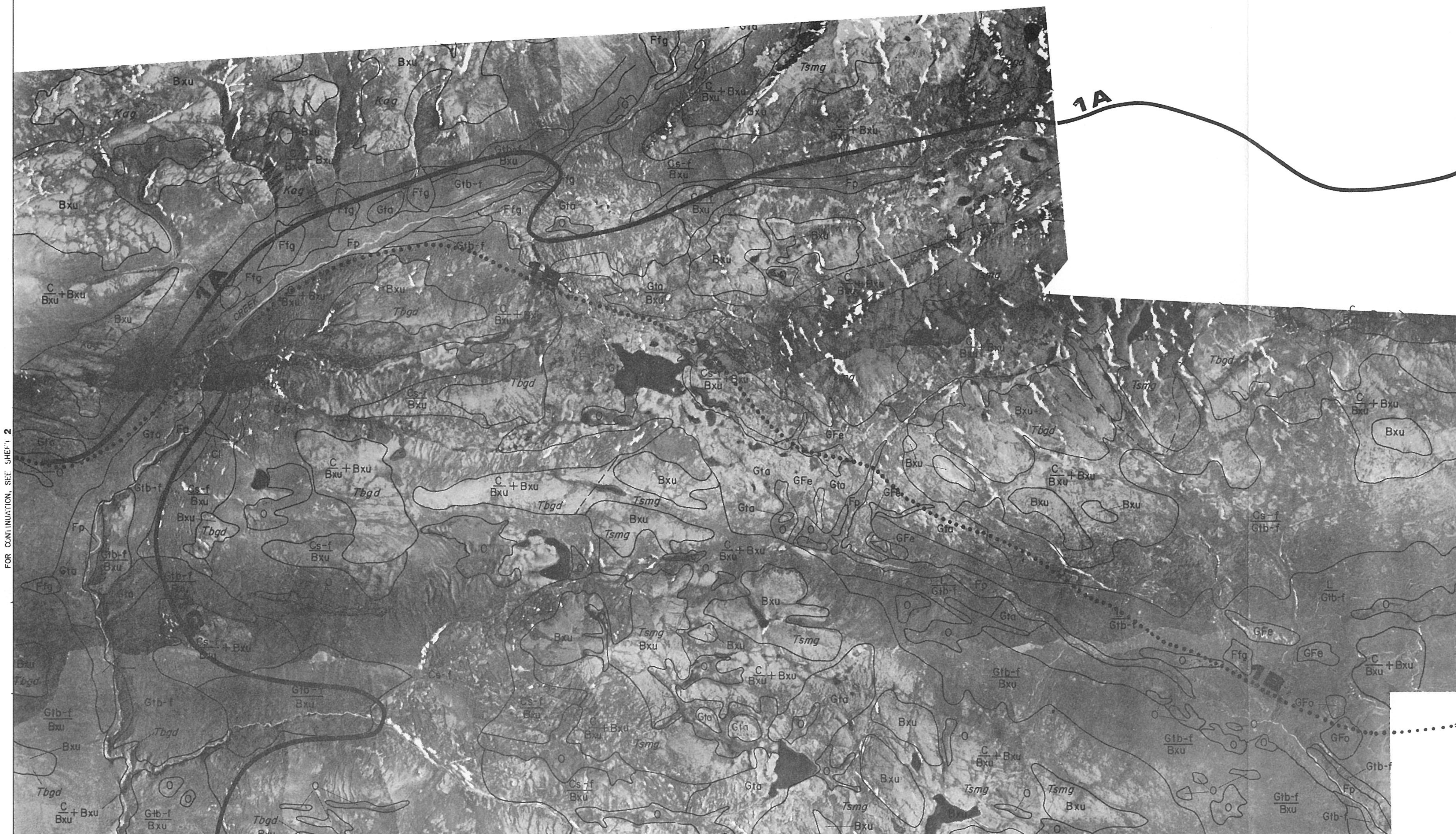

FOR CONTINUATION, SEE SHEET 2

FOR CONTINUATION, SEE SHEET 4

FOR CONTINUATION, SEE SHEET 8

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
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Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*T̄Rv*	*Pzv (Pls)*	*Kag*	*T̄Rvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp Slide Scar Buried Channel Trail Rock Contact

SCALE 0 2000 4000 FEET

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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

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TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.

DATE APRIL 1981

DEPARTMENT

PROJECT 052502

SCALE

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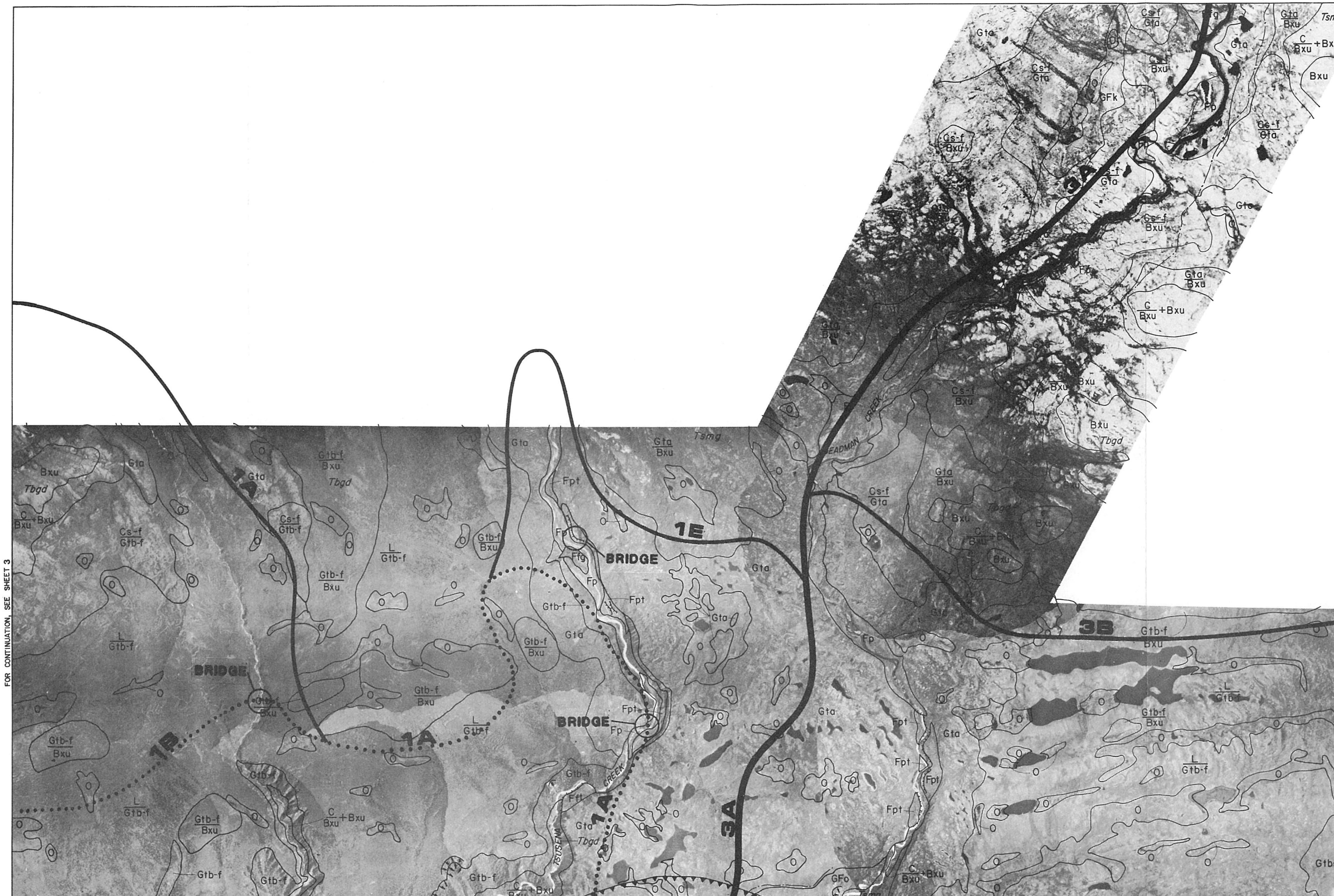
FOR CONTINUATION, SEE SHEET 3



FOR CONTINUATION, SEE SHEET 5

FOR CONTINUATION, SEE SHEET 9

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
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SCALE 0 2000 4000 FEET

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SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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DATE APRIL 1981 | SCALE
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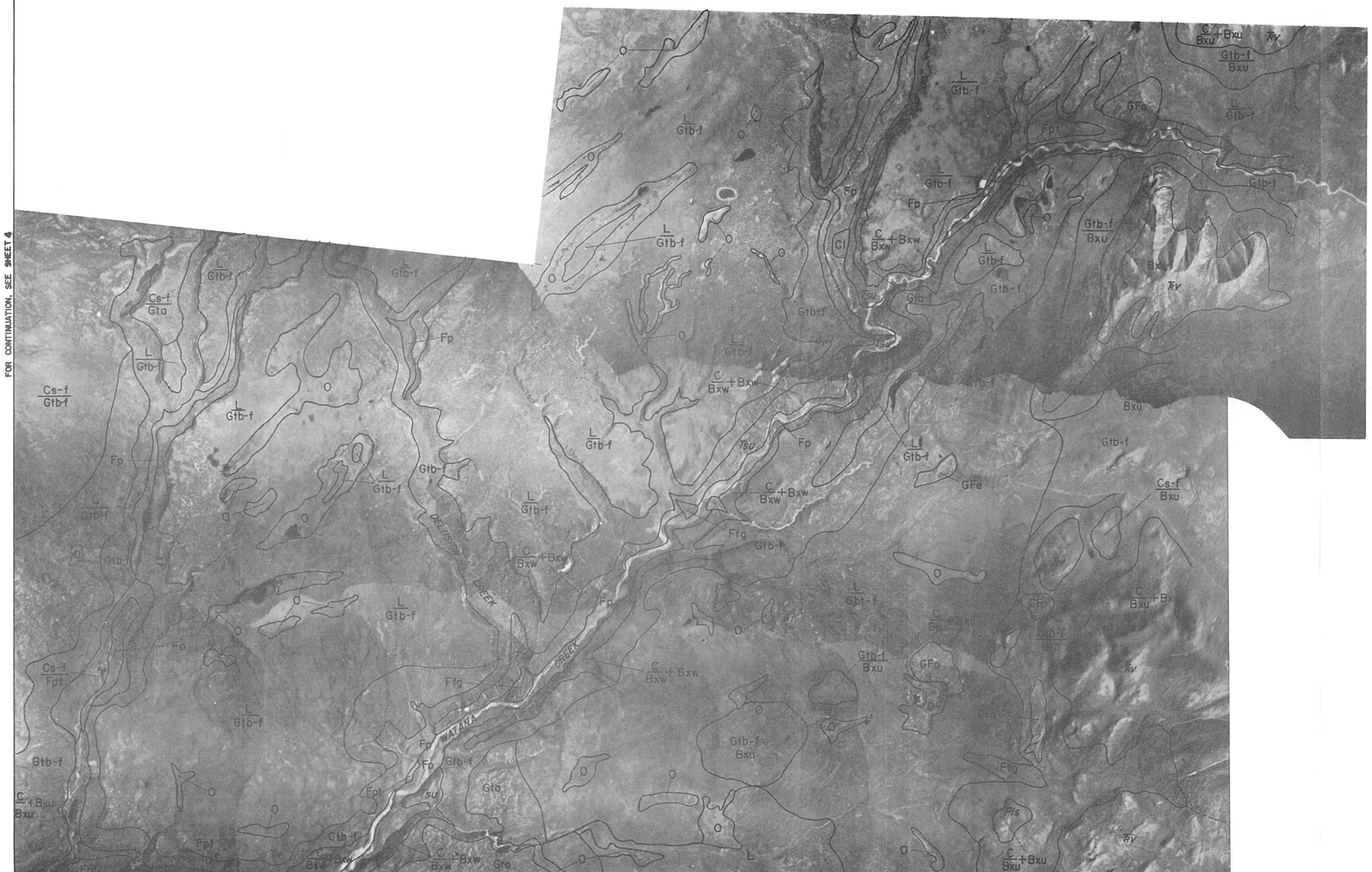
FOR CONTINUATION, SEE SHEET 4



FOR CONTINUATION, SEE SHEET 10

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C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*R̄v*	*Pzv (Pls)*	*Kag*	*R̄vs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sand-stone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of green-schist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic meta-volcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp Slide Scar Buried Channel Trail Rock Contact

SCALE 0 2000 4000 FEET

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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

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FOR CONTINUATION, SEE SHEET 1

FOR CONTINUATION, SEE SHEET 7

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
$\frac{L}{Gta}$	Lacustrine sediments over ablation till
$\frac{L}{Gtb\text{-}f}$	Lacustrine deposits over basal till (frozen)
$\frac{Cs\text{-}f}{Gtb\text{-}f}$	Solifluction deposits (frozen) over basal till (frozen)
$\frac{Cs\text{-}f}{Gta}$	Solifluction deposits (frozen) over ablation till
$\frac{Cs\text{-}f}{Fpt}$	Solifluction deposits (frozen) over terrace sediments
$\frac{Cs\text{-}f}{Bxu}$	Solifluction deposits (frozen) over bedrock
$\frac{Gtb\text{-}f}{Bxu}$	Frozen basal till over bedrock
$\frac{Gta}{Bxu}$	Ablation till over unweathered bedrock
$\frac{C}{Bxu}$ + Bxu	Colluvium over bedrock and bedrock exposures
$\frac{C}{Bxw}$ + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*TRv*	*Pzv (Pls)*	*Kag*	*TRvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

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ALASKA POWER AUTHORITY

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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FOR CONTINUATION, SEE SHEET 6

FOR CONTINUATION, SEE SHEET 8

FOR CONTINUATION, SEE SHEET 14

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over unweathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*TRv*	*Pzv (Pls)*	*Kag*	*TRvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp Slide Scar Buried Channel Trail Rock Contact

SCALE 0 2000 4000 FEET

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ALASKA POWER AUTHORITY

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TERRAIN UNIT MAPS

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FOR CONTINUATION, SEE SHEET 7

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FOR CONTINUATION, SEE SHEET 14

FOR CONTINUATION, SEE SHEET 15

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L / Gta	Lacustrine sediments over ablation till
L / Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f / Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f / Gta	Solifluction deposits (frozen) over ablation till
Cs-f / Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f / Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f / Bxu	Frozen basal till over bedrock
Gta / Bxu	Ablation till over un-weathered bedrock
C / Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C / Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*T̄Rv*	*Pzv (Pls)*	*Kag*	*T̄Rvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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ALASKA POWER AUTHORITY

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SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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DATE APRIL 1981

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SCALE

DRAWING NO.

SHEET 8 OF 21

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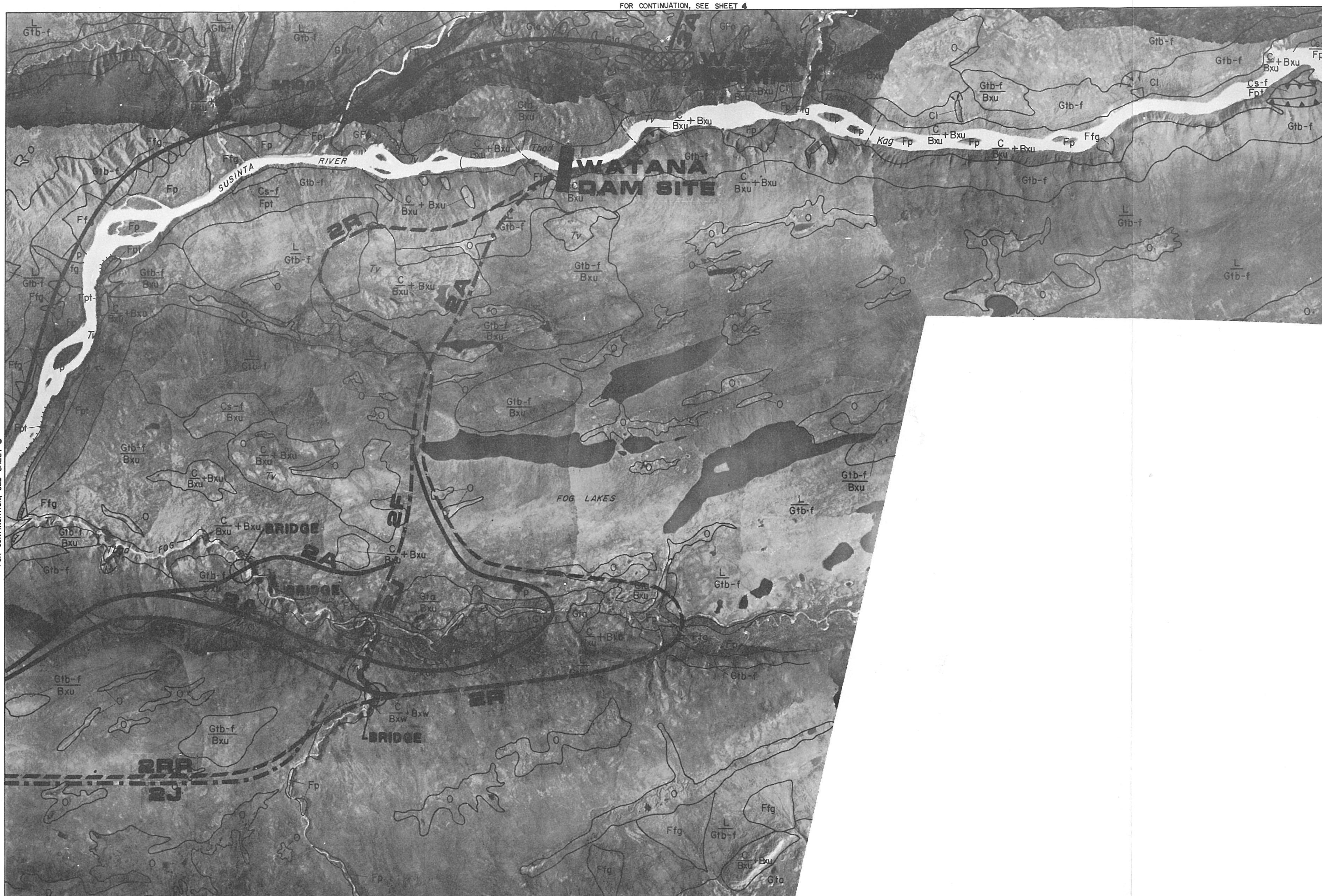

FOR CONTINUATION, SEE SHEET 8

FOR CONTINUATION, SEE SHEET 10

FOR CONTINUATION, SEE SHEET 15

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L / Gta	Lacustrine sediments over ablation till
L / Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f / Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f / Gta	Solifluction deposits (frozen) over ablation till
Cs-f / Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f / Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f / Bxu	Frozen basal till over bedrock
Gta / Bxu	Ablation till over un-weathered bedrock
C / Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C / Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*T̄Rv*	*Pzv (Pls)*	*Kag*	*T̄Rvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of green-schist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic meta-volcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.

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FOR CONTINUATION, SEE SHEET 5

FOR CONTINUATION, SEE SHEET 9

FOR CONTINUATION, SEE SHEET 11

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over unweathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	Abbreviated Descriptions
Tv	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.
Tsu	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.
Tbgd	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).
Tsmg	Tertiary schist, migmatite and granite, representing the roof of a large stock.
TKgr	Tertiary and/or Cretaceous granitics forming small plutons.
Jam (Jtr)(Jgd)	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).
₮v	Triassic basaltic metavolcanic rocks formed in shallow marine environment.
Pzv (Pls)	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).
Kag	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.
₮vs	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.

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FOR CONTINUATION, SEE SHEET 10

FOR CONTINUATION, SEE SHEET 12

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over un-weathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*Ŧv*	*Pzv (Pls)*	*Kag*	*Ŧvs*
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sand-stone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of green-schist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic meta-volcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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DATE APRIL 1981

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PROJECT 052502

SCALE

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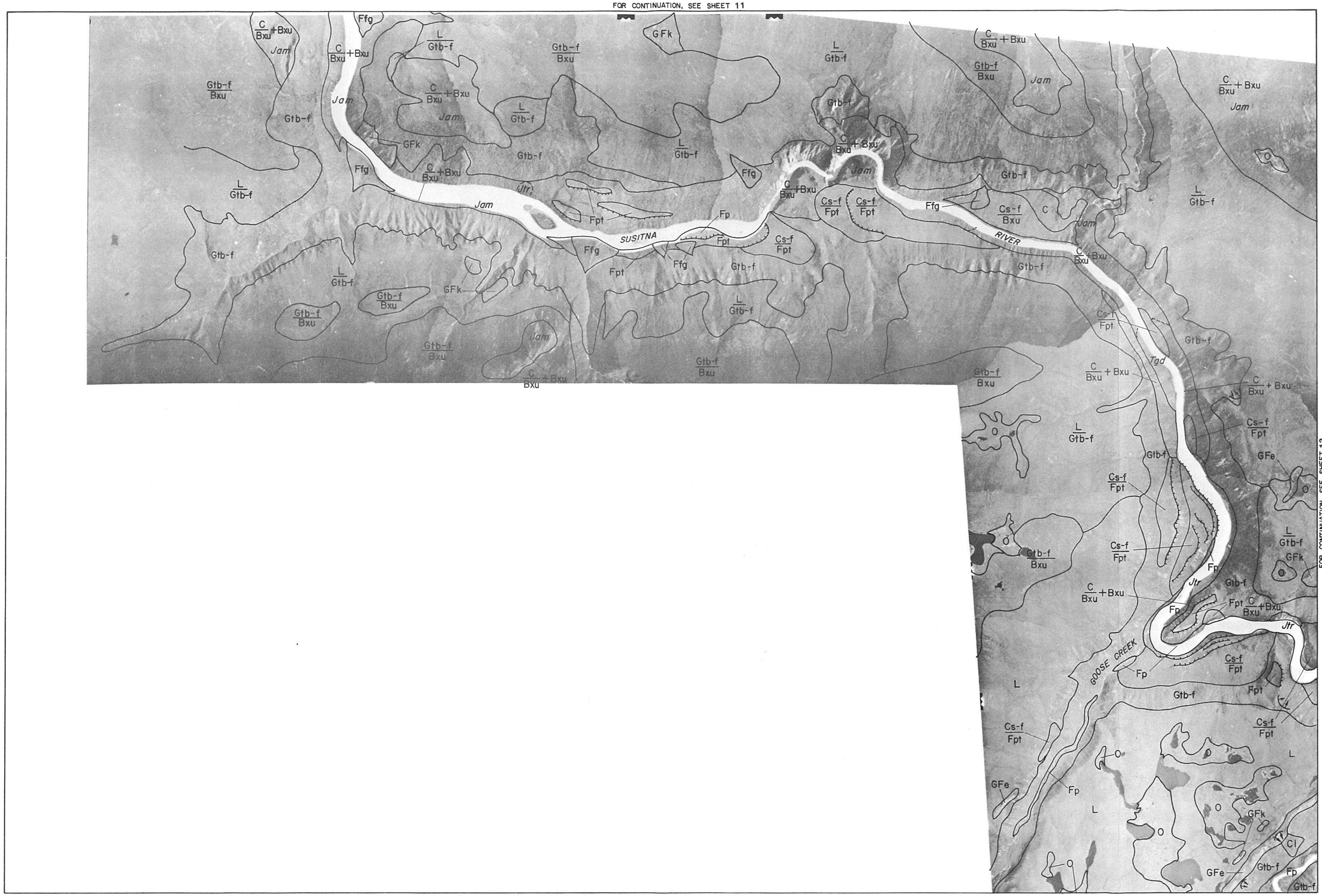
FOR CONTINUATION, SEE SHEET 11



FOR CONTINUATION, SEE SHEET 13

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over unweathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	Tv	Tsu	Tbgd	Tsmg	TKgr	Jam (Jtr)(Jgd)	₸v	Pzv (Pls)	Kag	₸vs
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over un-weathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	Tv	Tsu	Tbgd	Tsmg	TKgr	Jam (Jtr)(Jgd)	TRv	Pzv (Pls)	Kag	TRvs
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sand-stone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of green-schist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic meta-volcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

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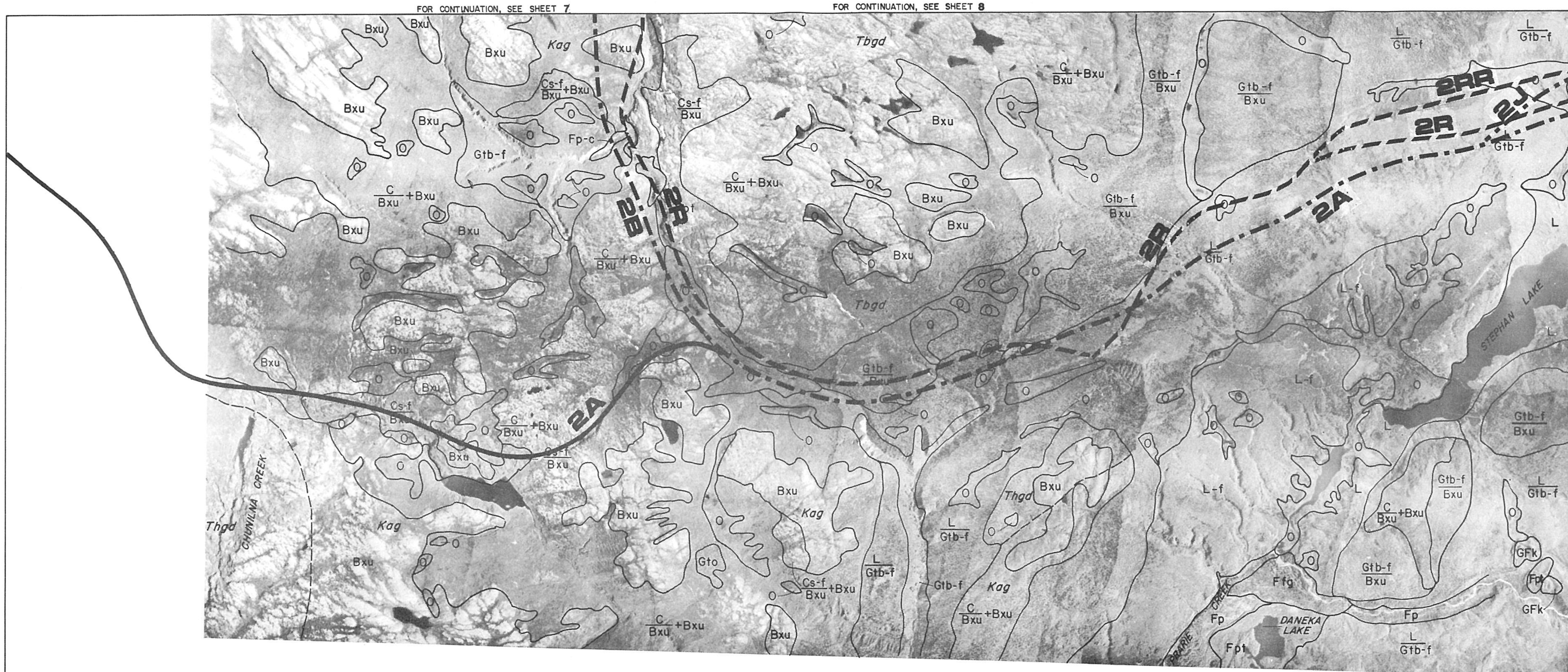
FOR CONTINUATION, SEE SHEET 8



FOR CONTINUATION, SEE SHEET 15

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
Cs-f/Gtb-f	Solifluction deposits (frozen) over basal till (frozen)
Cs-f/Gta	Solifluction deposits (frozen) over ablation till
Cs-f/Fpt	Solifluction deposits (frozen) over terrace sediments
Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over unweathered bedrock
C/Bxu + Bxu	Colluvium over bedrock and bedrock exposures
C/Bxw + Bxw	Colluvium over weathered or poorly consolidated bedrock

Bedrock Mapping Units	Tv	Tsu	Tbgd	Tsmg	TKgr	Jam (Jtr)(Jgd)	₮v	Pzv (Pls)	Kag	₮vs
Abbreviated Descriptions	Tertiary Volcanic rocks; shallow intrusives, flows, and pyroclastics; rhyolitic to basaltic.	Tertiary non-marine sedimentary rocks; conglomerate, sandstone, and claystone.	Tertiary biotite granodiorite; local hornblende granodiorite (Thgd).	Tertiary schist, migmatite and granite, representing the roof of a large stock.	Tertiary and/or Cretaceous granitics forming small plutons.	Jurassic amphibolite, inclusions of greenschist & marble; local trondjemite (Jtr) and granodiorite (Jgd).	Triassic basaltic metavolcanic rocks formed in shallow marine environment.	Late Paleozoic basaltic and andesitic metavolcanogenic rocks, local meta-limestone (Pls).	Cretaceous argillite and graywacke, of a thick deformed turbidite sequence, lowgrade metamorphism.	Triassic metabasalt and slate, an interbedded shallow marine sequence.

Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

DATE	NO.	REVISIONS	CH.	APP.	APP.

ACRES

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

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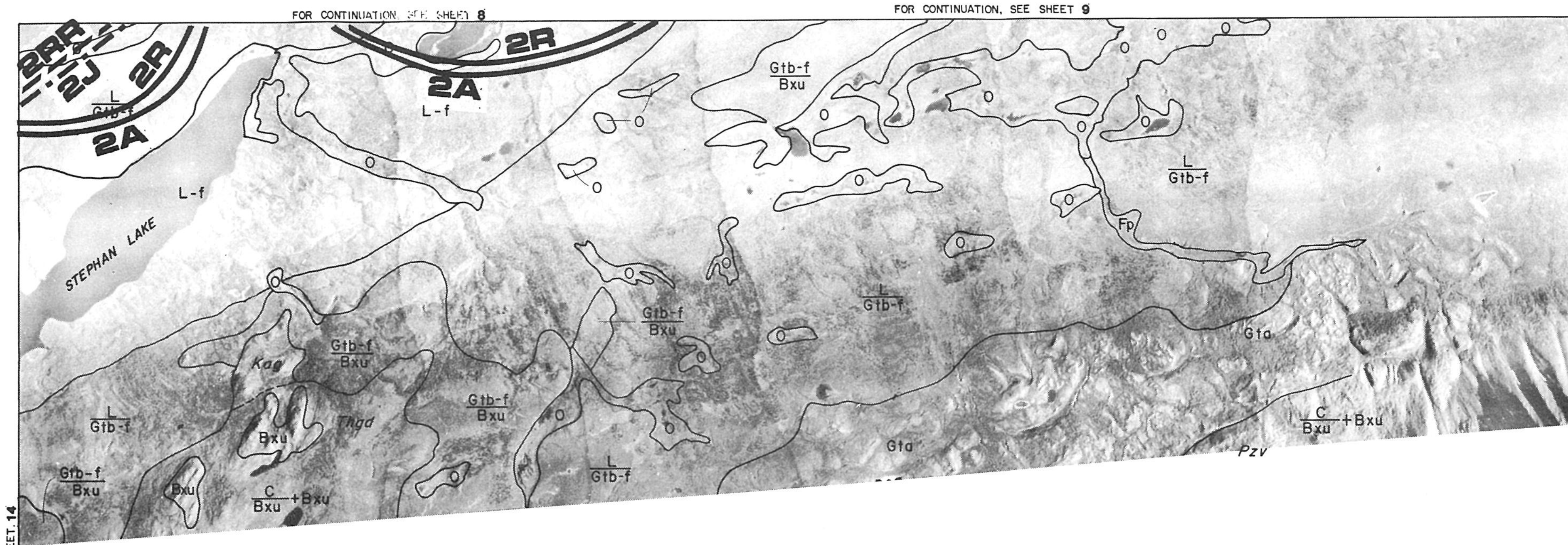
FOR CONTINUATION, SEE SHEET 9
FOR CONTINUATION, SEE SHEET 14



Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
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Cl	Landslide
Cs-f	Solifluction deposits (frozen)
Ffg	Granular alluvial fan
Fp	Floodplain deposits
Fpt	Terrace
GFo	Outwash deposits
GFe	Esker deposits
GFk	Kame deposits
Gta	Ablation till
Gtb-f	Basal till (frozen)
O	Organic deposits
L-f	Lacustrines (frozen)
L/Gta	Lacustrine sediments over ablation till
L/Gtb-f	Lacustrine deposits over basal till (frozen)
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Cs-f/Bxu	Solifluction deposits (frozen) over bedrock
Gtb-f/Bxu	Frozen basal till over bedrock
Gta/Bxu	Ablation till over un-weathered bedrock
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Bedrock Mapping Units	*Tv*	*Tsu*	*Tbgd*	*Tsmg*	*TKgr*	*Jam (Jtr)(Jgd)*	*TRv*	*Pzv (Pls)*	*Kag*	*TRvs*
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Miscellaneous Map Symbols

Scarp · Slide Scar · Buried Channel · Trail · Rock Contact

SCALE 0 2000 4000 FEET

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SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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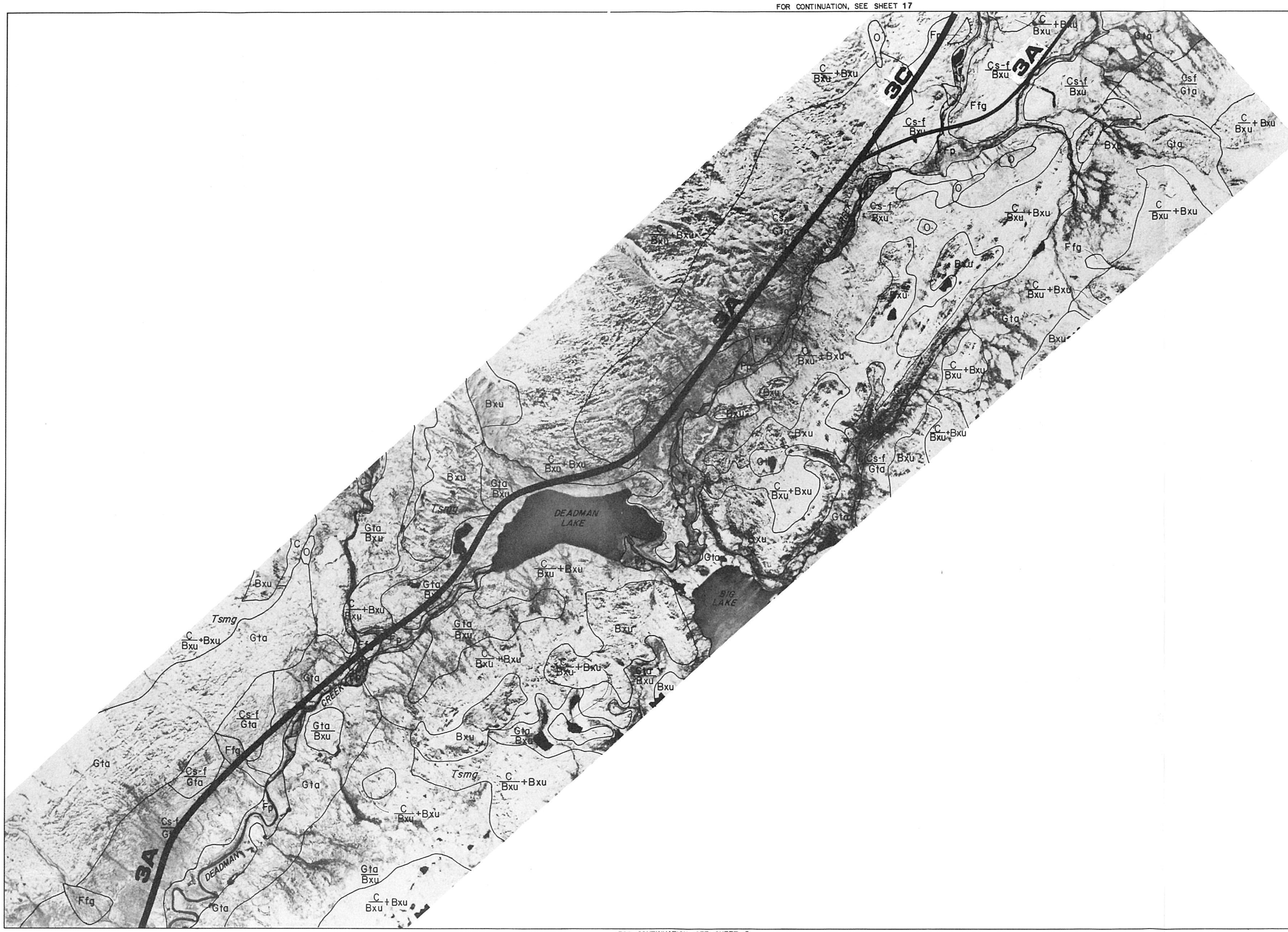

FOR CONTINUATION, SEE SHEET 9

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
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Cs-f	Solifluction deposits (frozen)
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GFk	Kame deposits
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O	Organic deposits
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Miscellaneous Map Symbols

Scarp Slide Scar Buried Channel Trail Rock Contact

SCALE 0 2000 4000 FEET

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SUSITNA HYDROELECTRIC PROJECT

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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

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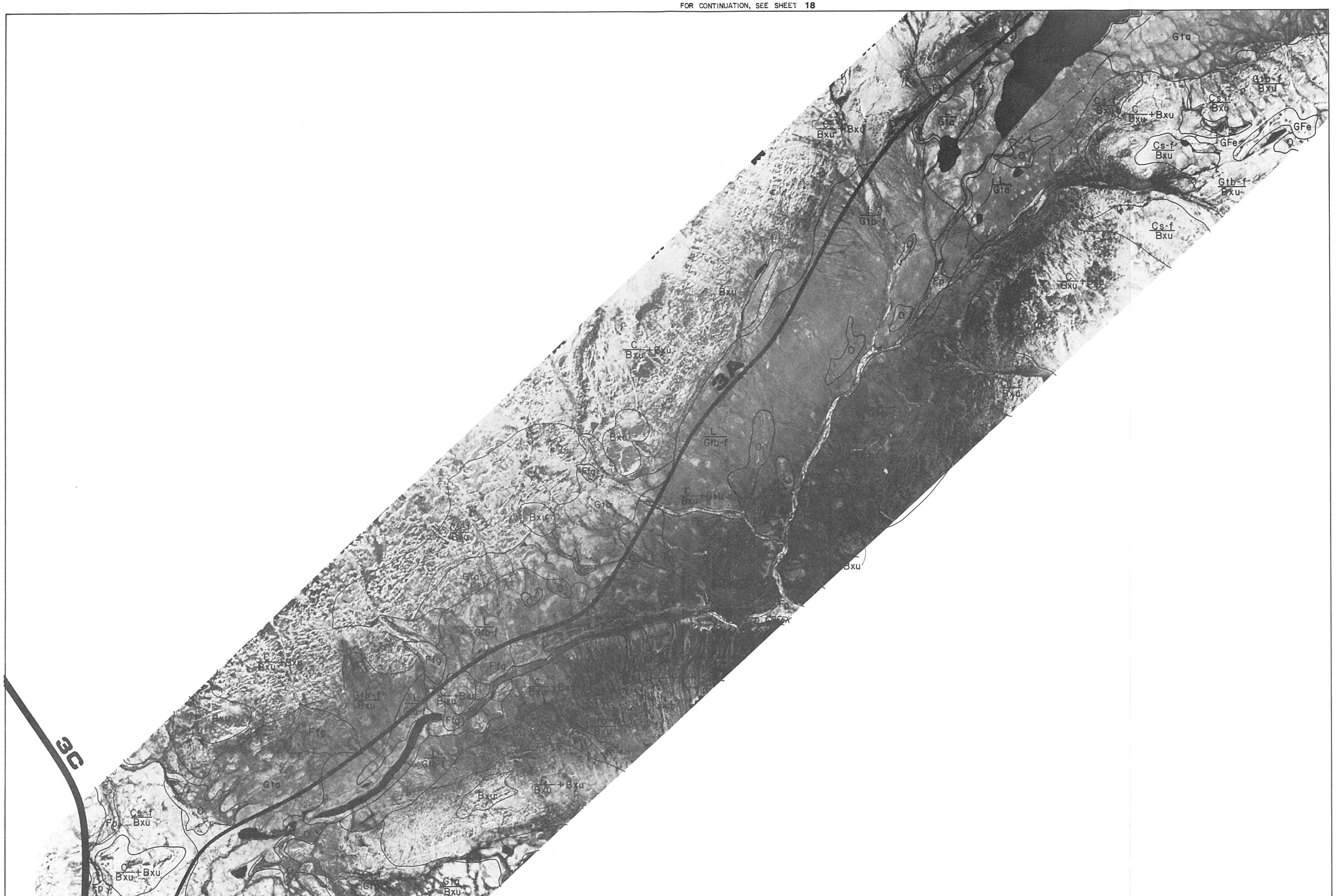

FOR CONTINUATION, SEE SHEET 16

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
C	Colluvial deposits
Cl	Landslide
Cs-f	Solifluction deposits (frozen)
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Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

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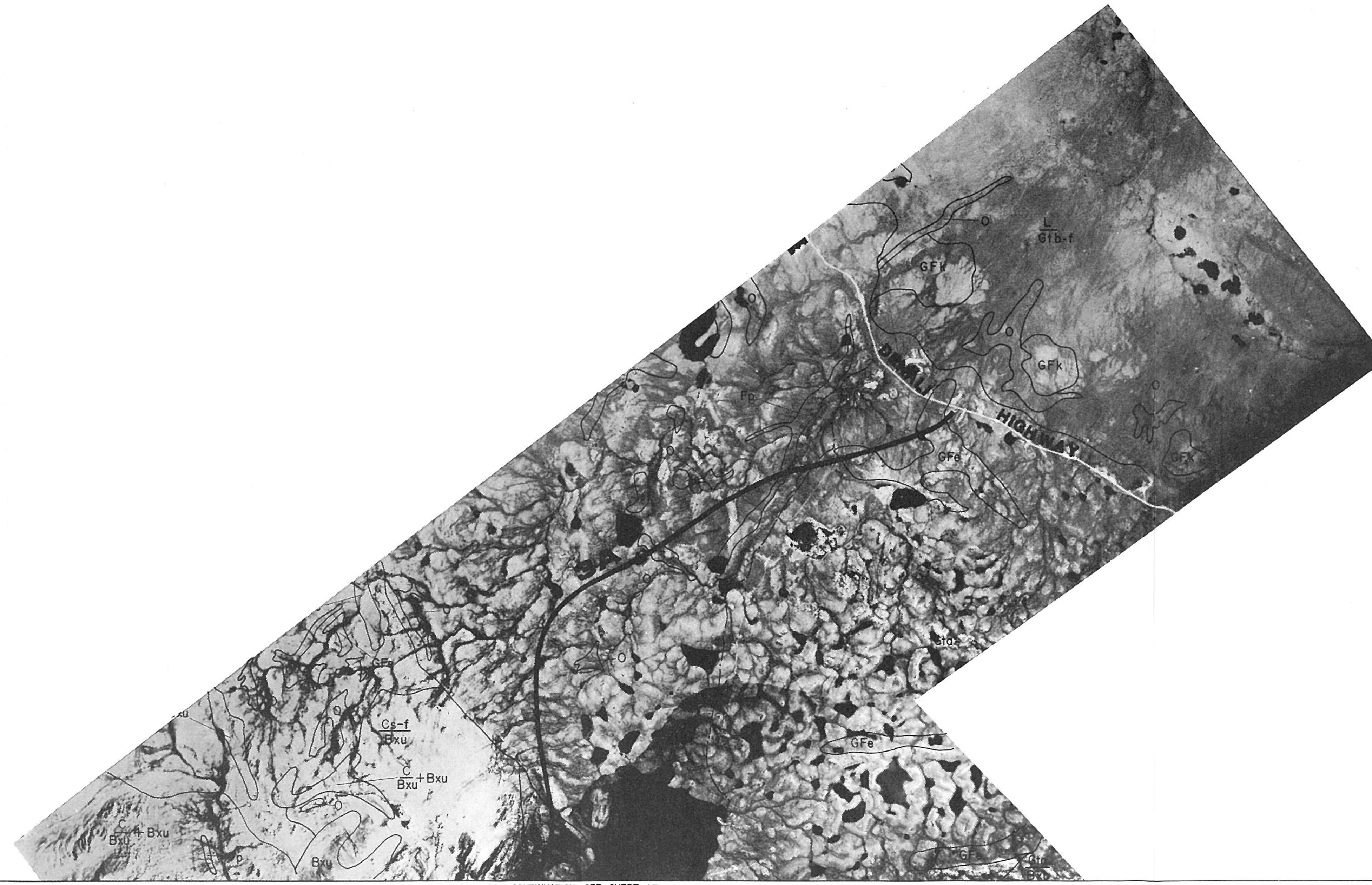

FOR CONTINUATION, SEE SHEET 17

Terrain Unit Symbol	Terrain Unit Name
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Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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SUBTASK 5.02

PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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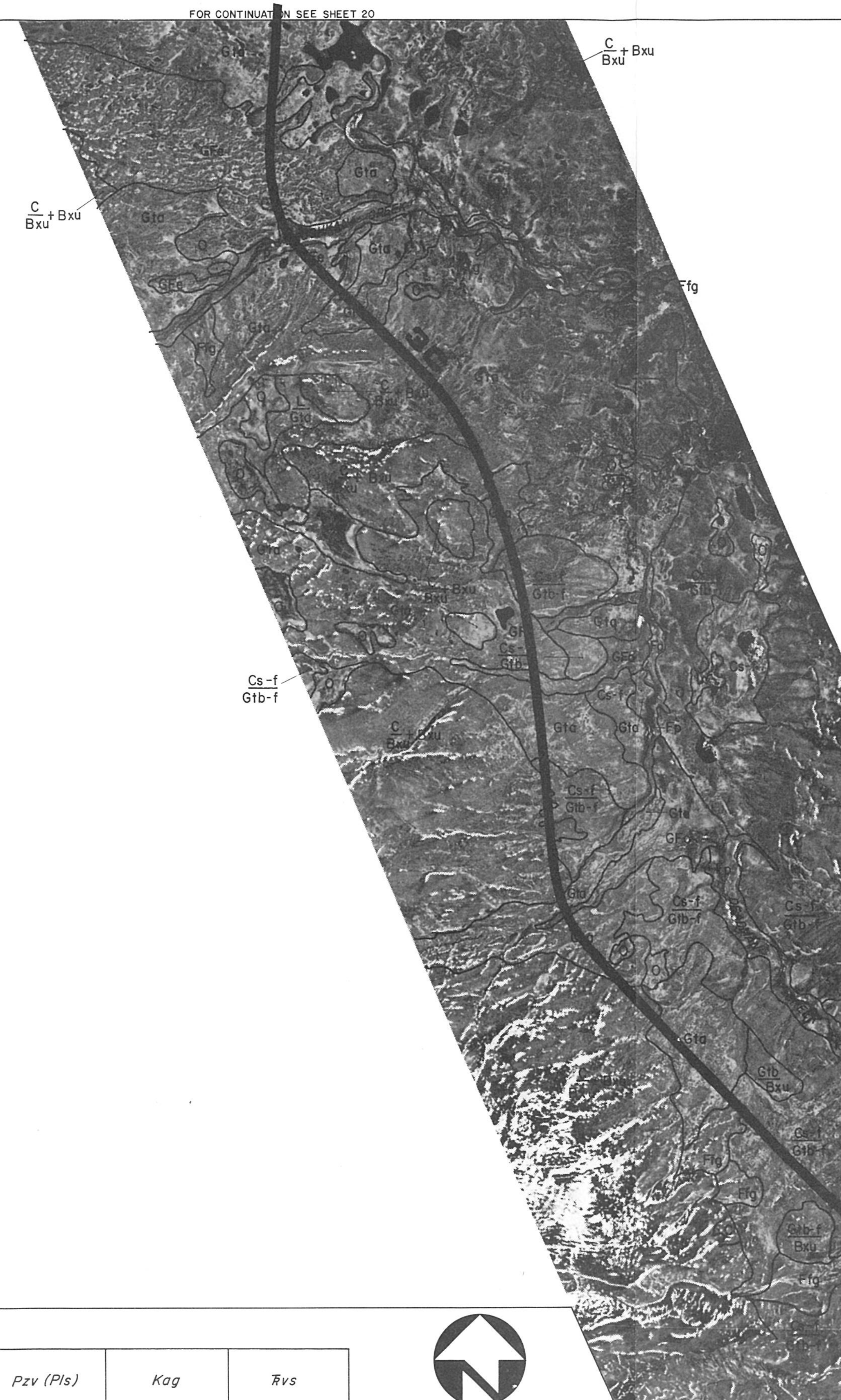

FOR CONTINUATION SEE SHEET 16

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
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Miscellaneous Map Symbols

Scarp — Slide Scar — Buried Channel — Trail — Rock Contact

SCALE 0 2000 4000 FEET

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SUBTASK 5.02

PHOTO INTERPRETATION

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FOR CONTINUATION SEE SHEET 19

Terrain Unit Symbol	Terrain Unit Name
Bxu	Unweathered, consolidated bedrock
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PHOTO INTERPRETATION

TERRAIN UNIT MAPS

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DEPARTMENT

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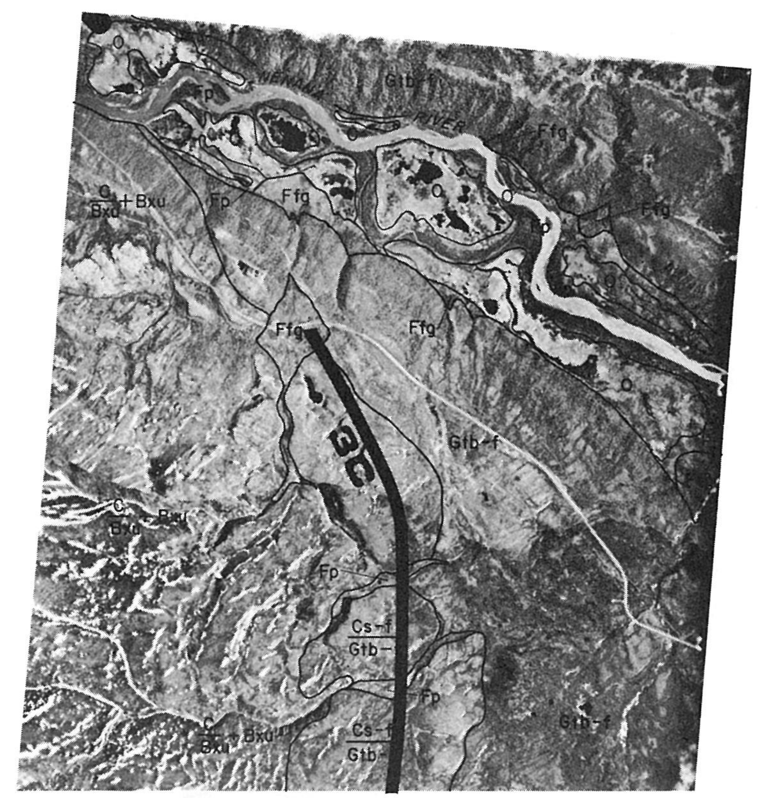

FOR CONTINUATION SEE SHEET 20

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D.10 SOILS LOGS

SOILS
CLASSIFICATION AND CONSISTENCY

CLASSIFICATION: Identification and classification of the soil is accomplished in accordance with the Unified Soil Classification System. Normally, the grain size distirbution determines classification of the soil. The soil is defined according to major and minor constituents with the minor elements serving as modifiers of the major elements. Minor soil constitutents may be added to the classification breakdown in accordance with the particle size proportions listed below; (i.e., sandy silt with some gravel, trace clay).

no call - 0-3%   trace - 3-12%   some - 13-30%   sandy, silty, gravelly - >30%

Identification and classification of soil strata which have a significant cobble and boulder content is based on the unified classification of the minus 3 inch fraction augmented by a description (i.e., cobbles and boulders) of the plus 3 inch fraction. Where a gradation curve, which includes the plus 3 inch fraction, exists (samples from test trenches and pits) a modifier is used to describe independently the percentage of each of the two plus 3 inch components. If there is no gradation curve incorporating the plus 3-inch fraction (as in auger holes), the plus 3-inch material is described as a single component (i.e., cobbles and boulders), and a modifier is used to indicate the relative percentage of the plus 3-inch fraction based on the field logs. The modifiers in each case are used as follows:

Scattered - 0-40%   Numerous - >40%

SOIL CONSISTENCY - CRITERIA: Soil consistency as defined below and determined by normal field and laboratory methods applies only to non-frozen material. For these materials, the influence of such factors as soil structure, i.e. fissure systems, shrinkage cracks, slickensides, etc., must be taken into consideration in making any correlation with the consistency values listed below. In permafrost zones, the consistency and strength of frozen soils may vary significantly and unexplainably with ice content, thermal regime and soil type.

Cohesionless Soils	N* (blows/ft)	Relative Density
Very Loose	0 - 4	20%
Loose	4 - 10	20 to 40%
Medium Dense	10 - 30	40 to 60%
Dense	30 - 50	60 to 80%
Very Dense	>50	>80%

Cohesive Soils	N* (blows/ft)	qu - (tsf)
Very Soft	0 - 2	0 - 0.25
Soft	2 - 4	0.25 - 0.5
Medium	4 - 8	0.5 - 1.0
Stiff	8 - 15	1.0 - 2.0
Very Stiff	15 - 30	2.0 - 4.0
Hard	>30	>4.0

* Standard Penetration "N": Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch OD split-spoon except where noted.

Often the split-spoon samplers do not reach the total intended sample depth. Where this occurs the graphic log notes a refusal (Ref.) and give an indication of the cause of the refusal. Tight soils are indicated by a blow count value followed by a penetration length in inches. The presense of large rock fragments is indicated by a cobble and boulder callout following the refusal callout. In certain instances a blow count of 100+ may be listed to indicate tight soils where total sampler penetration is possible with more than 100 blows per foot.

PREPARED BY: R&M CONSULTANTS, INC.

PREPARED FOR: ACRES

EXPLANATION OF SELECTED SYMBOLS

STANDARD SYMBOLS

- ORGANIC MATERIAL
- CLAY
- SILT
- SAND
- GRAVEL
- COBBLES & BOULDERS
- CONGLOMERATE
- SANDSTONE
- MUDSTONE
- LIMESTONE
- IGNEOUS ROCK
- METAMORPHIC ROCK
- ICE, MASSIVE
- ICE - SILT
- ORGANIC SILT
- SANDY SILT
- SILT GRADING TO SANDY SILT
- SANDY GRAVEL, SCATTERED COBBLES (ROCK FRAGMENTS)
- INTERLAYERED SAND & SANDY GRAVEL
- SILTY CLAY w/TR. SAND

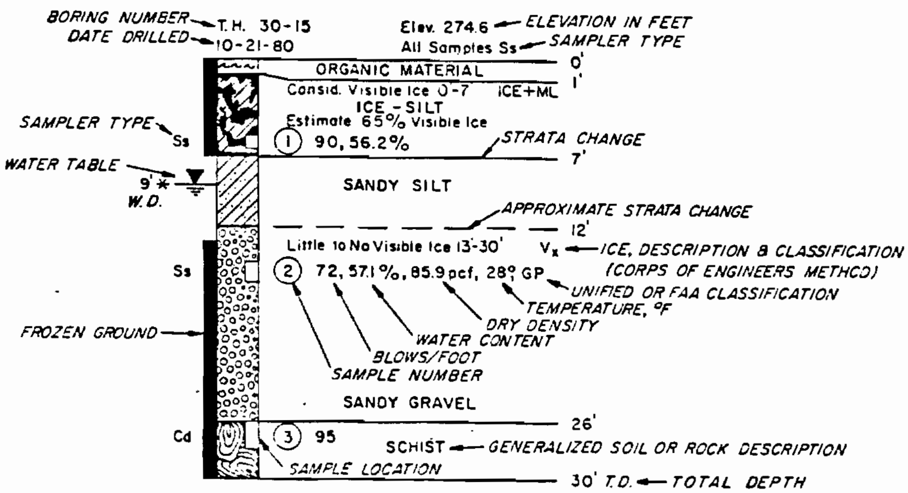
SAMPLER TYPE SYMBOLS

St . . . . . 1.4" SPLIT SPOON WITH 47 # HAMMER
Ss . . . . . 1.4" SPLIT SPOON WITH 140 # HAMMER
Sl . . . . . 2.5" SPLIT SPOON WITH 140 # HAMMER
Sh . . . . . 2.5" SPLIT SPOON WITH 340# HAMMER
Sx . . . . . 2.0" SPLIT SPOON WITH 140 # HAMMER
Sz . . . . . 1.4" SPLIT SPOON WITH 340# HAMMER
Sp . . . . . 2.5" SPLIT SPOON, PUSHED
Hs . . . . . 1.4" SPLIT SPOON DRIVEN WITH AIR HAMMER
Hl . . . . . 2.5" SPLIT SPOON DRIVEN WITH AIR HAMMER

Ts . . . . SHELBY TUBE
Tm. . . . MODIFIED SHELBY TUBE
Pb . . . . PITCHER BARREL
Cs . . . . CORE BARREL WITH SINGLE TUBE
Cd . . . . CORE BARREL WITH DOUBLE TUBE
Bs . . . . BULK SAMPLE
A. . . . . AUGER SAMPLE
G. . . . . GRAB SAMPLE

NOTE: SAMPLER TYPES ARE EITHER NOTED ABOVE THE BORING LOG OR ADJACENT TO IT AT THE RESPECTIVE SAMPLE DEPTH.

TYPICAL BORING LOG



DRILLING SYMBOLS

WD: While Drilling
WL: Water Level
WS: While Sampling
AB: After Boring
TD: Total Depth

Note: Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious unfrozen soils, the indicated elevations are considered to represent actual ground water conditions. In impervious and frozen soils, accurate determinations of ground water elevations cannot be obtained within a limited period of observation and other evidence on ground water elevations and conditions are required.

PREPARED BY: R&M CONSULTANTS, INC.

EXPLANATION OF SELECTED SYMBOLS

PREPARED FOR: ACRES

EXPLANATION OF ICE SYMBOLS

Percentage of visible ice has been grouped for the purpose of designating the amount of soil ice content. These groups have arbitrarily been set out as follows:

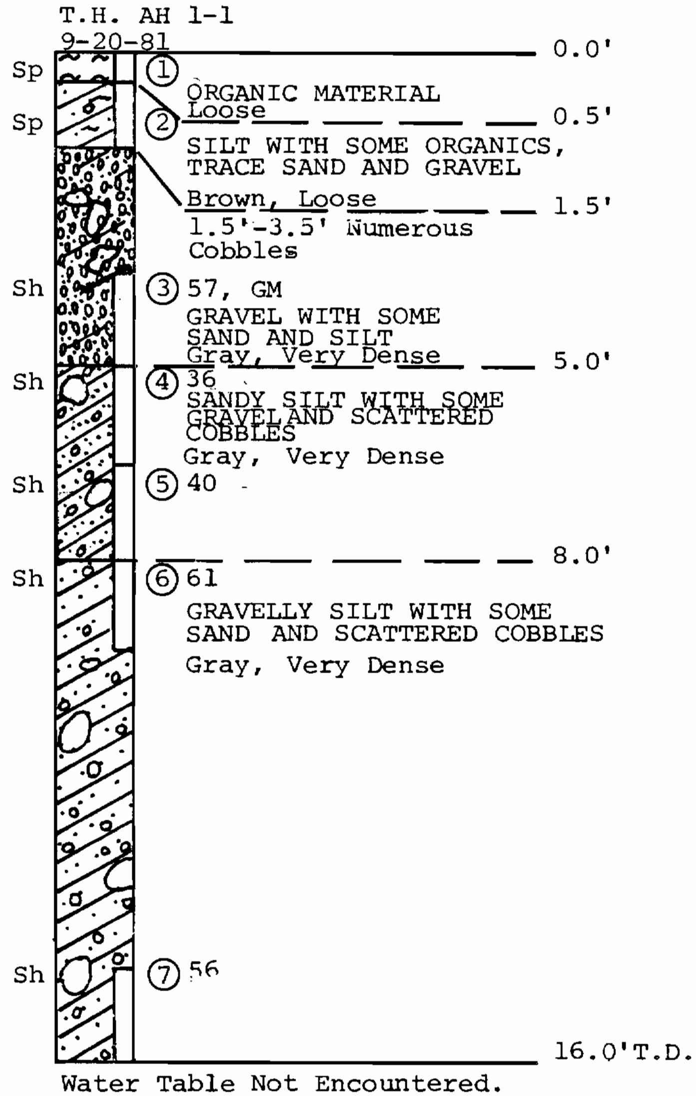
0%	No Visible Ice
1% - 10%	Little Visible Ice
11% - 20%	Occasional Visible Ice
21% - 35%	Some Visible Ice
>35%	Considerable Visible Ice

The ice description system is based on that presented by K. A. Linell, and C. W. Kaplar (1966). In this system, which is an extension of the Unified Soil Classification System, the amount and physical characteristics of the soil ice are accounted for. The following table is a brief summary of the salient points of their classification system as modified to meet the needs of this study.

ICE DESCRIPTIONS

GROUP SYMBOL	ICE VISIBILITY & CONTENT	SUBGROUP DESCRIPTION	SUBGROUP SYMBOL
N	Ice not visible	Poorly bonded or friable	N_f
		Well bonded — No excess ice	N_b — N_{bn}
		Well bonded — Excess ice	N_b — N_{be}
V	Ice visible, <50%	Individual ice crystals or inclusions	V_x
		Ice coatings on particles	V_c
		Random or irregularly oriented ice formations	V_r
		Stratified or distinctly oriented ice formations	V_s
ICE	Ice visible, >50%	Ice with soil inclusions	ICE + soil type
	Individual layer >6" thick *	Ice without soil inclusions	ICE

* In some cases where the soil is ice poor a thin ice layer may be called out by special notation on the log, i.e. 2" ice lens at 7'



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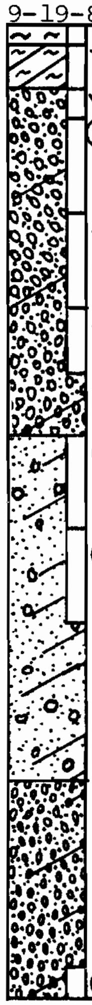
ACCESS CORRIDORS
AUGER HOLE AH 1-1

Prepared for: ACRES

Scale: 1"=3'

T.H.- AH 2-2
9-19-81



Sample type	No.	Description	Depth
			0.0'
Sp	(1)	ORGANIC MATERIAL Loose	
			0.3'
Sp	(2)	SILT WITH SOME ORGANICS	
Sp	(3)	Brown, Loose	
			1.0'
Sh	(4)	41	
Sh	(5)	46, GM SANDY GRAVEL WITH SOME SILT Gray, Dense to Very Dense	
Sh	(6)	Ref, 50/4.0"	
			6.5'
Sh	(7)	105	
Sh	(8)	110 , 6.5%, 124.3 pcf., SM	
		SILTY SAND WITH SOME GRAVEL Gray, Very Dense	
12.0' W.D.			12.0'
		Completely Weathered PHYLLITE	
14.0' A.B.		SANDY GRAVEL WITH SOME SILT Gray	
Sh	(9)	Ref, 50/2.0"	15.5' T.D.

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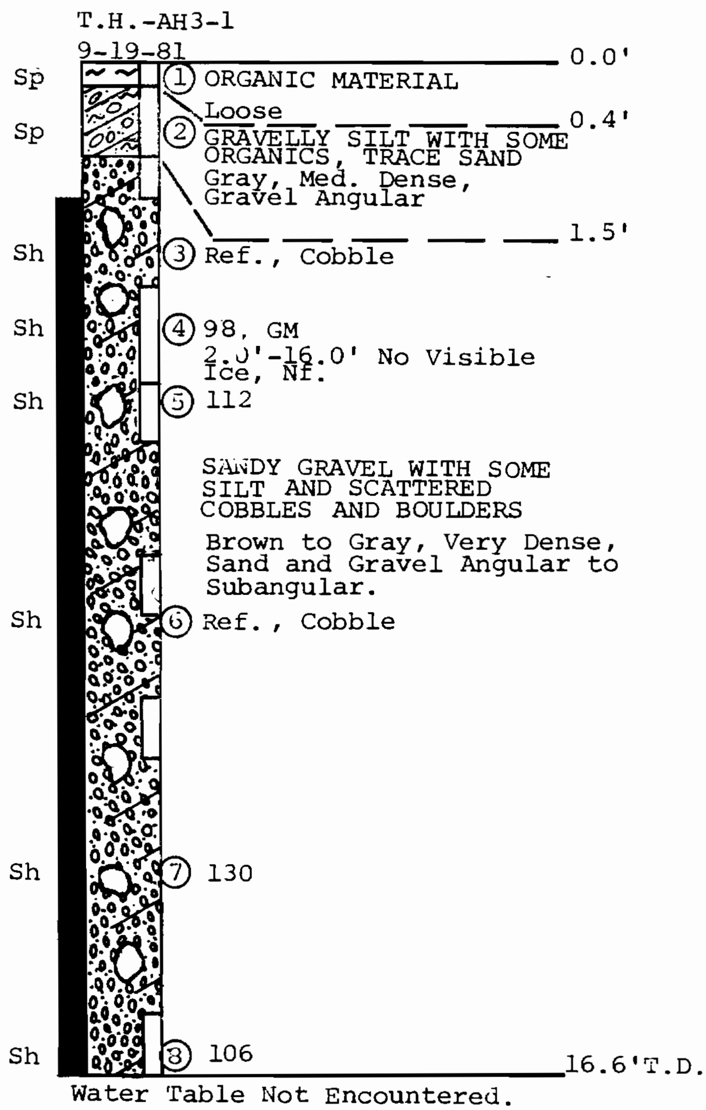
ACCESS CORRIDORS
AUGER HOLE AH 2-2

Prepared for:

ACRES

Scale:1"=3'



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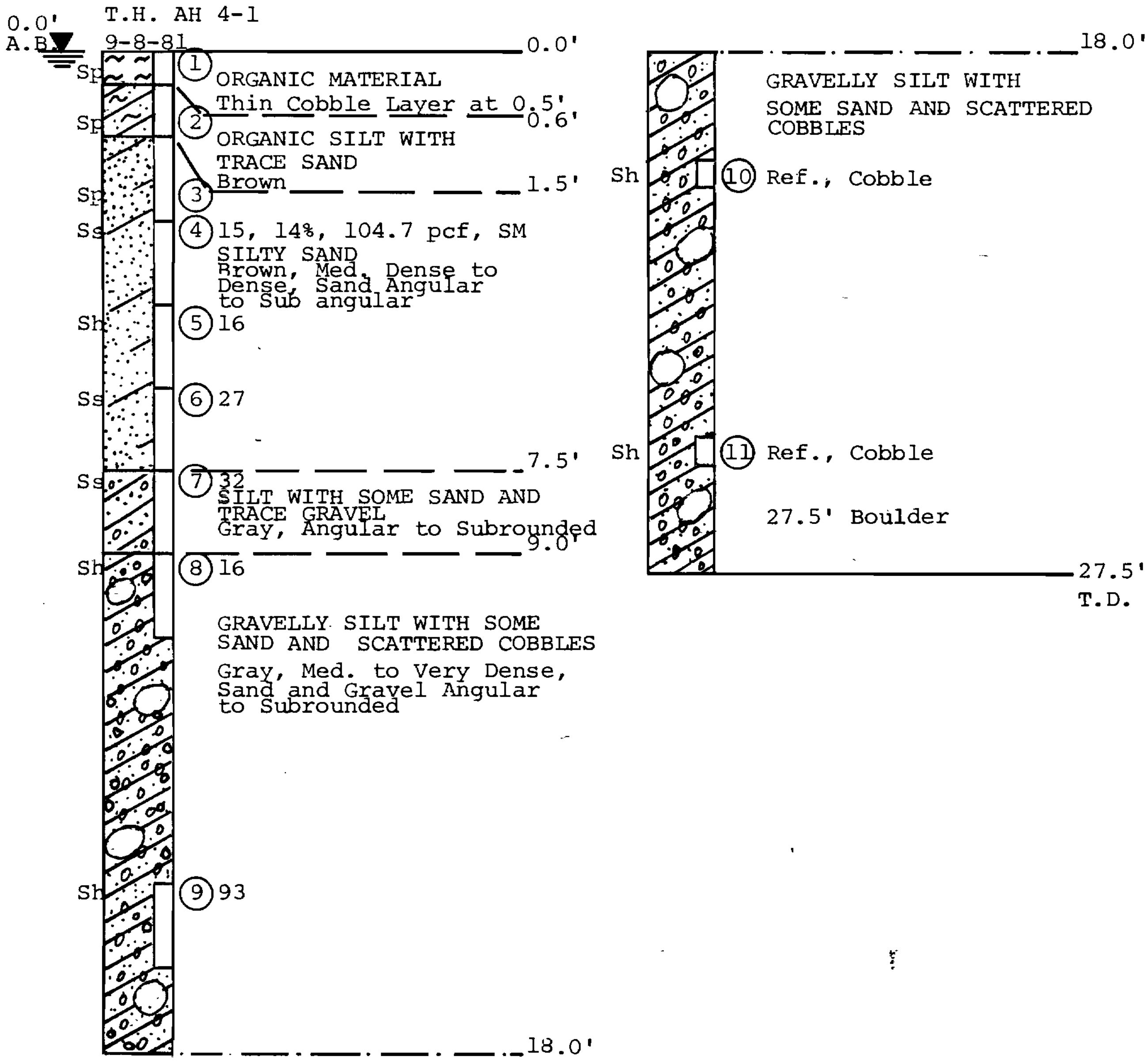
ACCESS CORRIDORS

AUGER HOLE AH3-1

Scale: 1"=3'



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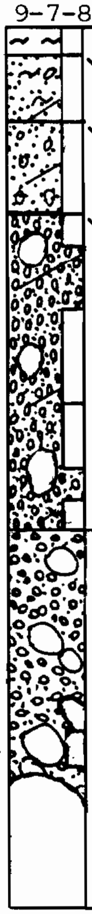
Prepared for:

ACRES

ACCESS CORRIDORS
AUGER HOLE AH 4-1

Scale: 1"=3'

AH 4-2
9-7-81



Sample	Description	Depth
		0.0'
Sp ①	ORGANIC MATERIAL Loose Cobbles at Surface	
		0.5'
Sp ②	SAND WITH SOME ORGANICS AND SILT, TRACE GRAVEL Brown Med. Dense	
		1.5'
Sp ③	SAND WITH SOME GRAVEL AND SILT Brown Med. Dense, Sand and Gravel Subangular	
		3.0'
Ss ④	Ref., Cobble SANDY GRAVEL AND GRAVELLY SAND WITH SOME SILT AND SCATTERED COBBLES	
Sh 5	Ref., Cobble, SM	
Sh 6	Ref., Cobble	
Sh ⑦	Ref., Cobble	8.0'
	SANDY GRAVEL AND GRAVELLY SAND WITH SCATTERED COBBLES AND BOULDERS	
Sh ⑧	Ref., Boulder 12.0'-14.0' Boulder	
		14.0'T.D.

Water Table Not Encountered.

Prepared by:

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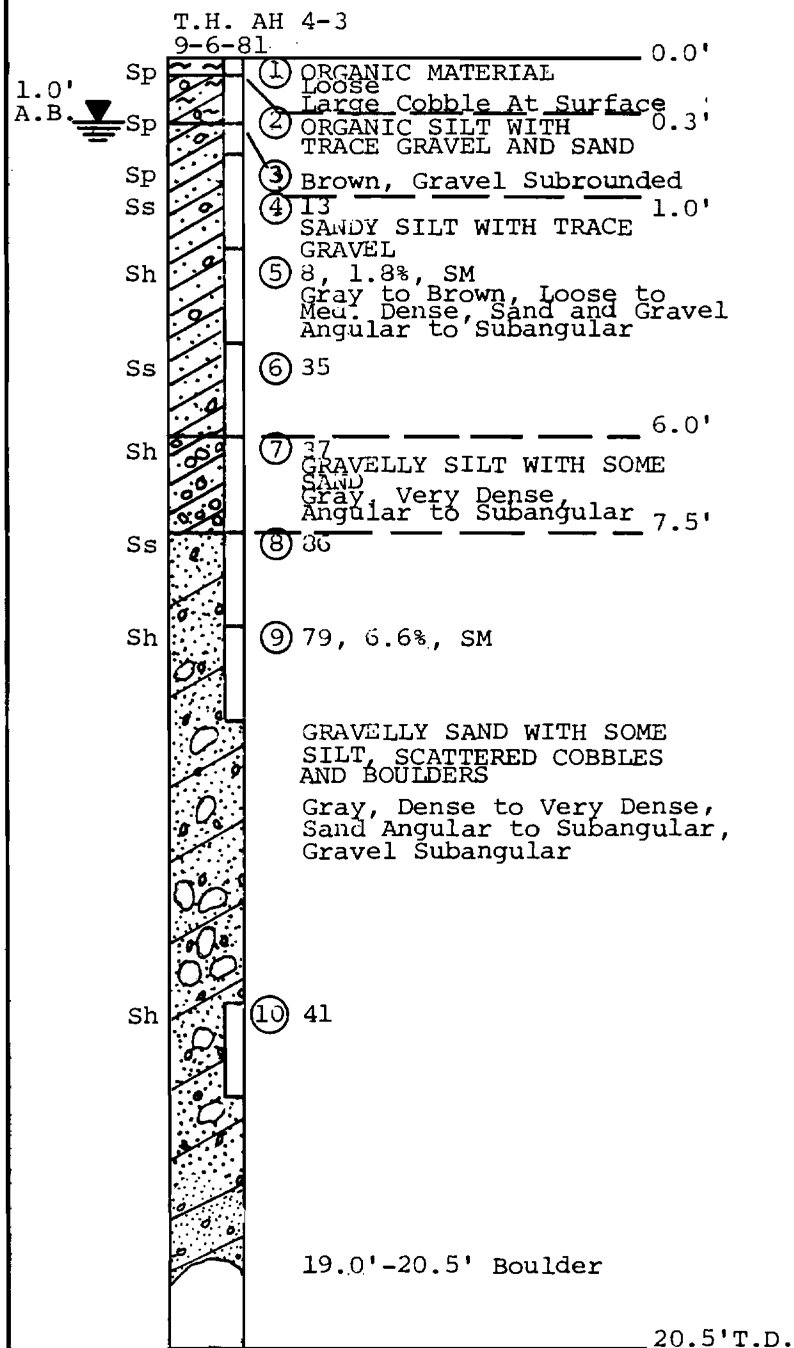
ACCESS CORRIDORS
AUGER HOLE AH 4-2

Prepared for:

ACRES

Scale: 1"=3'



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ACCESS CORRIDORS
AUGER HOLE AH4-3

Scale: 1"=3'

Prepared for:

ACRES

T.H. AH6-1

9-20-81

Sample	Depth	Description
Sp		0.0'
Sp (1)		ORGANIC MATERIAL Loose
	0.8'	
Sp (2)		GRAVELLY SILT WITH SOME ORGANICS AND SAND Brown, Sand Subangular
	1.5'	
Sh (3) 25		GRAVEL WITH SOME SAND AND TRACE SILT Brown-Gray, Angular to Rounded.
	3.0'	
Sh (4) 17, SM		SILTY SAND WITH SOME GRAVEL Gray, Med. Dense
	5.0'	
Sh (5) 18		SILTY SAND WITH GRAVEL Gray, Med. Dense, Angular to Subrounded
	6.5'	
Sh (6) 42		GRAVELLY SAND WITH SOME SILT
Sh (7) 39		Gray, Dense, Gravel Angular to Subrounded. 3.0'-17.5' Scattered Cobbles
	12.5'	
		SANDY SILT WITH TRACE GRAVEL Gray, Very Dense, Sand Angular to Subangular
Sh (8) Ref.,50/3.0"		
	17.5'	
		SILTY GRAVEL WITH SOME SAND Gray, Very Dense, Gravel Angular to Subangular
Sh (9) Ref., 50/4.0"	20.5'T.D.	

Water Table Not Encountered

Prepared by:

R&M CONSULTANTS, INC.

ACCESS CORRIDORS

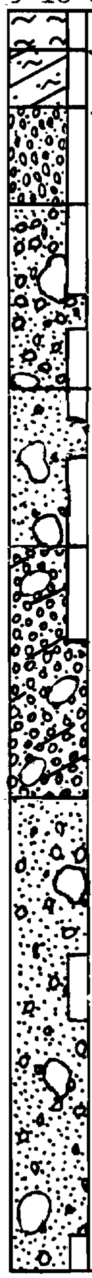
AUGER HOLE AH6-1

Prepared for:

ACRES

Scale: 1"=3'

0.0' T.H. AH7-1
A.B. 9-18-81



Sample	Blows / Note	Description	Depth
			0.0'
Sp ①		ORGANIC MATERIAL Loose	
			0.6'
Sp ②		ORGANIC SILT WITH SAND Gray-Brown, Sand Angular to Subrounded	
			1.5'
Sh ③	37	GRAVEL WITH SOME SAND Brown, Dense, Gravel Angular to Subrounded	
			3.0'
Sh ④	33	SANDY GRAVEL WITH SCATTERED COBBLES Brown, Med. Dense to Dense Gravel Angular to Rounded	
Sh ⑤	11		
			6.0'
		GRAVELLY SAND WITH SCATTERED COBBLES Brown, Med. Dense, Sand Angular to Rounded	
Sh ⑥	27		
			8.5'
Sh ⑦	82, GM	GRAVEL WITH SOME SAND AND TRACE TO SOME SILT, SCATTERED COBBLES Brown, Very Dense Angular to Subangular	
			12.5'
Sh ⑧	80	GRAVELLY SAND WITH SCATTERED COBBLES Brown, Very Dense, Sand Angular to Subrounded.	
Sh ⑨	Ref., Cobble		20.0'T.D.

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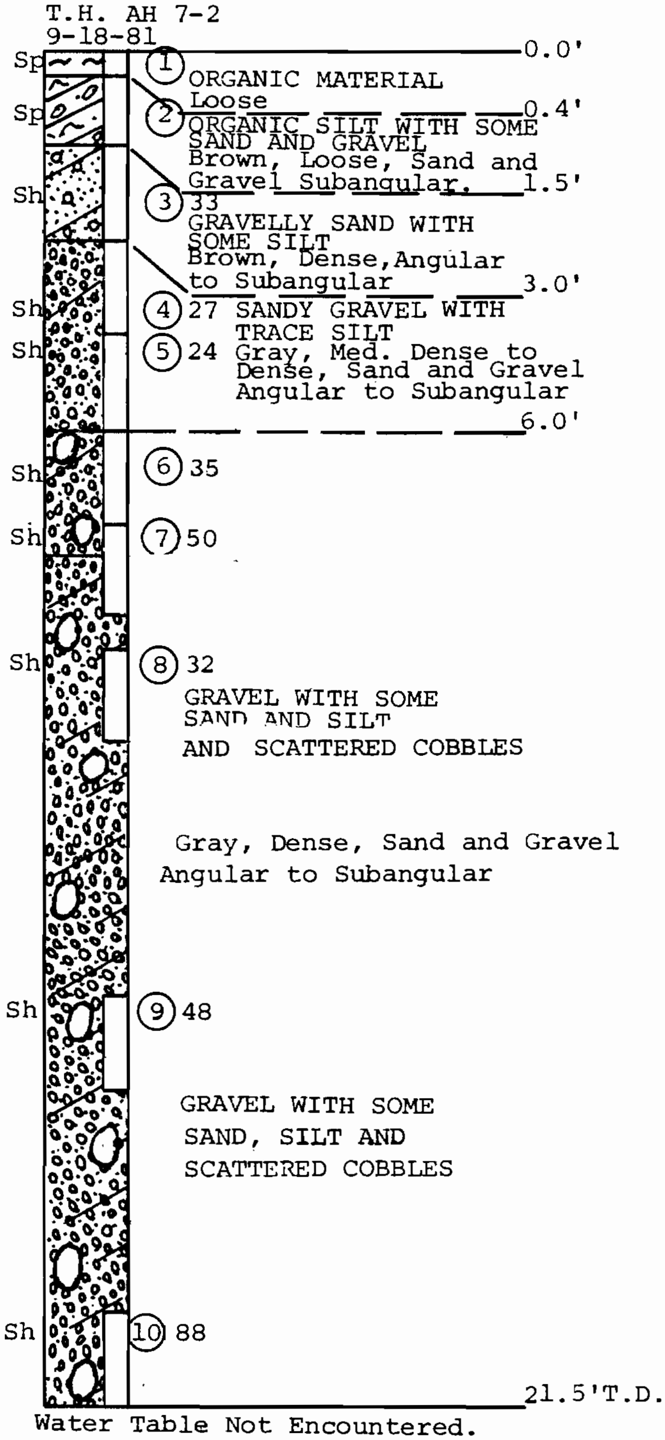
ACCESS CORRIDOR
AUGER HOLE AH7-1

Prepared for: ACRES

Scale: 1"=3'



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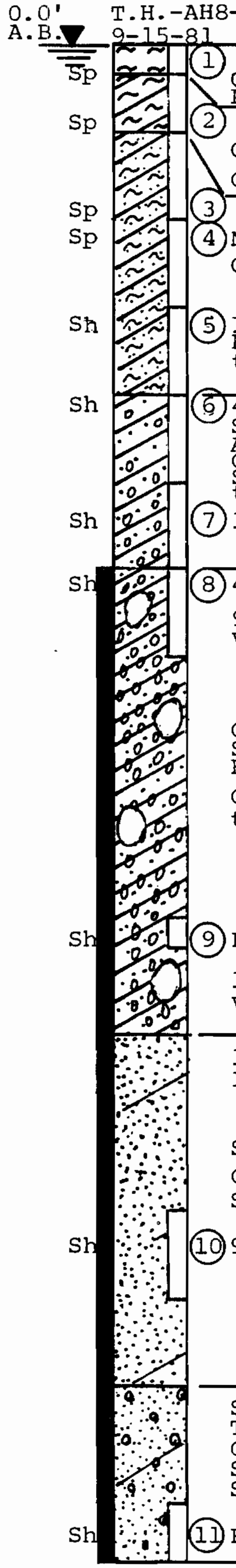
R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH 7-2

Prepared for:

ACRES

Scale: 1"=3'



0.0'

(1) ORGANIC MATERIAL
Loose

0.6'

(2) ORGANIC SILT
Grown, Loose

1.5'

(3)
(4) ML
ORGANIC SANDY SILT

(5) 19
Brown to Gray, Loose
to Medium Dense.

6.0'

(6) 4
SILT WITH SOME SAND
AND GRAVEL
Gray, Loose to Med. Dense,
Sand and Gravel Subangular
to Subrounded.

(7) 13

9.0'

(8) 40, 9.0%
9.0'-13.0' Some
Visible Ice VR

GRAVELLY SILT WITH SOME
SAND, SCATTERED COBBLES AND
BOULDERS
Green-Gray, Gravel Angular
to Rounded.

(9) Ref., Cobble
13.0'-17.0' Little
Visible Ice VR

17.0'

17.0'-26.0' No Visible
Ice Nbn

SAND WITH TRACE SILT
Gray, Sand Angular to
Subangular

(10) 90

23.0'

SAND WITH SOME GRAVEL,
TRACE SILT
Gray, Sand Angular to
Subangular, Gravel
Subangular to Subrounded

(11) Ref., 50/4.0"

26.0'T.D.

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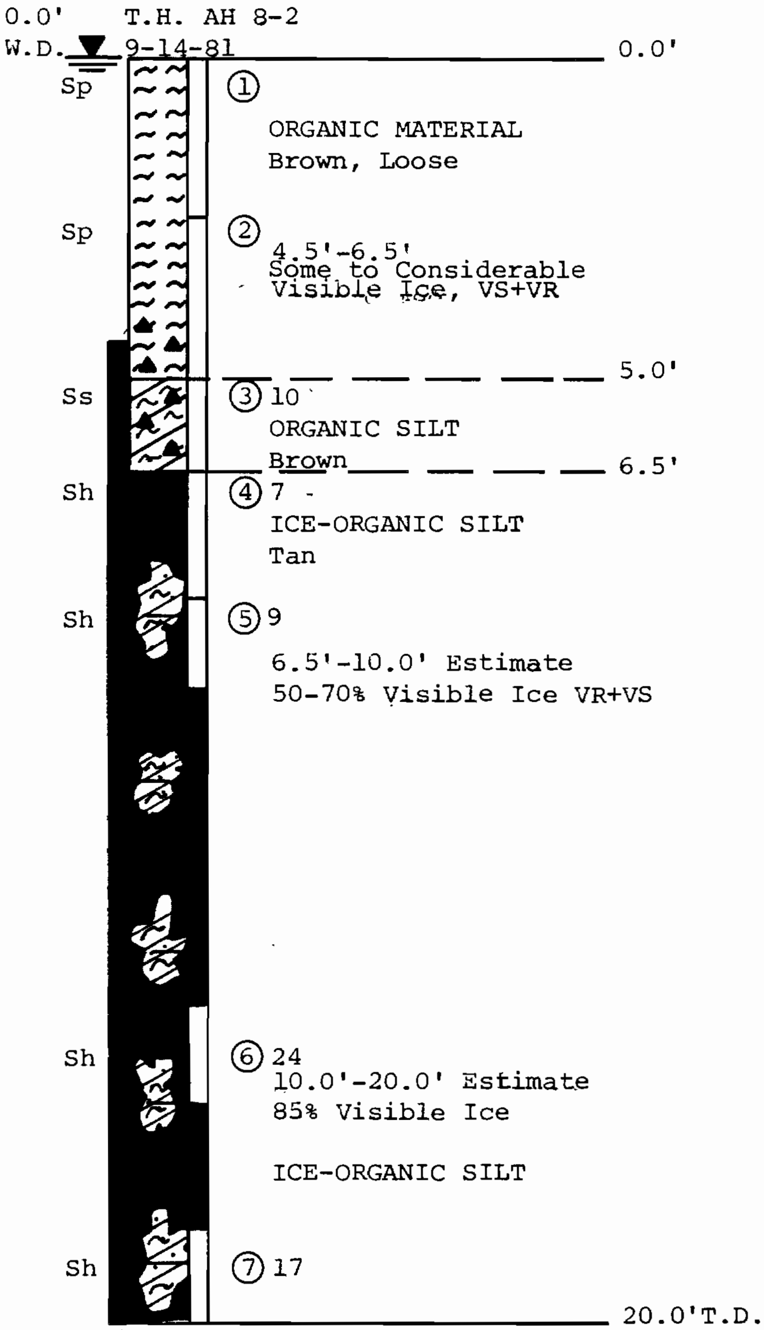
Prepared for: ACRES

ACCESS CORRIDORS
AUGER HOLE AH 8-1

Scale: 1"=3'



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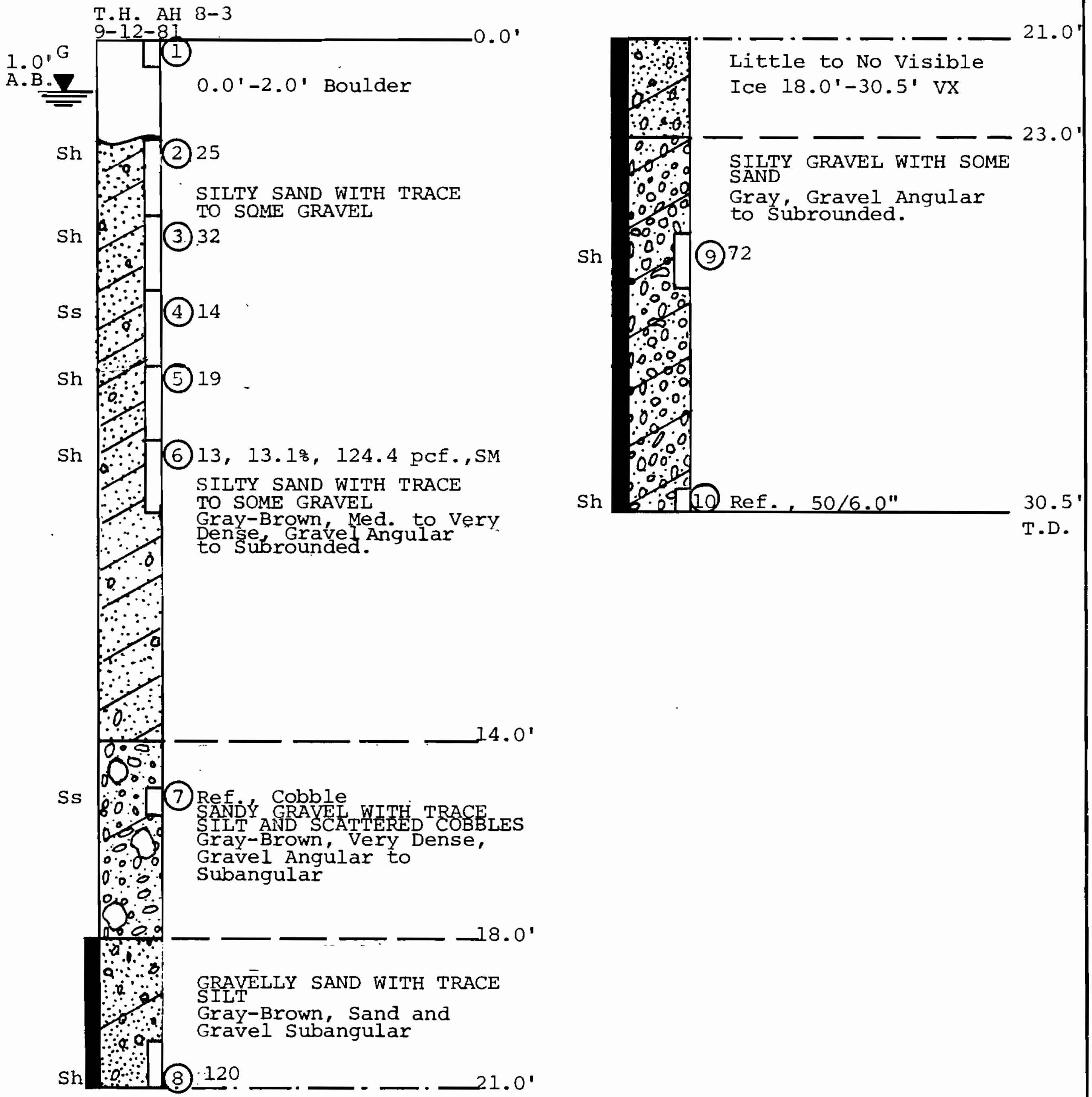
ACCESS CORRIDORS
AUGER HOLE AH 8-2

Scale: 1"=3'

ACRES



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ACCESS CORRIDORS

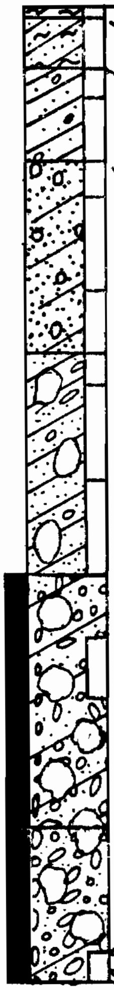
AUGER HOLE AH 8-3

Prepared for:

ACRES

Scale: 1"=3'

T.H. AH9-1
9-9-81



Unit	Sample / Description	Depth
		0.0'
Tm	(1) ORGANIC MATERIAL	0.2'
Tm	(2) ORGANIC SILT WITH SOME SAND Brown, Loose, Sand Subrounded.	
Tm Ss	(3) (4) 15 SILT WITH SOME SAND AND GRAVEL	2.5'
Sh	(5) 16 SAND WITH SOME GRAVEL AND SILT Gray, Med. Dense, Angular to Subrounded	
Ss	(6) 37	5.5'
Sh	5.5'-9.0' Scattered Cobbles (7) 83 SANDY SILT WITH SOME GRAVEL Brown-Gray, Very Dense, Sand and Gravel Angular to Subrounded.	
Sh	(8) 53	9.0'
	9.0'-15.5' No Visible Ice,	
Sh	(9) 150 SILTY GRAVEL WITH SOME SAND AND SCATTERED COBBLES Gray, Very Dense, Gravel Angular	13.0'
	SANDY GRAVEL WITH SOME SILT AND SCATTERED COBBLES Gray, Very Dense, Sand and Gravel Angular to Subangular	
Sh	(10) Ref., 35/2.0"	15.5'T.D.

Water Table Not Encountered.

Prepared by:

R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH9-1

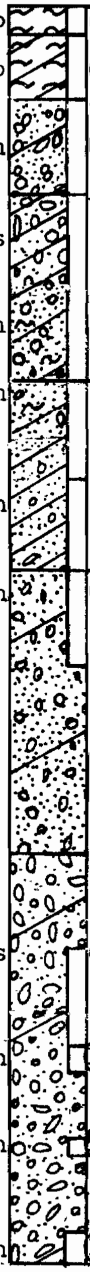
Prepared for:

ACRES

Scale:1"=3'

0.0' T.H. AH9-2

A.B. 9-10-81



0.0'

Sp ① ORGANIC MATERIAL
Loose

0.5'

Sp ② ORGANIC SILT
Brown

1.5'

Sh ③ 18
SANDYGRAVEL WITH TRACE SILT
Gray-Brown, Angular

3.0'

Ss ④ 23
GRAVELLY SILT WITH SOME SAND
Gray-Brown, Subrounded to Angular

Sh ⑤ 10
4.5'-7.5'Trace Organics

6.0'

Sh ⑥ 22
SILTY SAND WITH SOME GRAVEL

Sh ⑦ 24,11.8%,122.9pcf., SM.
Gray-Green, Med. Dense,
Gravel Subangular

9.0'

Sh ⑧ 26
GRAVELLY SAND WITH TRACE SILT
Gray-Green, Med. Dense,
Gravel Subangular

13.5'

Highly Weathered Bedrock
(Angular Rock Fragments)
13.5'-20.0'

Ss ⑨ Ref., Cobble

Sh ⑩ Ref., 40/1.0"
SANDY GRAVEL WITH TRACE SILT

Sh ⑪ Ref.
Green, Dense to Very
Dense, Gravel Angular

Sh ⑫ 84

20.0'T.D.

Prepared by: R&M CONSULTANTS, INC.

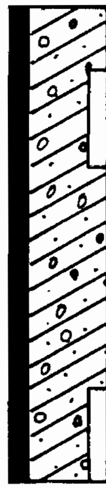
ACCESS CORRIDORS
AUGER HOLE AH9-2

Prepared for: ACRES

Scale: 1"=3'

T.H. AH 9-3
9-10-81

Class	Depth / Sample	Description
	0.0'	
Sp	(1)	Scattered Cobbles at Surface ORGANIC MATERIAL Loose
Sp	(2)	0.5'
Sp	(3)	ORGANIC SILT WITH TRACE SAND Brown, Loose, Sand Angular to Subangular
	3.0'	
Ss	(4) 39	
Sh	(5) 22	SILTY SAND WITH SOME GRAVEL Green Gray, Med. Dense, Angular to Subrounded.
Ss	(6) 43	
Ss	(7) 38	
	9.0'	
Sh	(8) Ref., 50/3.0"	9.0'-13.5' Occasional Visible Ice VR+VX SANDY GRAVEL WITH SOME SILT AND SCATTERED COBBLES Gray, Gravel Angular to Subangular
	13.5'	13.5'-31.5' Little Visible Ice VR
Sh	(9) 22	SILT WITH SOME GRAVEL, TRACE TO SOME SAND Gray, Gravel Subangular to Subrounded
Sh	(10) 35	
	24.0'	



Class	Depth / Sample	Description
	24.0'	
Sh	(11) 36	SILT WITH SOME GRAVEL, TRACE TO SOME SAND Gray, Gravel Subangular to Subrounded
Sh	(12) 40	
	31.5' T.D.	

Water Table Not Encountered.

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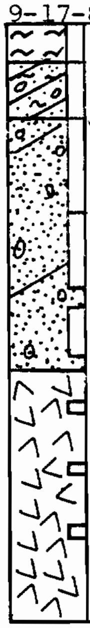
ACCESS CORRIDORS
AUGER HOLE AH 9-3

Prepared for: ACRES

Scale: 1"=3'

0.0'
A.B.

AH 14-1
9-17-81



Symbol	Sample / Description	Depth
		0.0'
Sp	① ORGANIC MATERIAL	0.6'
Sp	② ORGANIC SILT WITH SOME SAND, TRACE GRAVEL Brown, Loose, Sand and Gravel Subangular to Rounded.	1.5'
Sp	③ SAND WITH TRACE TO SOME GRAVEL, TRACE SILT	
Sh	④ 66 Tan, Med. to Very Dense, Sand Angular to Subrounded	
Sh	⑤ Ref., 50/5.0"	5.5'
Sh	⑥ Ref., 50/2.0"	
Sh	⑦ Ref., 50/3.0"	
Sh	⑧ Ref., 50/1.0" HIGHLY WEATHERED BEDROCK Diorite	9.5'T.D.

Prepared by:

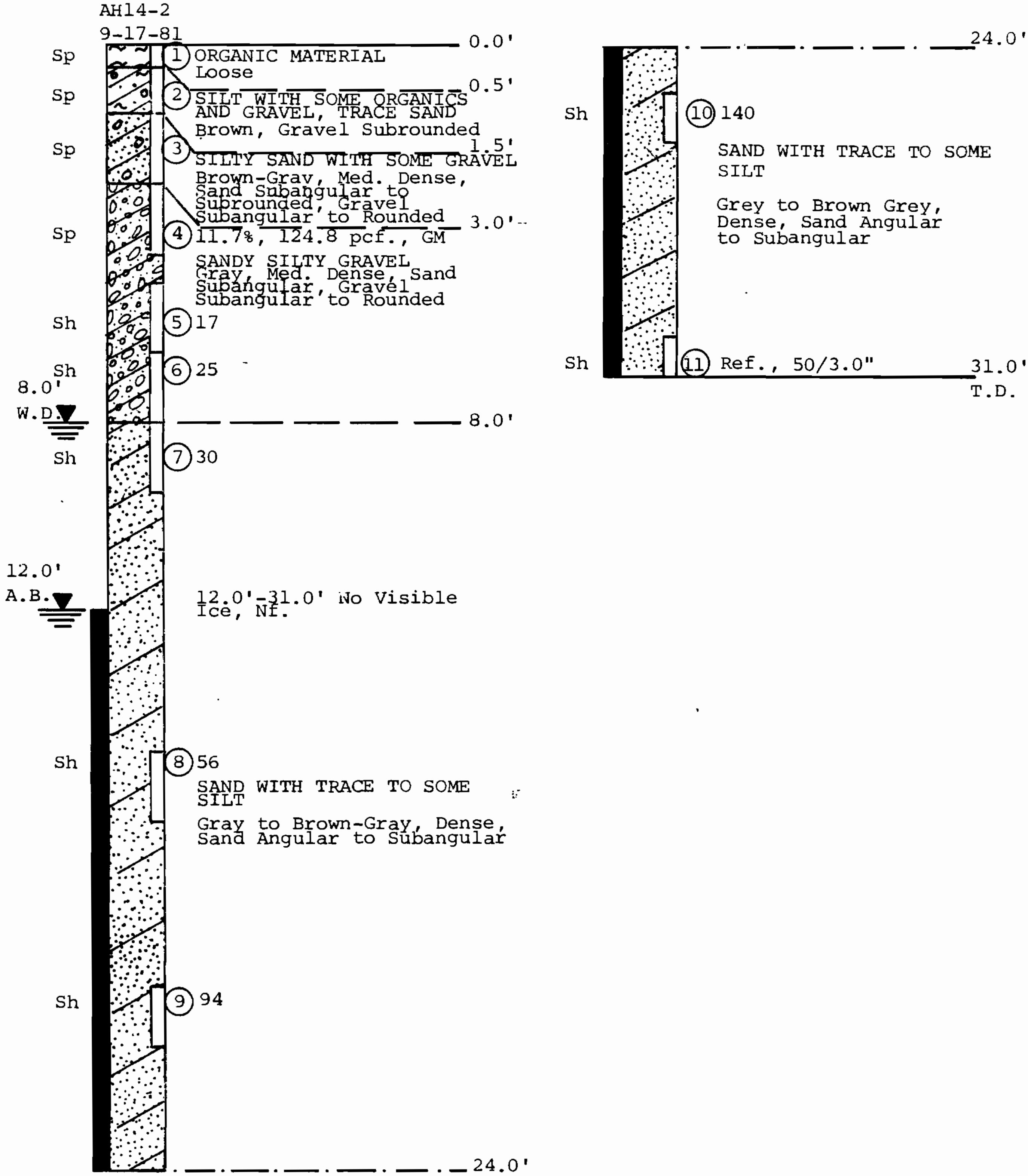
R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH 14-1

Scale 1"=3'

Prepared for:

ACRES



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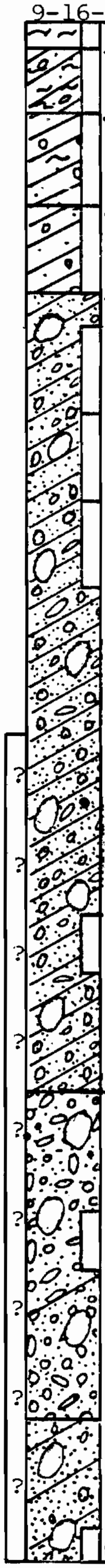
Prepared for: ACRES

ACCESS CORRIDORS

AUGER HOLE AH14-2

Scale: 1"=3'

Ah 14-3
9-16-81



0.0'

Sp (1) ORGANIC MATERIAL

Sp (2) Loose — 0.4'

ORGANIC SILT WITH TRACE SAND AND GRAVEL
Brown, Sand and Gravel Subangular — 1.5'

2.5' W.D.

(3) 13
SILT WITH SOME SAND AND GRAVEL, TRACE ORGANICS
Brown, Loose, Subangular — 3.0'

Sh (4) 12
SILT WITH SOME SAND AND GRAVEL
Brown, Loose, Subangular — 4.5'

Sh (5) 12

Ss (6) 29

Sh (7) 25

SANDY SILT WITH SOME GRAVEL TO GRAVELLY SANDY SILT, BOTH WITH SCATTERED COBBLES

Brown, Med. Dense to Very Dense, Sand Angular to Subangular, Gravel Subangular to Subrounded.

Sh (8) 112

18.0'

SANDY GRAVEL WITH TRACE SILT AND SCATTERED COBBLES

Sh (9) Ref., Cobble

Brown, Very Dense, Gravel Angular to Subrounded.

23.5'

GRAVELLY SAND WITH SILT AND SCATTERED COBBLES
Brown-Gray, Subangular to Rounded.

Sh (10) Ref., 50/3.0" — 26.0'T.D.

Questionably Frozen 12.0'-26.0'.

Prepared by:

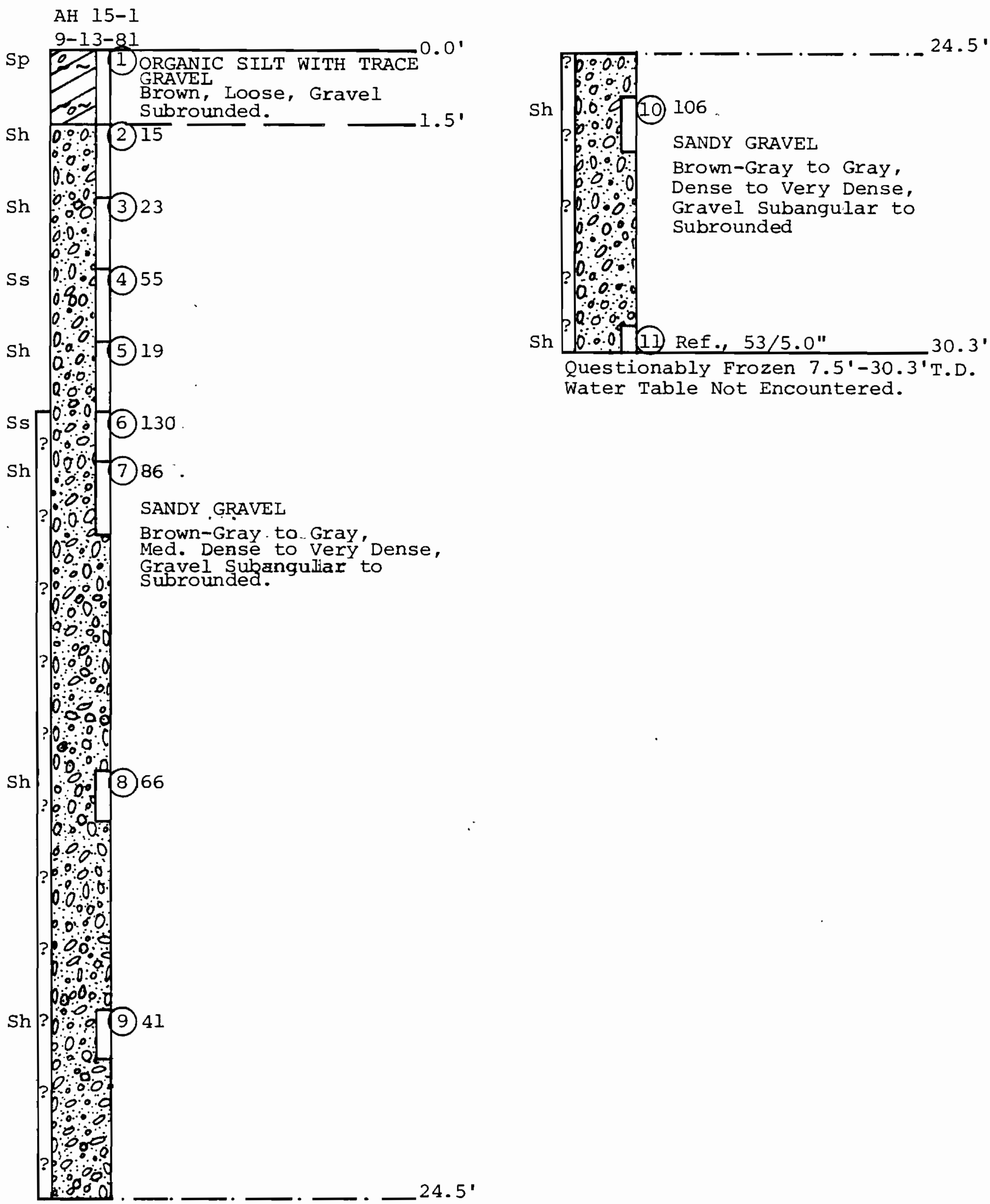
R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH 14-3

Prepared for:

ACRES

Scale: 1"=3'



Prepared by:

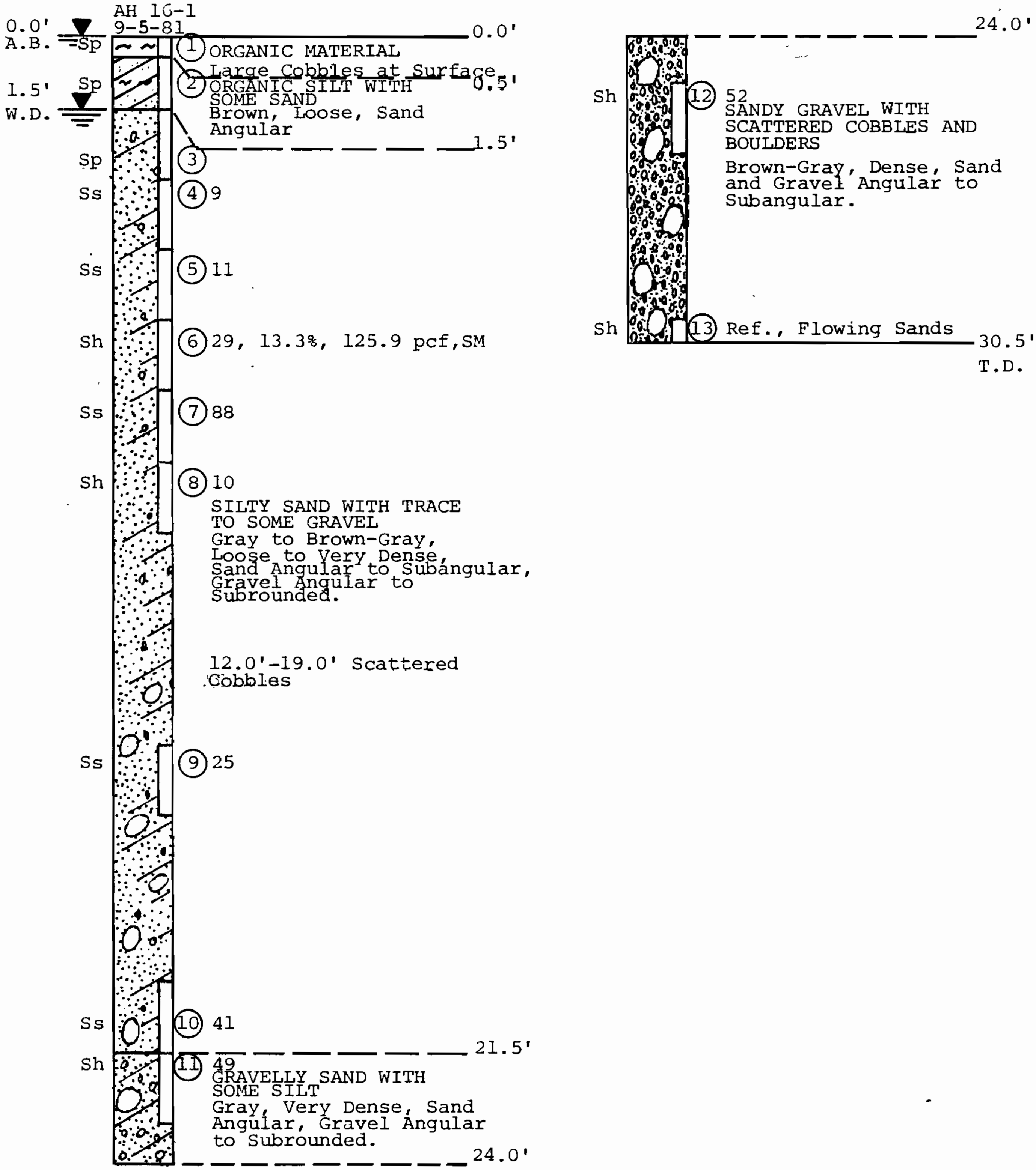
R&M CONSULTANTS, INC.

Prepared for:

ACCESS CORRIDORS
AUGER HOLE AH 15-1

ACRES

Scale 1"=3'



Prepared by:

R&M CONSULTANTS, INC.

ACCESS CORRIDORS

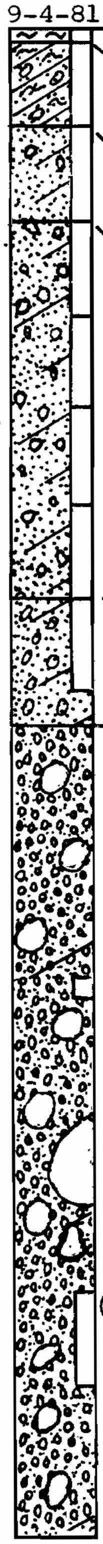
AUGER HOLE AH 16-1

Prepared for:

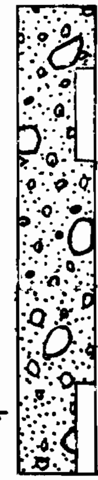
ACRES

Scale:1"=3'

AH19-1
9-4-81



Class	Sample / Description	Depth
		0.0'
Sp	(1) ORGANIC MATERIAL Loose	
		0.2'
Sp	(2) SANDY SILT WITH SOME GRAVEL AND ORGANICS Brown, Loose, Sand Subangular to Subrounded Gravel Subangular	
		1.5'
Ss	(3) 26 SILTY SAND WITH SOME GRAVEL Brown, Med. Dense, Sand Subangular to Subrounded, Gravel Subangular	
		3.0'
Sh	(4) 16, SW-SM	
Ss	(5) 12 GRAVELLY SAND WITH TRACE SILT	
Ss	(6) 21 Brown to Gray-Brown, Med. Dense to Dense, Sand Angular to Subrounded, Gravel Subrounded	
Sh	(7) 27	
		9.0'
Ss	(8) 68 SAND WITH SOME GRAVEL AND SILT Gray-Brown, Subangular to Subrounded.	
		11.0'
Sh	(9) REF. SANDY GRAVEL WITH TRACE SILT, SCATTERED COBBLES AND BOULDERS Gray-Brown, Dense to Very Dense, Sand and Gravel Angular to Subangular.	
Sh	(10) 47	
		24.0'



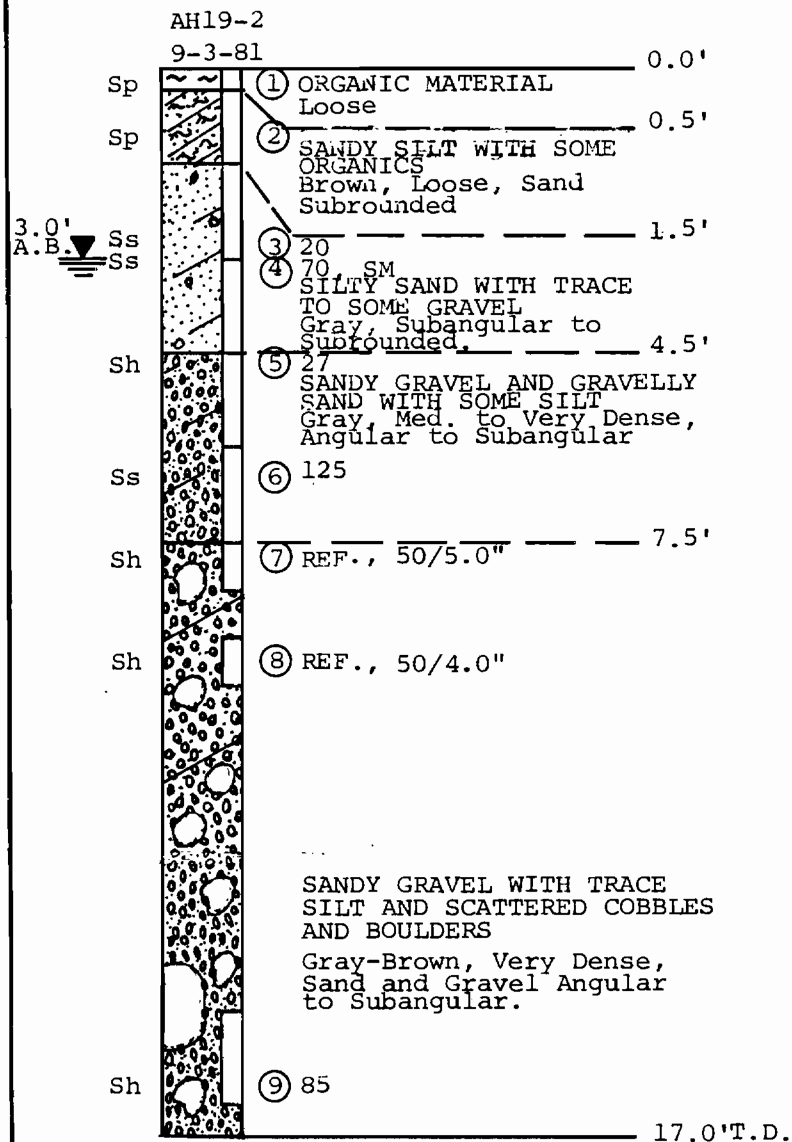
Class	Sample / Description	Depth
		24.0'
Sh	(11) 79 GRAVELLY SAND WITH SCATTERED COBBLES Gray-Brown, Dense, Sand and Gravel Angular to Subangular.	
31.5' W.D.		
Sh	(12) 53	31.5' T.D.

Prepared by: R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH19-1

Prepared for: ACRES

Scale: 1"=3'



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ACCESS CORRIDORS
AUGER HOLE AH19-2

Prepared for:

ACRES

Scale: 1"=3'

0.0' AH 20-1

A.B. 9-2-81 0.0'

Sp (1) ORGANIC MATERIAL
Medium Dense 0.3'

Sp (2)

Sp (3) SILT WITH SOME ORGANICS,
TRACE SAND AND GRAVEL
Brown-Gray, Med. Dense 1.0'

Ss (4) 15

Ss (5) 12,22.7%
SILT WITH TRACE SAND
AND GRAVEL

Ss (6) 13
Brown-Gray to Gray, Med.
Dense, Sand and Gravel
Angular to Subangular

3" Sand Layer at 5.0'

7.5' Ss (7) 47

W.D. 7.5'

Sh (8) 63
GRAVEL WITH SOME SAND
AND SILT AND SCATTERED
COBBLES

Gray, Very Dense, Gravel
Subangular. 10.0'

Ss (9) 42
SAND WITH SOME GRAVEL,
TRACE SILT
Brown-Gray, Dense, Sand
Angular to Subangular,
Gravel Subangular

13.5'

SILTY SANDY GRAVEL

Ss (10) 33
Gray, Dense, Sand and
Gravel Subangular

18.5'

GRAVELLY SAND WITH TRACE
SILT AND SCATTERED COBBLES

Ss (11) 35
Gray, Dense, Sand and
Gravel Subangular

24.0'

24.0'

Sh (12) 40
GRAVELLY SAND WITH
TRACE SILT AND SCATTERED
COBBLES
Gray, Dense Sand and
Gravel Subangular

28.5'

SANDY GRAVEL WITH
TRACE SILT

Ss (13) 108
Gray, Very Dense, Sand
Angular to Subangular,
Gravel Subrounded.

31.5'
T.D.

Prepared by:

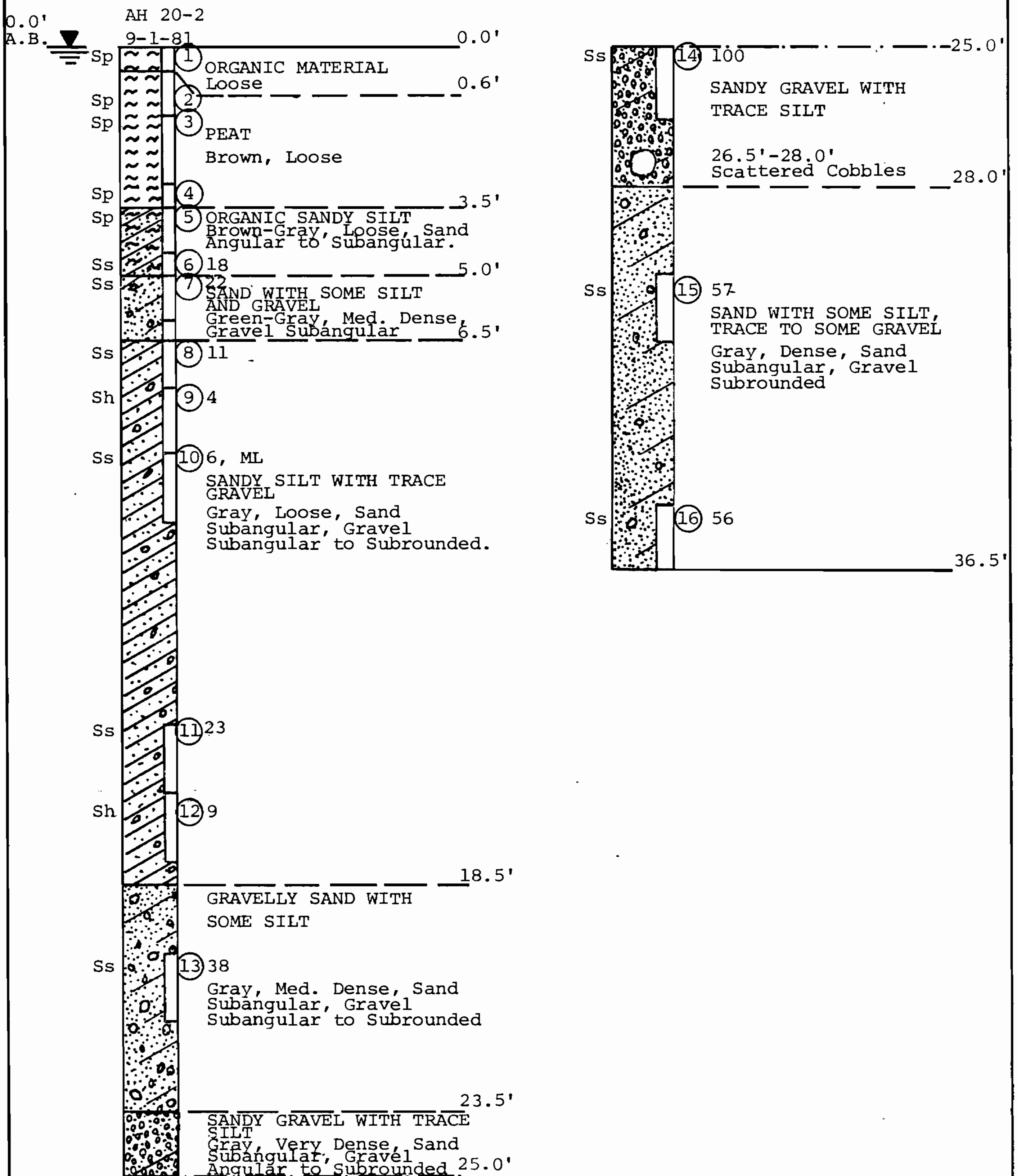
R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH 20-1

Prepared for:

ACRES

Scale: 1"=3'



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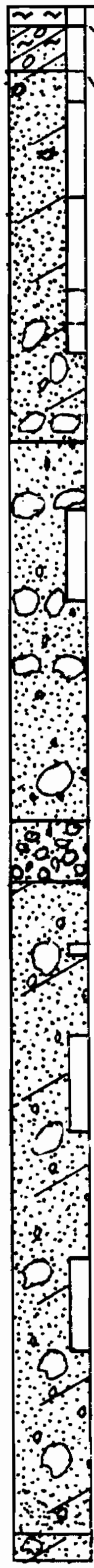
ACCESS CORRIDORS
AUGER HOLE AH 20-2

Prepared for:

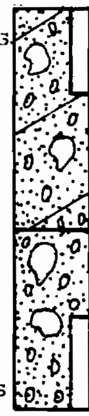
ACRES

Scale: 1"=3'

AH20-3
8-31-81



Sample	Depth	Description
Sp	0.0'	(1) ORGANIC MATERIAL Med. Dense
Sp	0.3'	(2) ORGANIC SILT WITH TRACE SAND AND GRAVEL Brown, Med Dense
Sp	1.0'	(3)
Ss		(4) 29 SAND WITH SOME SILT AND TRACE GRAVEL
Ss		(5) 62 Gray-Brown, Subangular to Subrounded.
Ss		(6) Ref., Cobble
Sh		(7) Ref., Cobble 5.5'-7.0' Numerous Cobbles
Ss	7.0'	(8) 82 GRAVELLY SAND WITH SCATTERED COBBLES Gray, Very Dense, Sand and Gravel Subangular
	13.0'	SANDY GRAVEL Gray, Subangular
Ss	14.0'	(9) Ref
Sh		(10) 24 GRAVELLY SAND WITH TRACE SILT WITH SCATTERED COBBLES Gray, Med. Dense to Dense, Sand and Gravel Subangular
Ss		(11) 42
	24.5'	SAND WITH SOME SILT AND GRAVEL AND SCATTERED COBBLES
	25.0'	



Sample	Depth	Description
Ss	25.0'	(12) 30 SAND WITH SOME SILT AND GRAVEL WITH SCATTERED COBBLES Gray, Dense, Sand and Gravel Subangular
	28.5'	GRAVELLY SAND WITH SCATTERED COBBLES Gray, Very Dense, Sand Subangular, Gravel Subangular to Subrounded
Ss		(13) 128
	31.5' T.D.	Water Table Not Encountered.

Prepared by:

R&M CONSULTANTS, INC.

ACCESS CORRIDORS
AUGER HOLE AH20-3

Prepared for:

ACRES

Scale: 1"=3'

PROJECT NO. 052506
CLIENT: Acres American, Inc.
PROJECT NAME Susitna Hydro.

R & M CONSULTANTS, INC.

SUMMARY OF LABORATORY TEST DATA

DATE December 1, 1981
PARTY NO.
PAGE NO. C-01

TEST HOLE	SAMPLE NO.	DEPTH (feet)	3"	2"	1½"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#100	#200	.02	LL	PI	WET DENSITY	DRY DENSITY	% MOISTURE	% ORGAN.
AH1-1	3	3.5- 5.0		100	56	43	41	41	39	35	30	26	24	19	18	15.8	9.0						
AH2-2	5	3.0- 4.5		100	76	76	74	71	66	57	50	43	38	32	31	27.0	11.7						
AH2-2	8	8.0- 9.5				100	97	94	91	82	73	62	54	43	40	33.4	13.3			132.4	124.3	6.5	
AH3-1	4	3.5- 5.0	100	69	69	69	63	60	56	48	39	31	25	17	15	12.2	3.3						
AH4-1	4	3.0- 4.5						100	98	98	94	87	77	64	59	48.8	25.8			119.3	104.7	14.0	—
AH4-2	5	4.5- 6.0			100	96	81	73	69	62	52	39	31	21	18	13.7	5.1						
AH4-3	5	3.0- 4.5					100	98	95	91	86	79	72	60	56	48.8	21.6					1.8	
AH4-3	9	9.0-10.5			100	97	95	95	93	87	76	63	51	36	33	25.6	7.1					6.6	
AH6-1	4	3.5- 5.0			100	92	92	87	85	81	76	70	63	50	47	38.0	18.0						
AH7-1	7	8.5-10.0		100	72	72	67	54	51	42	34	25	19	14	13	12.1	5.2						
AH8-1	4	3.0- 4.5								100	98	93	86	80	77	69.7					9.6	15.3	
AH8-1	8	9.0-10.5																			9.0		
AH8-2	4	6.5- 8.0																			27.3	27.8	
AH8-3	6	8.0- 9.5							100	95	89	79	70	56	52	42.6	24.9			140.7	124.4	13.1	
AH9-2	7	7.5- 9.0					100	93	90	83	76	69	64	55	53	45.8	23.6			137.4	122.9	11.8	
AH14-2	4	3.0- 4.5			100	78	78	74	70	65	60	55	51	41	39	33.2	19.7			139.3	124.8	11.7	
AH16-1	6	6.0- 7.5					100	96	95	88	81	70	60	46	42	34.8	20.4			142.6	125.9	13.3	
AH19-1	4	3.0- 4.5			100	74	71	67	66	63	57	47	36	18	15	11.7	3.5						
AH19-2	4	3.0-4.5					100	97	95	94	91	86	79	60	53	40.1	13.3						
AH20-1	5	3.0-4.5									100						62.8	NV	NP		22.7		

REMARKS:

NOTE: SIEVE ANALYSIS = PERCENT PASSIN

APPROVED

PROJECT NO. 052506

CLIENT: Acres American, Inc.

PROJECT NAME Susitna Hydro.

R & M CONSULTANTS, INC.

SUMMARY OF LABORATORY TEST DATA

DATE December 1, 1981

PARTY NO.

PAGE NO. C-02

TEST HOLE	SAMPLE NO.	DEPTH (feet)	3"	2"	1½"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#100	#200	.02	LL	PI	WET DENSITY	DRY DENSITY	% MOIST.	% ORGAN.
AH20-2	10	9.0-10.5					100	96	94	89	83	76	69	59	56	51.3	29.2						
AH20-3	5	3.0- 4.5					100	95	95	94	78	60	57	30	26	19.2	6.7						

REMARKS:

NOTE: SIEVE ANALYSIS = PERCENT PASSIN[G]

APPROVED [signature]

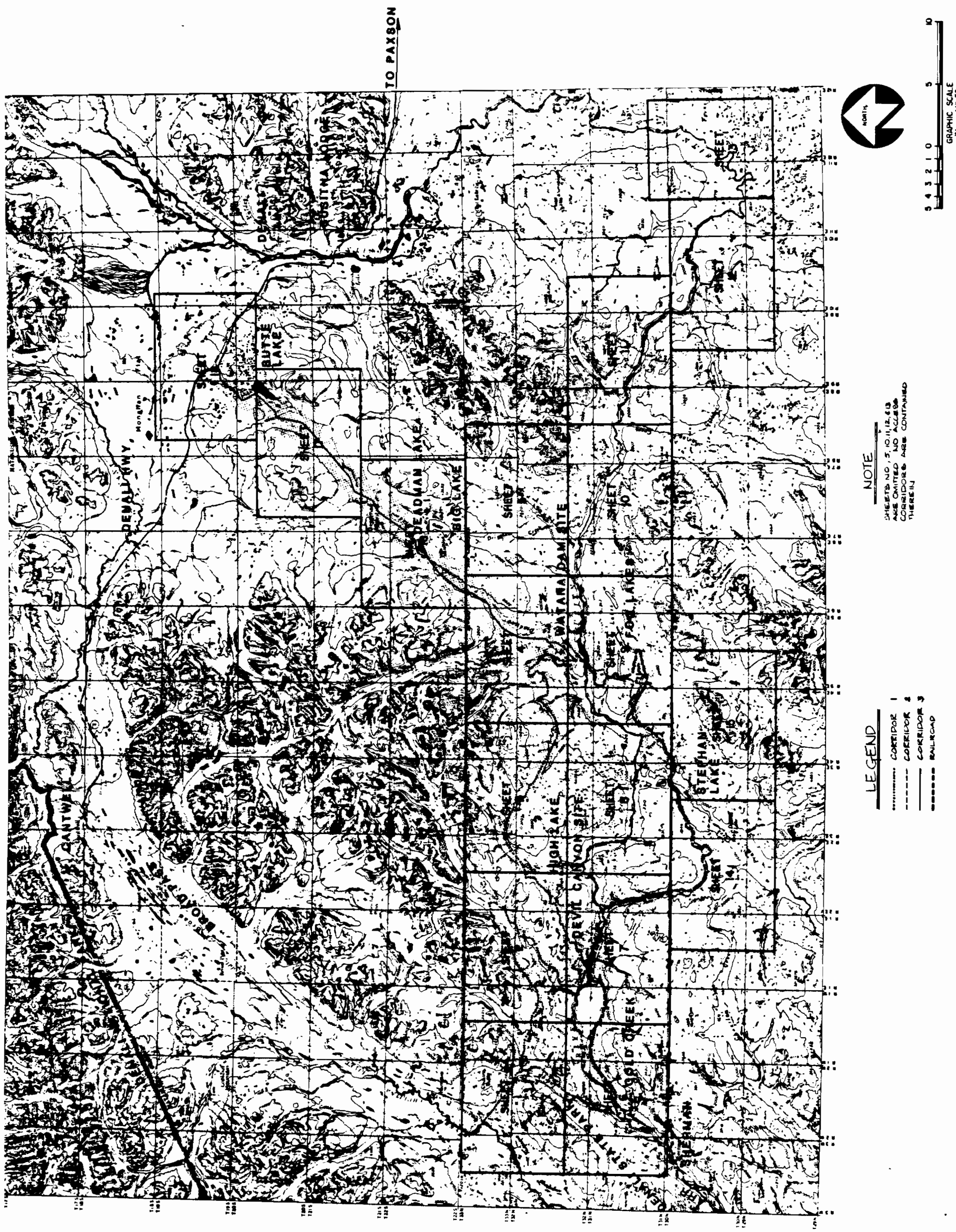
APPENDIX E

ENVIRONMENTAL CONCERNS

Appendix E - Environmental Conflicts

Appendix E is a series of maps on which the more obvious and/or critical potential environmental conflicts are indicated. This data has been provided by the Environmental team and is fully considered in analyzing the access plans.

The following exhibits do not cover the currently perferred alignment from Deadman Lake to the Denali Highway. This segment was selected to avoid the caribou calving area around Butte Lake. The new line, however, does infringe on summer Caribou range.



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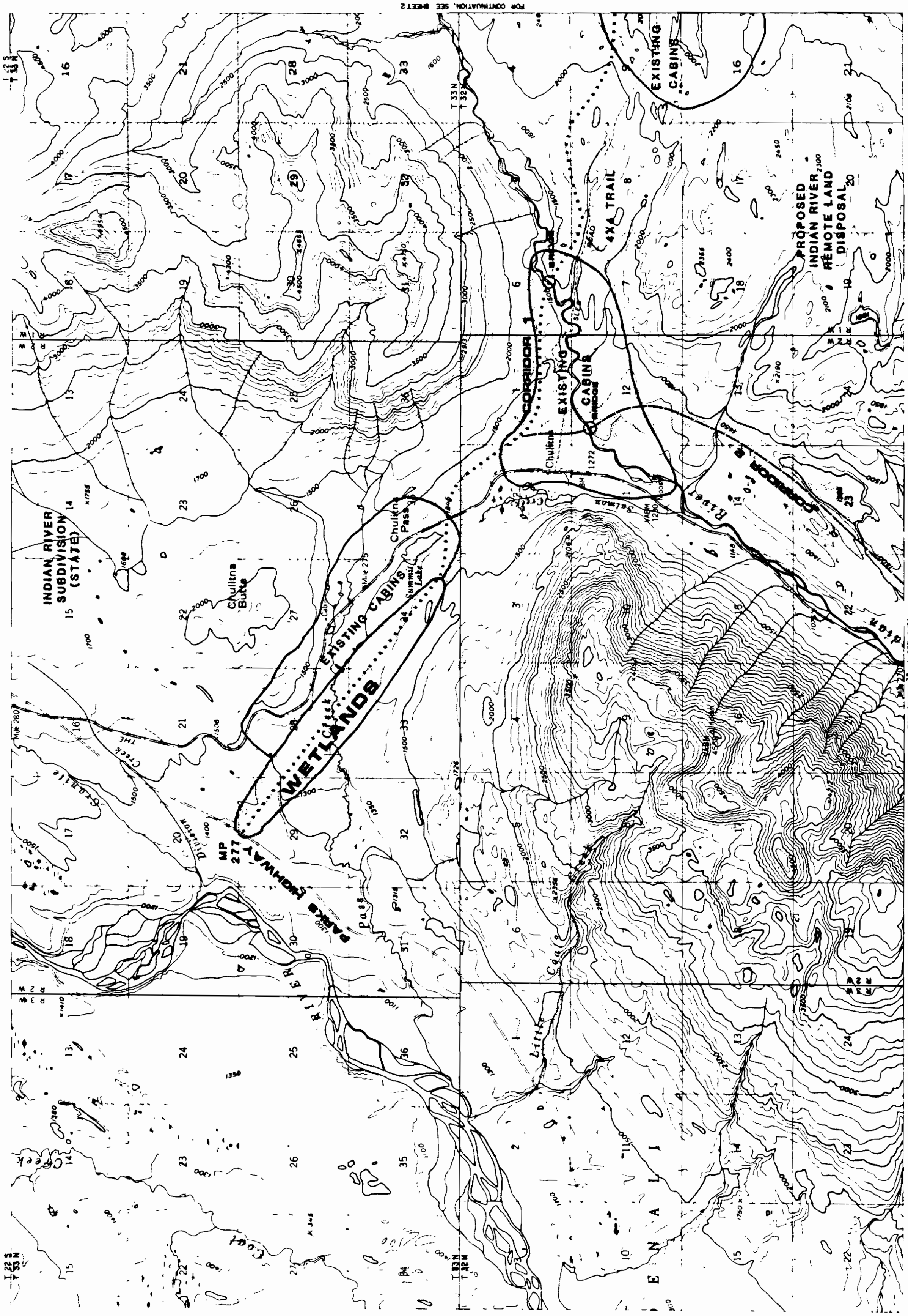
PREPARED FOR:

ACRES

SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS
INDEX MAP

FIGURE E.0



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SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

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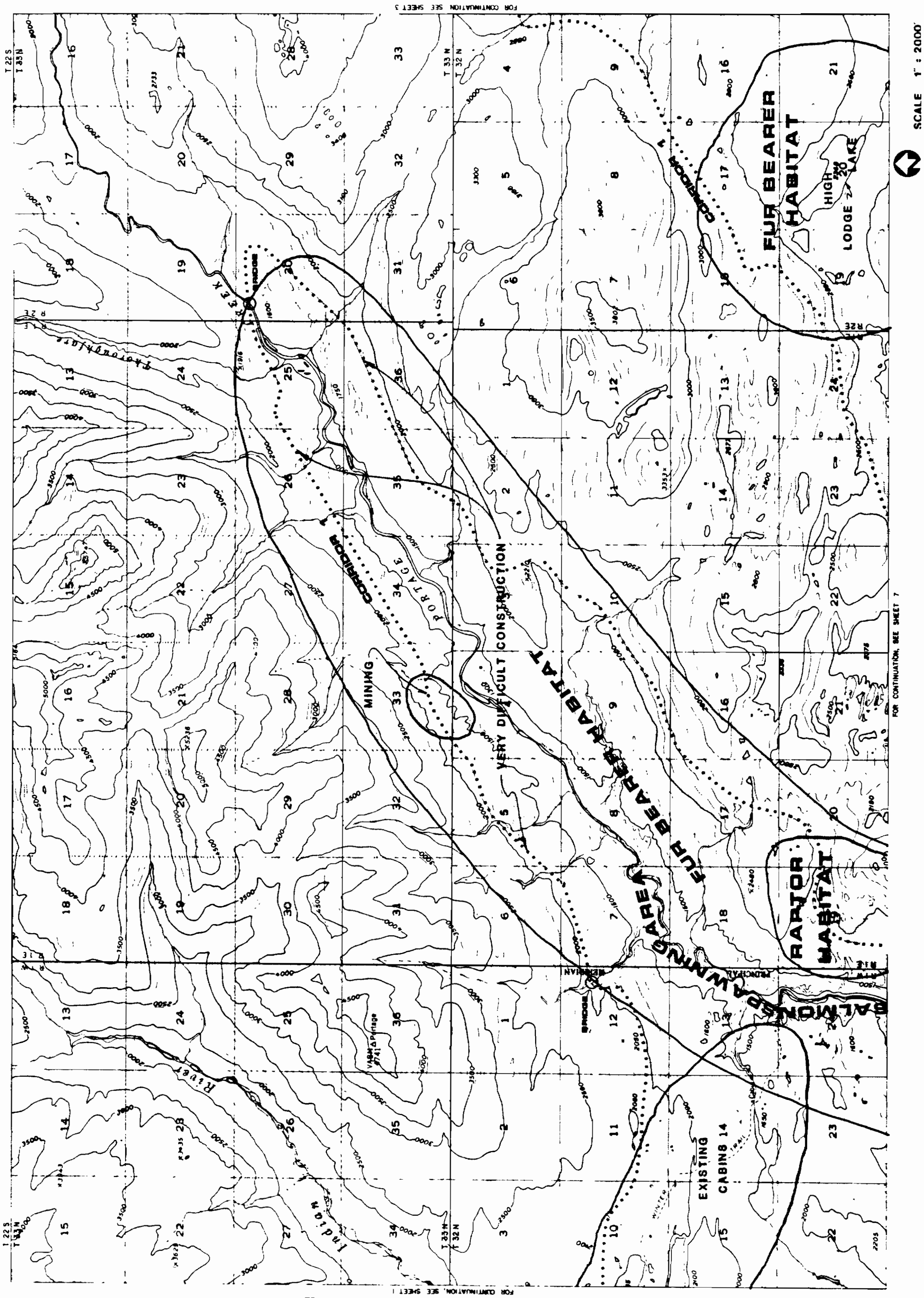
FIGURE E.1



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SUSITNA ACCESS CORRIDOR

ENVIRONMENTAL CONFLICTS

FIGURE E.2

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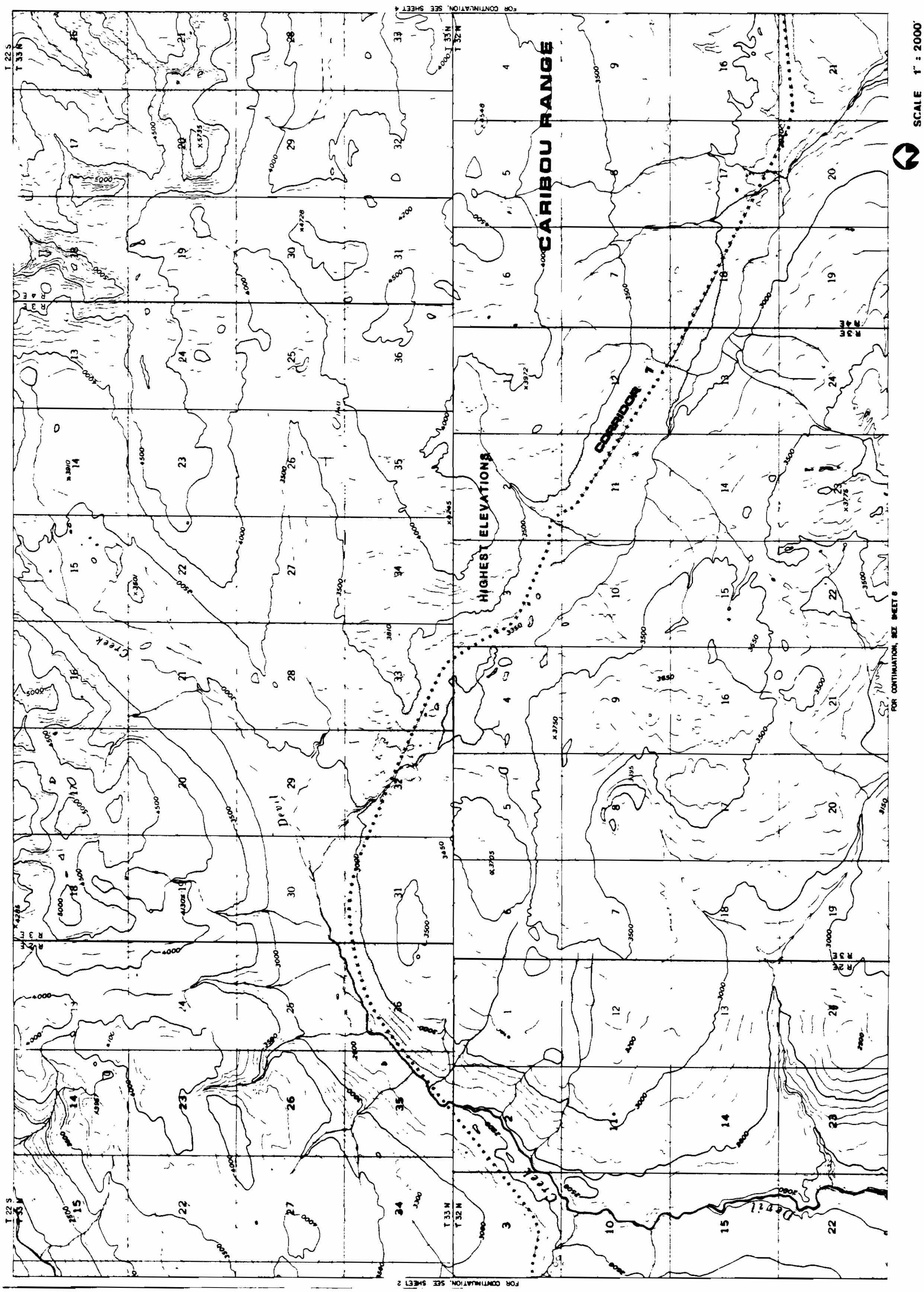

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SUSITNA ACCESS CORRIDOR

ENVIRONMENTAL CONFLICTS

FIGURE E.3

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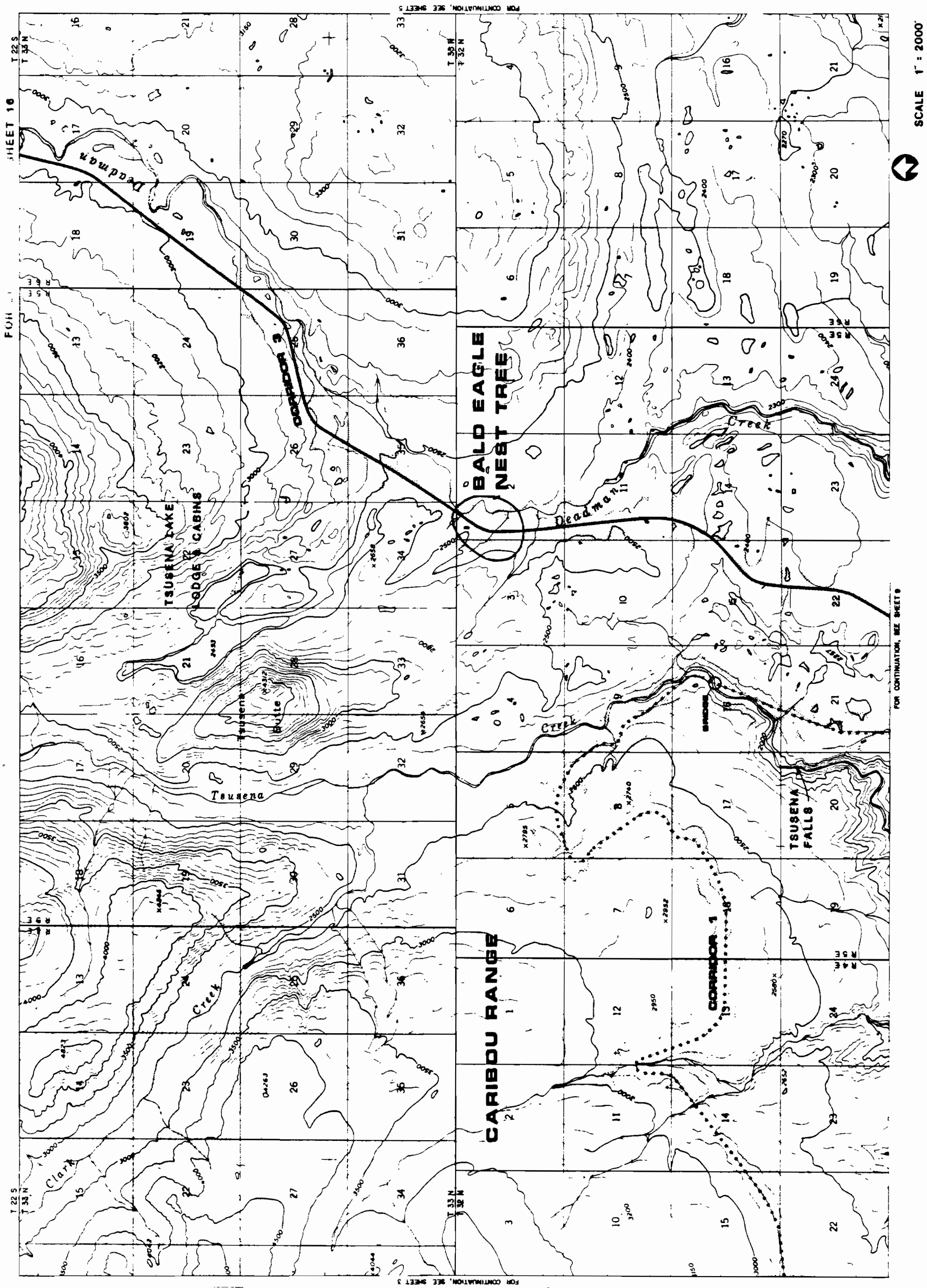

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SUSITNA ACCESS CORRIDOR

ENVIRONMENTAL CONFLICTS

FIGURE E.4

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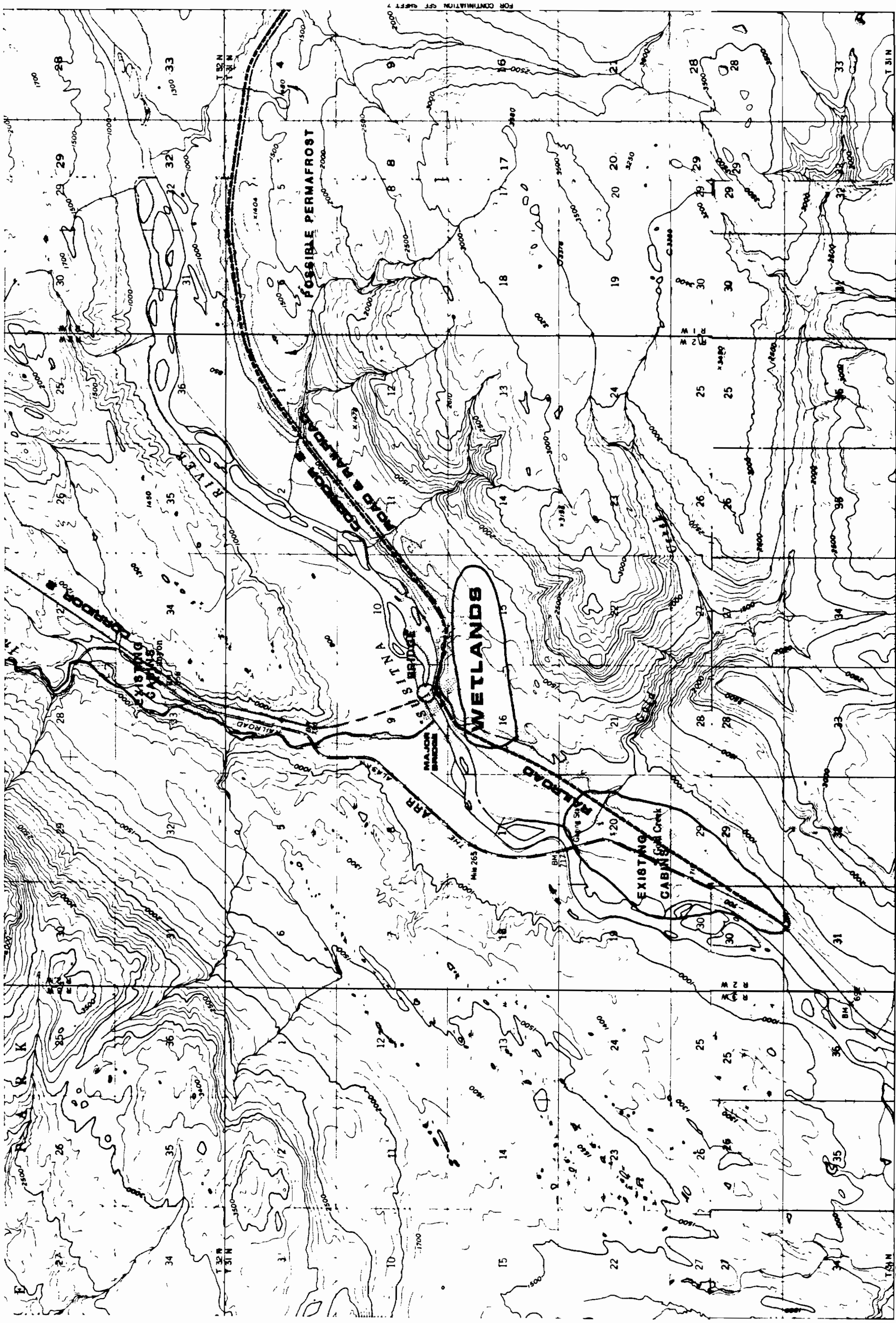

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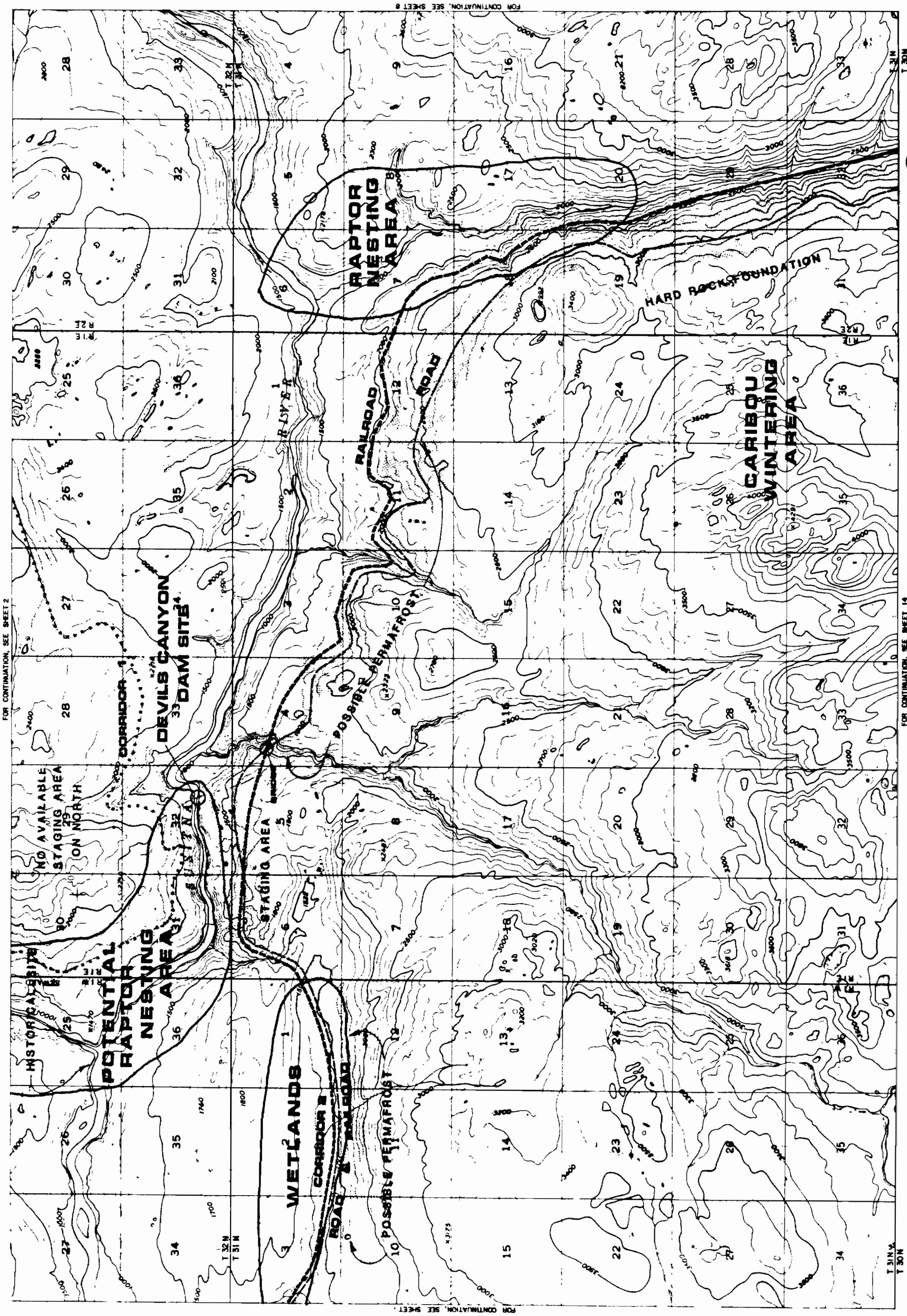
SUSITNA ACCESS CORRIDOR

ENVIRONMENTAL CONFLICTS

FIGURE E.6

ACRES



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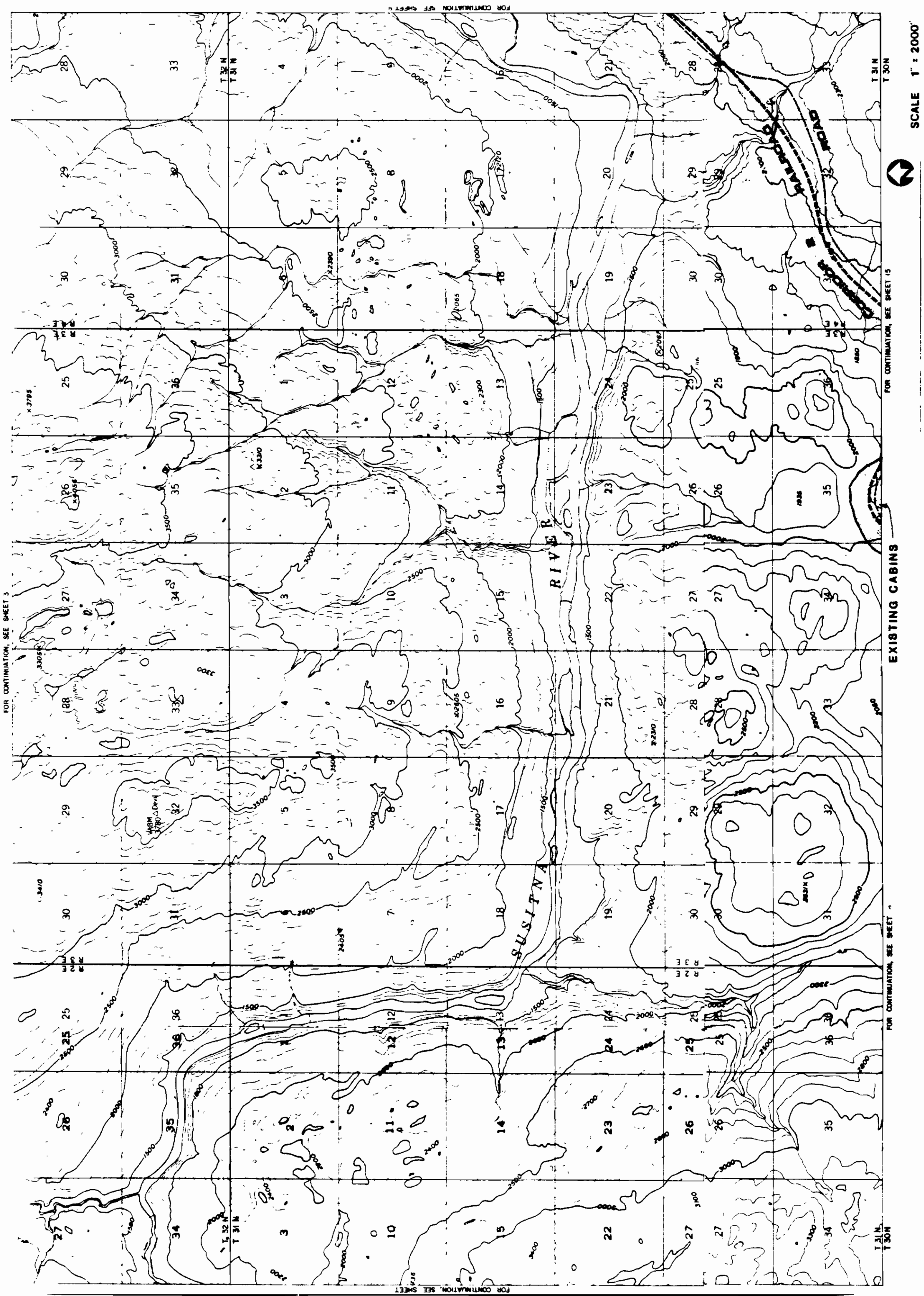
SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.7

ACRES



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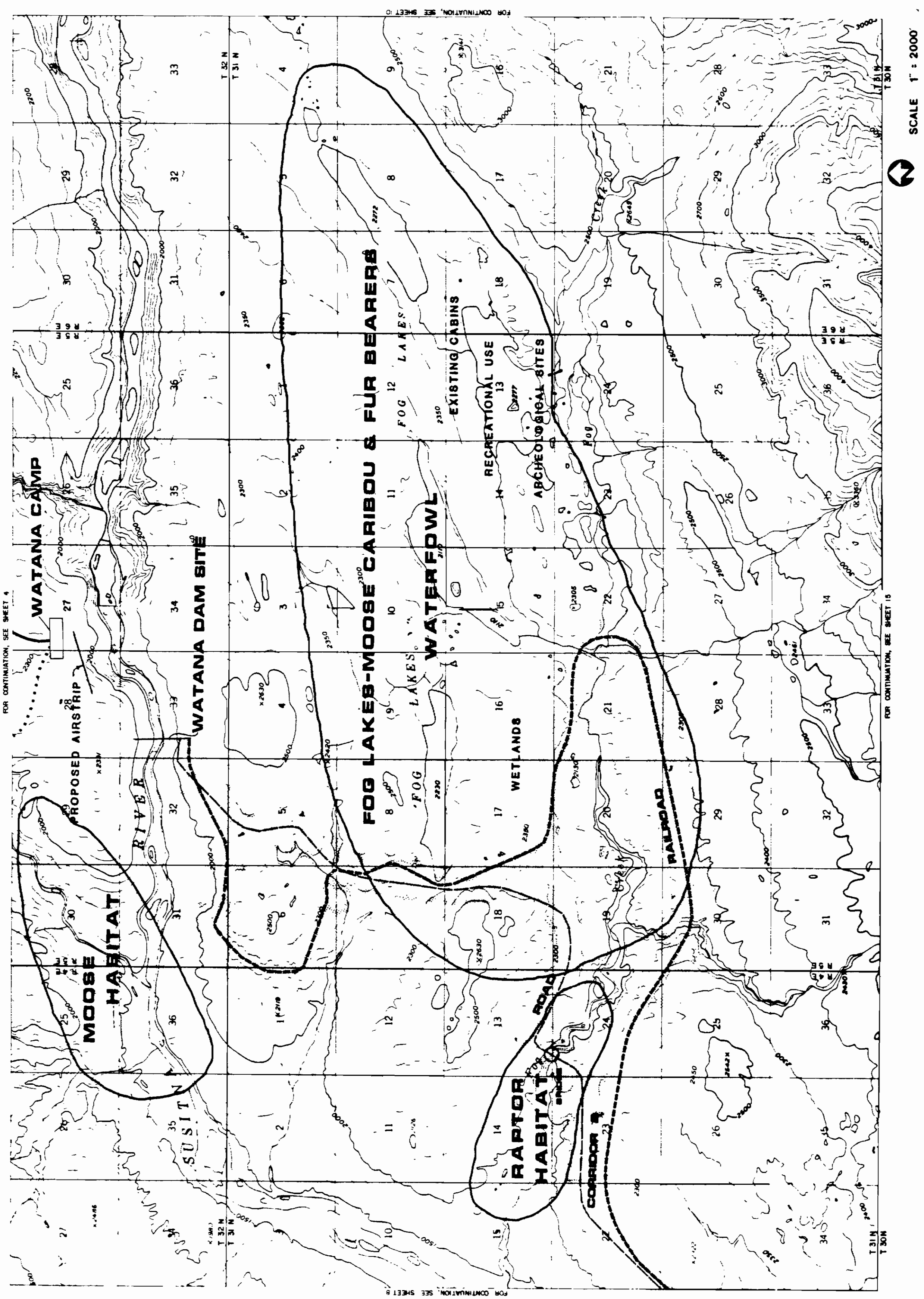
R&M CONSULTANTS, INC.

SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS
FIGURE E.8

ACRES



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SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.9

PREPARED FOR:

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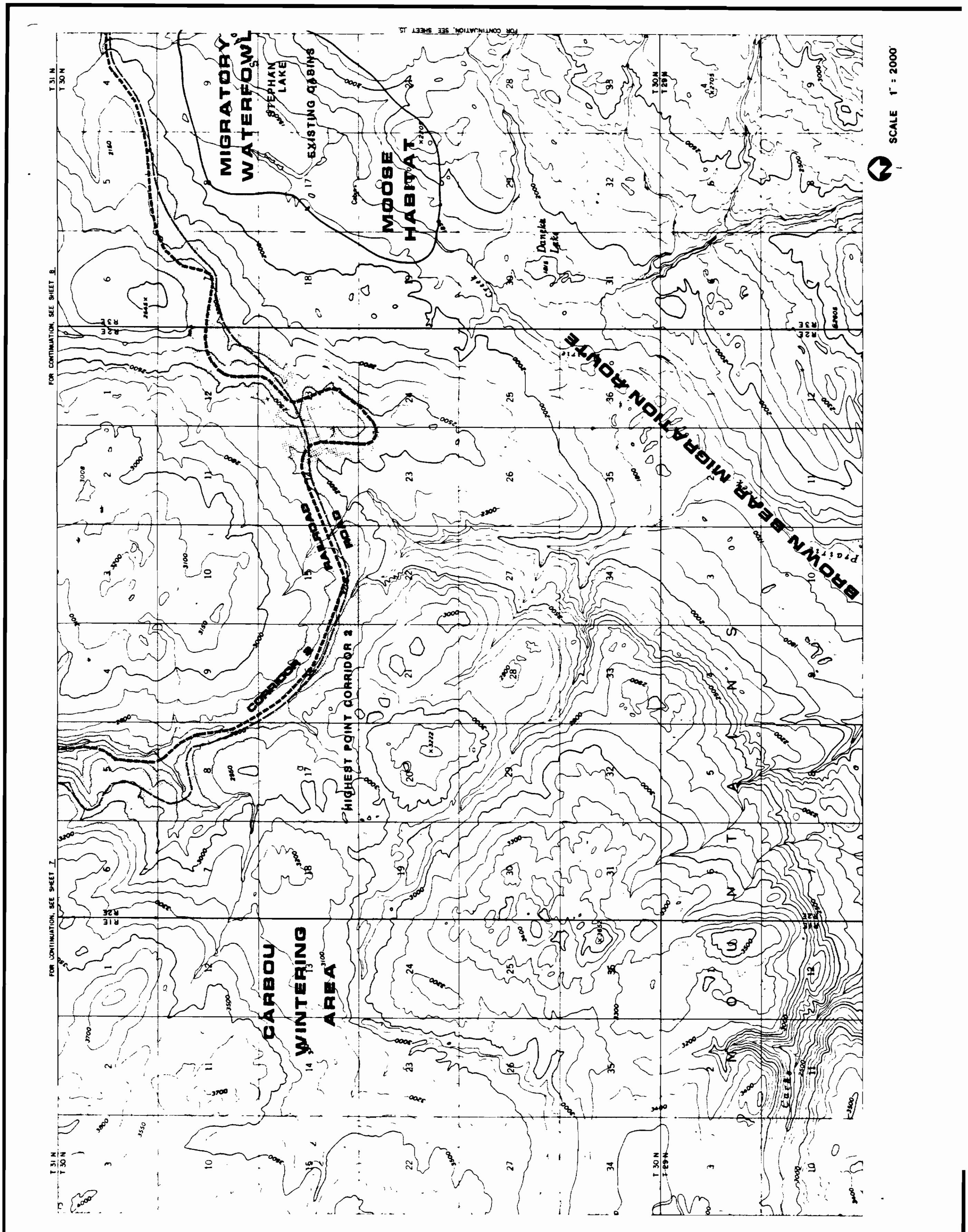

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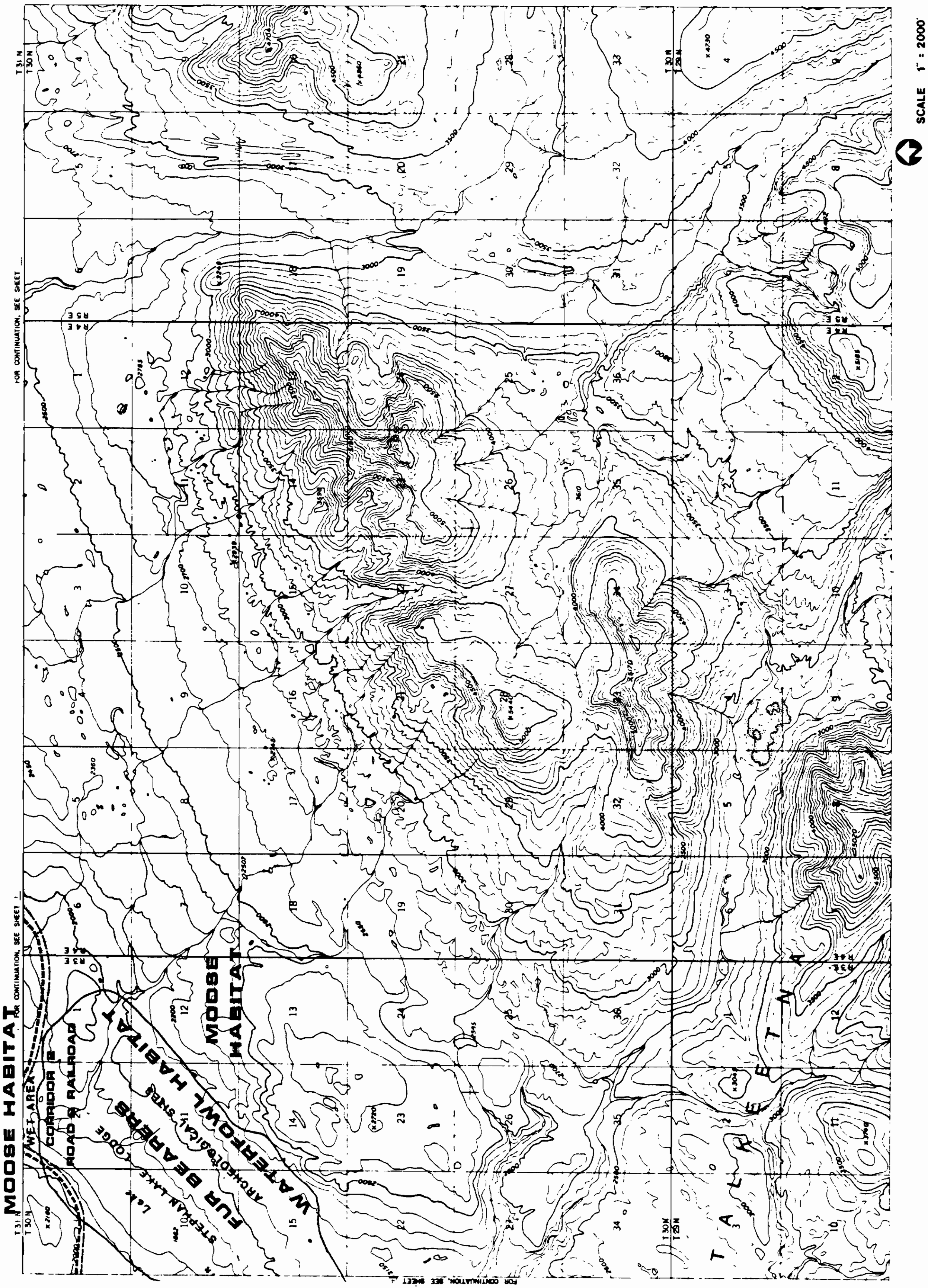
SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.14

ACRES



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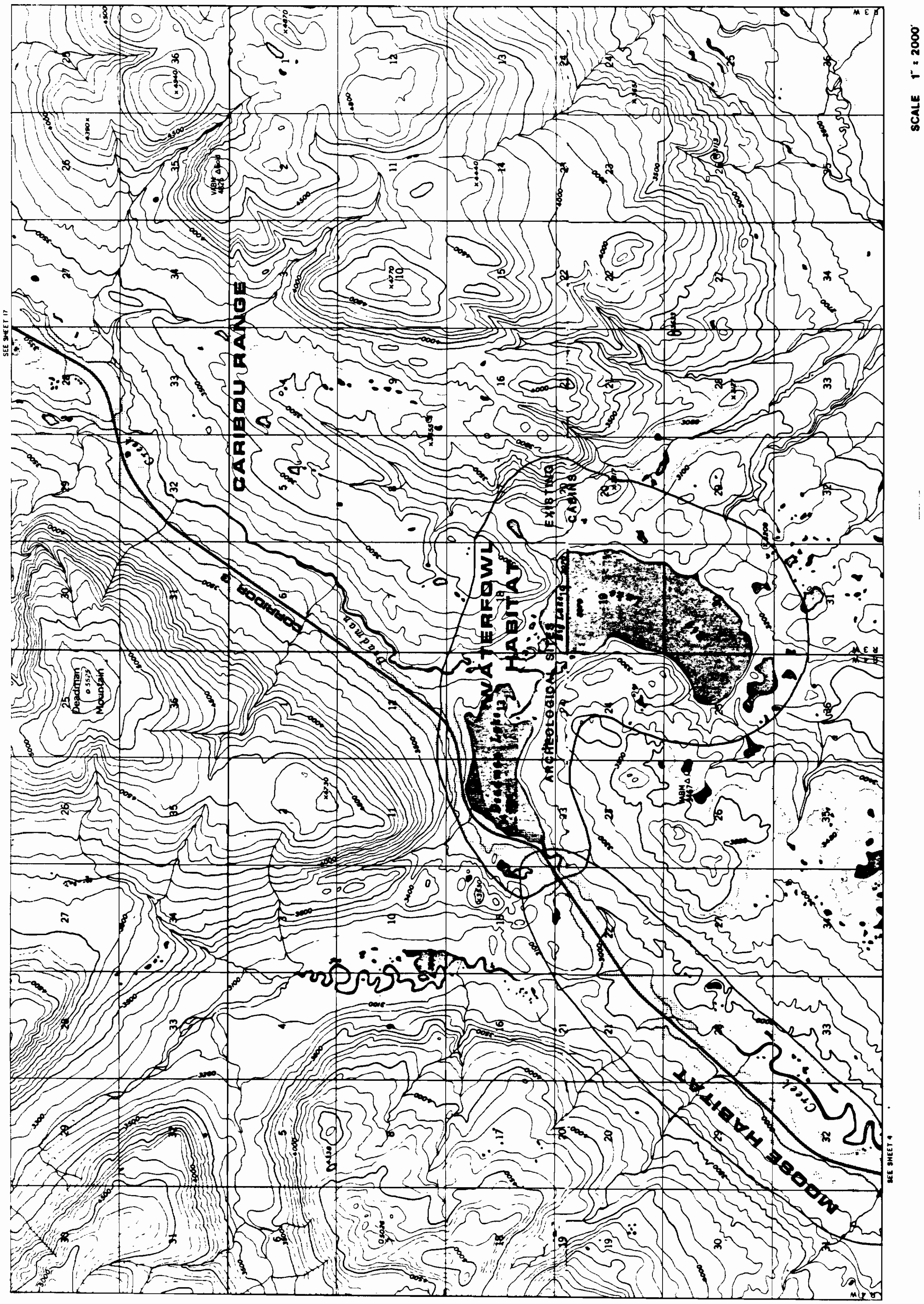
SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.15

ACRES



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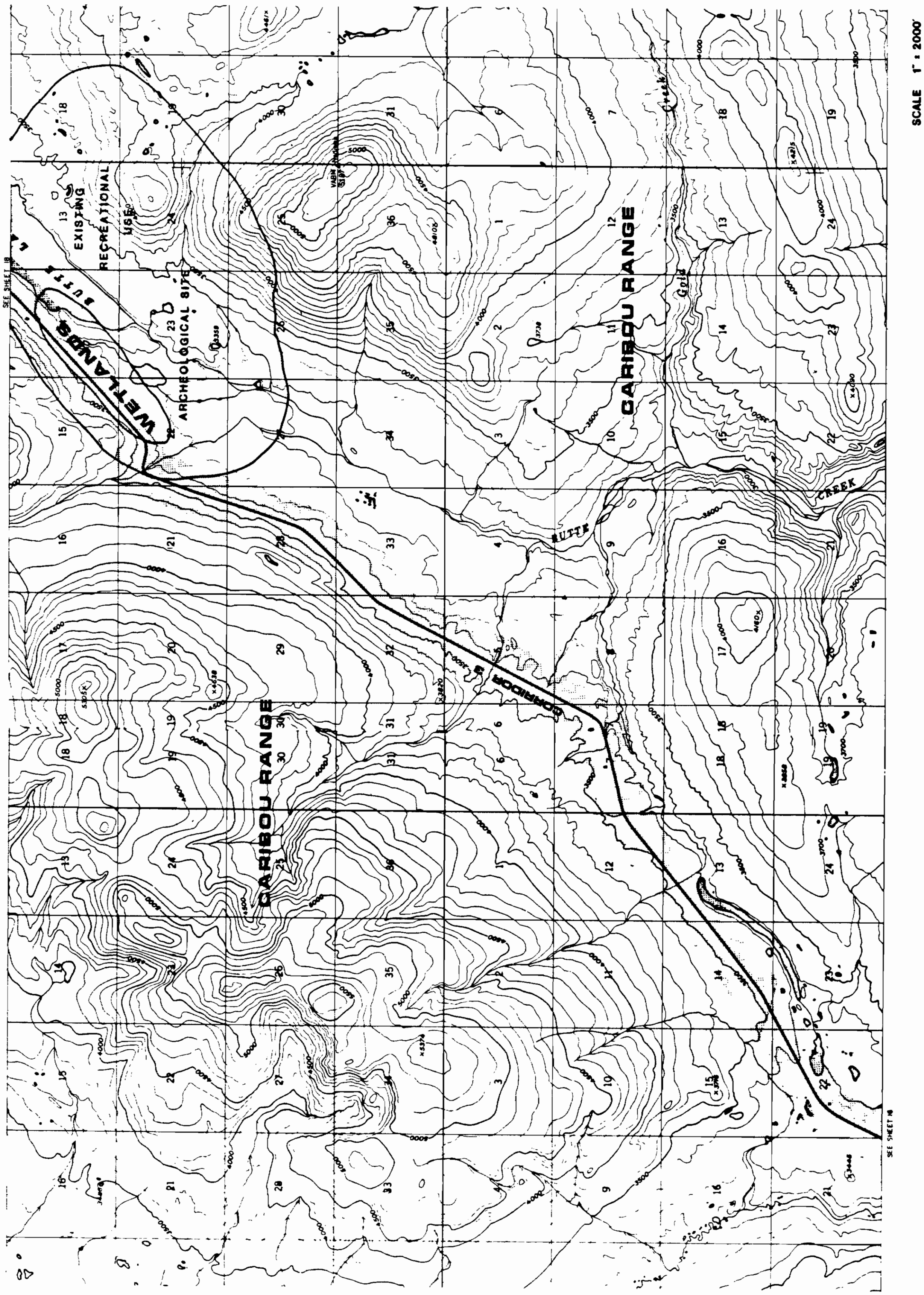
SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.16

ACRES



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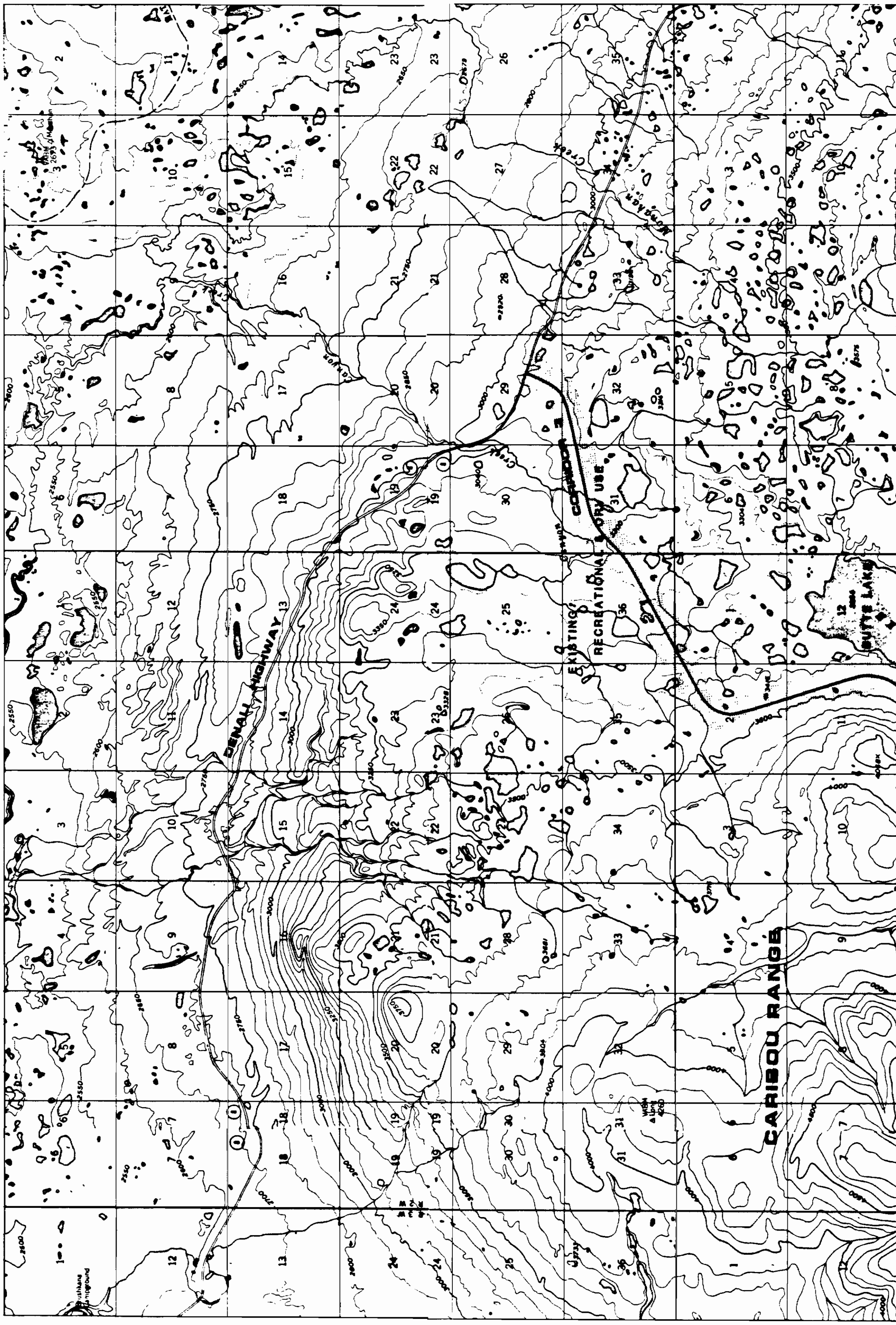
SUSITNA ACCESS CORRIDOR
ENVIRONMENTAL CONFLICTS

FIGURE E.17

ACRES



SCALE 1" = 2000'

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SUSITNA ACCESS CORRIDOR

ENVIRONMENTAL CONFLICTS

FIGURE E.18

PREPARED FOR:

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APPENDIX F

COST ESTIMATES

APPENDIX F - COST ESTIMATES

The overall costs of the various access plans must be a considered in the selection process. The access plans and their estimated costs are outlined herein. The process by which the estimates were generated is documented and the primary components of each plan are set forth.

F.1 - Introduction

Common elements to all plans include quantities to be moved, the ports through which all commodites are assumed to flow and the ton-mile costs of haul for rail and truck. The costs differences developed here in will result from differences in length, difficulty of construction and maintinance, bridges, rail heads, and the length of haul on each mode.

F.2 - Sea Ports

The Alaska sea ports identified for use in supplying the Susitna Hydroelectric Project are Anchorage and Whitter.

Anchorage is the perferred port for those items suitable for shipments in conventional containers and trucks. The port apparently has adequate capacity and the best facilities of any Alaska ports. The draw back in Anchorage is the lack of capabilities for roll-on roll-off rail shipments.

Whittier is unique in that there is roll-on roll-off rail capability. Because of freight rates and handling charges Whitter is the obvious choice for arrival of all materials that can be shipped by rail car.

Seward and Valdez were investigated and eliminated as primary ports for reasons of distance, port facilities and/or port costs.

TABLE F-2.1
ACROSS THE DOCK HANDLING COSTS

Material From Seattle (6)	Cost in $/Ton (1) To Anchorage	(2) To Seward	(4) To Whittier	(1) To Valdez
Reinforcing Steel	72.00	72.00	55.00	86.00
Structural Steel	85.40	85.40	55.00	125.00
Cement	66.00	66.00	55.00(3)	80.00
General Cargo	80.00	80.00	55.00	110.00
Equipment	160.00	160.00	120.00	191.00
Explosives	89.00	Not Allowed	55.00	115.00

1 Quoted by Pacific Western.

2 Information not received - Estimated equal to Anchorge. Rates for fuel included in modal alternate section.

3 Rate for 140,000 lb Hopper Cars - Rates for Bags 100.00/ton as per ARR.

4 Rates derived from quotion by ARR.

5 Includes Stevedoring at all ports.

6 Explosives must flow through Prince Rupert, B.C.

F.3 - Linehaul

Line Haul rates were collected from the Alaska Railroad and several trucking firms. Comparison of line haul rates is shown below.

TABLE F-2.2
LINE HAUL RATES IN DOLLARS/TON-MILE

Item	Rail	Truck
Equipment	0.1878	0.2069
Steel	0.2577	0.2069
Cement	0.1565	0.2069
Fuel	0.1450	0.2069
General Cargo	0.1262	0.2069
Explosives	0.6267	0.2069

While certain items may move by truck with lower costs, the mix of items and quantities make it clear that the overall most cost effective line haul mode is rail. For this reason all plans contemplate rail haul to the maximum extent practicable.

F.4 - Railhead

Railhead facilities will be required at one or more locations depending on the final plan adopted. The logistics estimates indicate a need to be able to handle a flow of 40 to 60 rail car loads per week. The detailed requirements for the railhead will vary with location however for the purposes of the study a typical facility has been developed and will be considered as applicable at all locations.

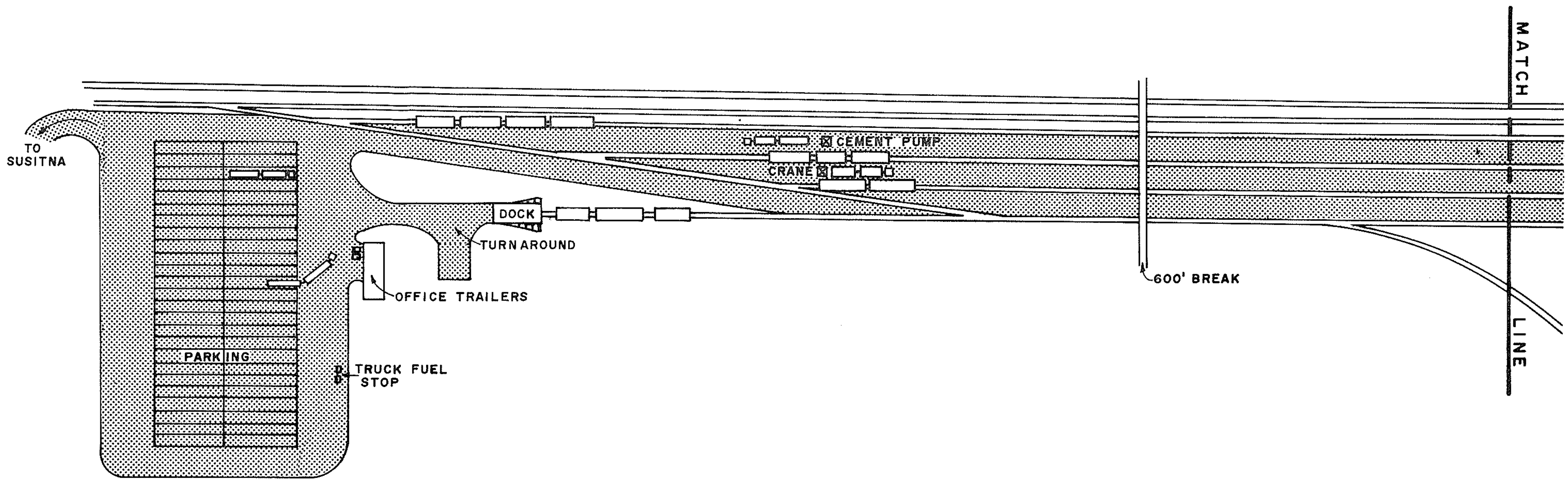
The typical railhead layout is based on the following requirements. The proposed layout is shown in Figure F-4.1. The estimated construction materials for the typical rail head is are as shown in Table F-4.1.

Scope: The rail head must be capable of handling about 50 cars at a time.

1) Piggybacks
2) Containerized (Sealand type)
3) Tank Cars
4) Hopper Cars

Elements:

1) Sidings to store rail cars arriving and departing
2) Siding(s) to store rail tankers for on-demand pumping into truck tankers
3) Cement pumping areas



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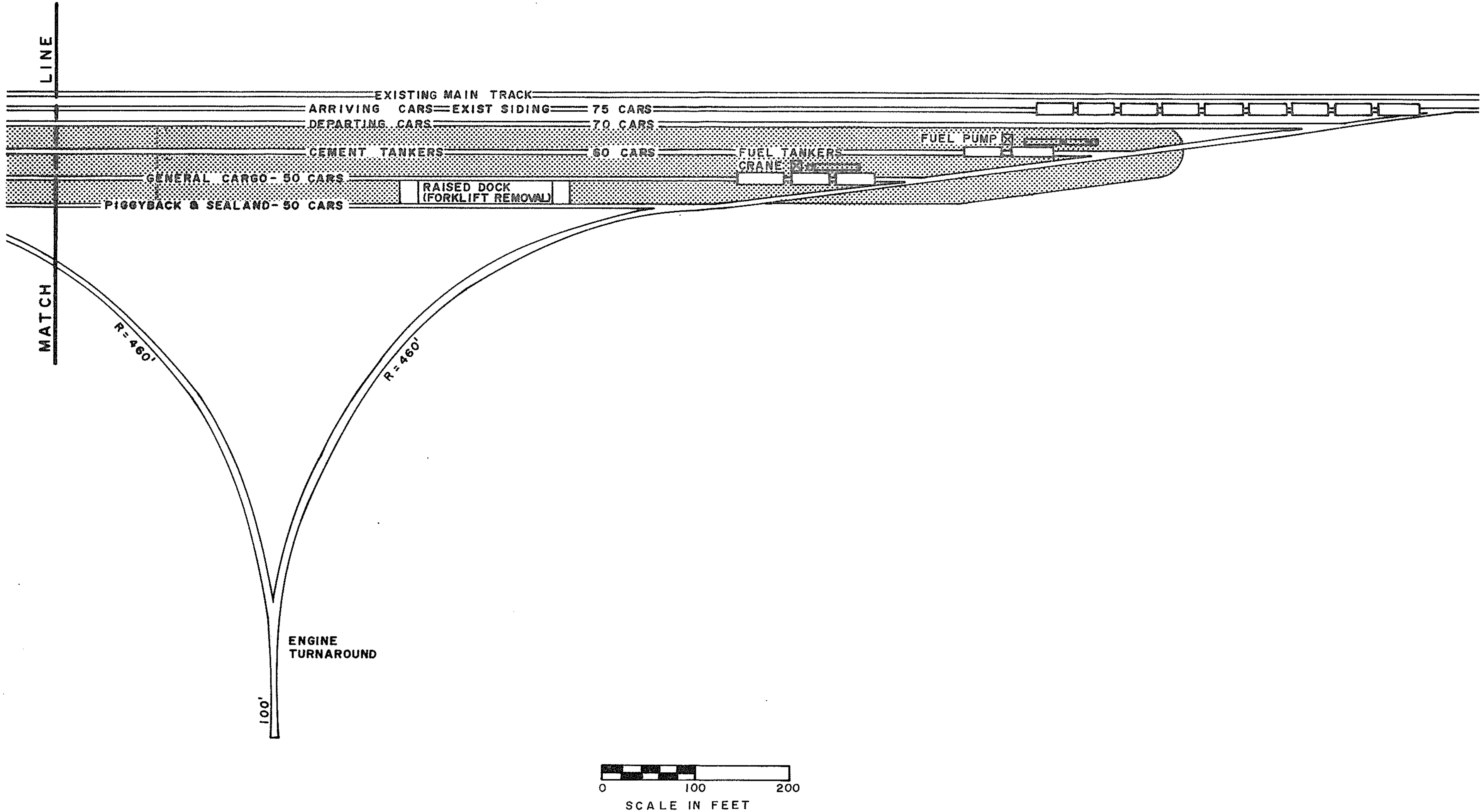

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R&M CONSULTANTS, INC.

TYPICAL PLAN RAIL TO TRUCK TRANSFER FACILITY

PREPARED FOR:

ACRES

FIGURE F.4.1

4) Piggyback off loading area (ramp)
5) Containerized off loading area (w/crane or forklift) (contractors to supply equipment)
6) Truck storage and maneuvering area
7) Office space and employee facilities (contractor supplies)
8) Truck fueling/servicing (contractor supplies)

Details

° Degree of curvature should not exceed 12° 30'

° Require 45' length of track per car. Minimum main line or ladder to ladder spacing 18' center to center. Minimum body to body track spacing 14 feet.

° Maximum angle of ladder to sideing, for a slow moving freight yard, #8 frog, is 7°9'10".

° Arrival and departure tracks should each be long enough to hold the longest train anticipated. Optimum yard capacity = 110% of arrival rate.

Parameters:

° Volume: 50 cars/wk. Use a maximum of 50 cars arriving in 1 day. These could all be of one type.

° Length: need 45' per car = 2,250'

° Between Sidings: Need 2 lane road (24' plus track width), minimum 14' from No. 1 to 2, 14' from No. 2 to 3, 29' from No. 3 to 4, and 29' from No. 4 to 5.

° Ladder Lengths: When spacing = 14', difference in length = 111½', when spacing = 29', difference in length = 231'

- Actual Lengths: No. 5 Minimum = 2,250', leg could be longer if terrain dictates.

  No. 4 = 2,250' (min.)
  No. 3 = 2,250' + 2 (231) = 2,712
  No. 2 = 2,712 + 2 (231) = 3,174
  No. 1 = 3,174 + 111½ = 3,397

  Note, No. 1 siding already exists at Gold Creek and is 4000' long.

- Turnaround:
  R = 460'
  A = 100' (2 cars) (Tangent length beyond switch)

- Trucks: WB-60, WB-50, maximum turning radius = 45', minimum turning radius = 19.8, maximum length = 65', max width = 8.5' or for wide load parking slots: use 12' x 70' aisle: 55' wide to allow for turn into stalls, # of slots = 50 ea.

Sources:

- Hennes, Robert G. and Ekse, Martin I., Fundamentals of Transportation Engineering. McGraw Hill Book Company, 1955 New York.

- Merritt, Frederick S., Standard Handbook for Civil Engineers 2nd Ed. McGraw - Hill Book Company 1976 New York.

TABLE F-4.1
RAIL HEAD ESTIMATE

		AMOUNT
1.	Clearing	25 ac.
2.	Waste Excavation	78,000 cy
3.	Common Excavation	505,000 cy
4.	Rock Excavation	-0-
5.	Borrow	-0-
6.	Grade A Base	4,900 cy
7.	D-1 Base	2,400 cy
8.	AC Surfacing	2,200 tons
9.	Fabric	-0-
10.	Topsoil and Seed	15 ac.
11.	Traffic Control Devices	L.S.
12.	Subballast	25,800 cy
13.	Trackage	19,700 l.f.
14.	Dock Lumber (6"x6")	16 mbf

Note: Plans that call for rail segments (R-1 and/or R-2) include the attached railhead(s) within the rail estimate. Separate railheads at Cantwell and/or Gold Creek are costed separately. The quantities used are the same in both cases.

F.5 - Bridges

Bridges are major cost items and for some plans, major schedule constraints. Layout plans for the major bridges are included. Bridge cost estimates are based on Alaska Department of Transporation and Public Facilities average bid information. This information was provided by a Department of Transporation and Public Facilities estimator. Bridge prices up-dated to 1982 dollars are approaching $150.00/square foot of deck for complete installations.

The railroad bridges normally include heavier members and foundation elements, however they are narrower. Information received from the Alaska Railroad Engineering department indicates that square foot costs for railroad bridges are approximately double that for highway bridge. Therefore a cost of $300.00/square foot will be used for estimating railroad bridge costs.

Figure F 5.1 shows a 180-foot steel box girder structure over Indian River. This structure, with slight variations in height and/or length is typical of all possible crossings of Indian River.

Figure F 5.2 shows the Susitna River structure proposed for segment 2-L. Other segments crossing the Susitna near Gold Creek would have a bridge that would have different alignment characteristics, however over-all demensions would be similar in most cases. Cost estimates are based on the structure shown.

Figure F5.3 shows the road and railroad bridges over Cheechako Creek immediately above Devil Canyon. This structure is in a location that makes it a major time constraint.

Figure F5.4 shows the roadway structure over Fog Creek.

Figure F5.5 a roadway structure over an unnamed creek about two miles east of Cheechako Creek in Corridor 2.

Figure F5.6 shows the type and approximate size of structure that would be required to serve as a high bridge at Devil Canyon. This bridge will take approximately three years to construct. The $150/square foot cost is probably low for this type of structure however there is no eqivalent Alaska bridge, so that estimate is used.

Figure F5.7 shows a railroad structure spanning the same unnamed creek crossed by the bridge in Figure F5.5

F.6 Quantity Estimating Cross Sections

For purposes of estimating excavation quantities along the preferred routes within each of the 3 corridors and the railroad corridor, cross slopes were taken from available contour maps along with lengths of alignments.

Cross sections were prepared for cross slopes of 0-10%, 15%, 25%, 30%, 35%, 40%, 45%, and 50%. The upper 2 feet of material was considered as waste excavation on all alignments.

It was considered that average variations of subgrade from the ideal cut equal fill section would be 10 feet.

Frozen materials were considered to have a maximum cut of 10 feet to protect the 15 feet depth of frozen indicated in the soils information. This maximum cut depth requires a higher grade line than would be most economical for a balanced cut = fill section. Local borrow would be necessary to make up the difference.

On cross slopes up to 10%, particulary along corridor #3 a borrow pit type of cross section is proposed to provide material for raising the subgrade elevation above the existing ground. Stripped or waste material can go back into the borrow pits.

Up to 15% cross slope, cuts will probably not exceed 10 feet. so no quantity variations would be anticiapted between frozen and unfrozen materials.

The 25%, 30%, and 35% cross slope sections indicate for unfrozen ground a + unfrozen and - unfrozen section 10 feet apart vertically with the excavation quantity balancing the fill quantities. The Frozen subgrade upper and lower limits with a maximum of 10 feet cut require borrow to balance.

On cross slopes of 40% and over, it was considered that after the 2 feet of waste excavation on the surface there would be another 3 feet of usuable excavation before encountering rock excavation. In rock excavation, the frozen condition does not require the maximum 10 feet cut requirement.

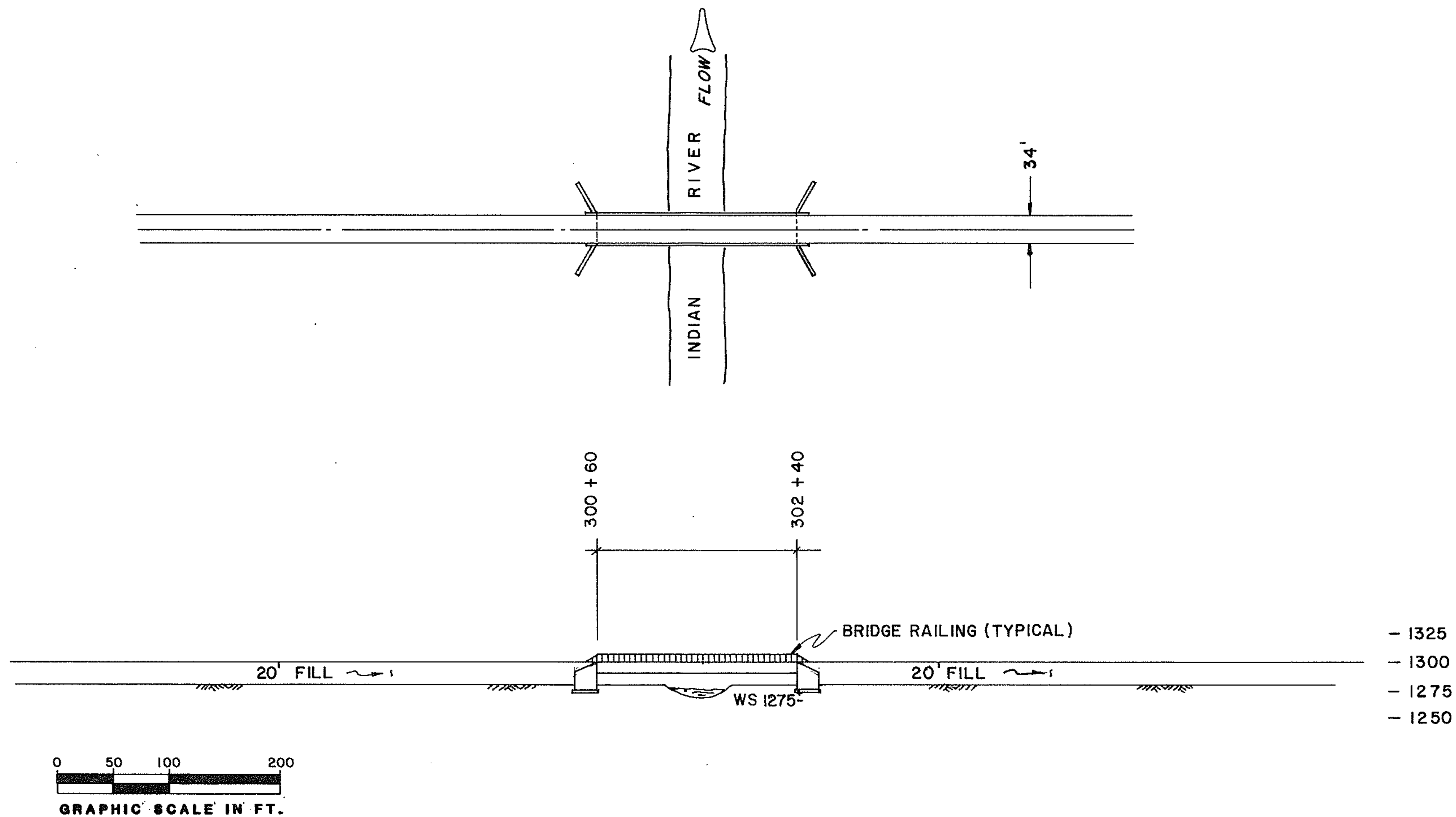
Fill slopes on the roadway sections vary depending on fill height. Cut slopes are used as ½:1 in rock and 1½:1 or flatter in normal materials.

Examination of the terrain unit maps provided additional information as to where rock and organics were to be encountered. Adjustments were made in rock and waste excavation from this information.

The sections used for estimating are shown in Figures F6.1-F6.16

F.7 - Drainage

The cross drainage requirements for the preferred alignment within each corridor were estimated. The design flows were determined by defining the respective drainage areas on USGS quadrangle maps and applying regression equations developed by the U.S. Geologic Survey. "Flood characteristic of Alaskan Streams". Water Resources Investigation 78-129 R.D. Lamke 1979.



180 FT. STEEL BOX GIRDER BRIDGE

PREPARED BY:

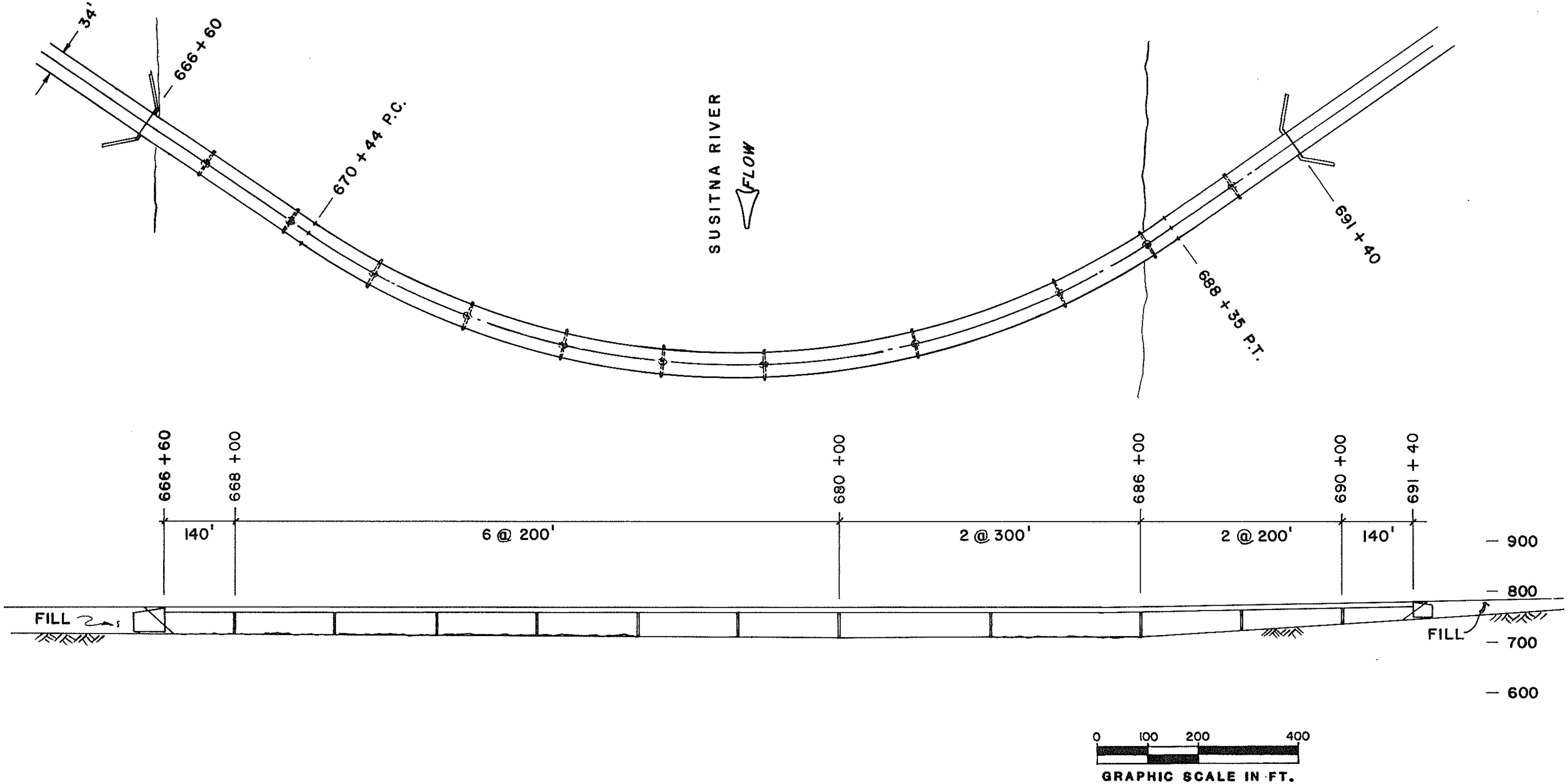
R&M CONSULTANTS, INC.

INDIAN RIVER BRIDGE

PREPARED FOR:

ACRES

FIGURE F.5.1



ORTHOTROPIC STEEL STRUCTURE 2480 FT. BRIDGE

PREPARED BY:

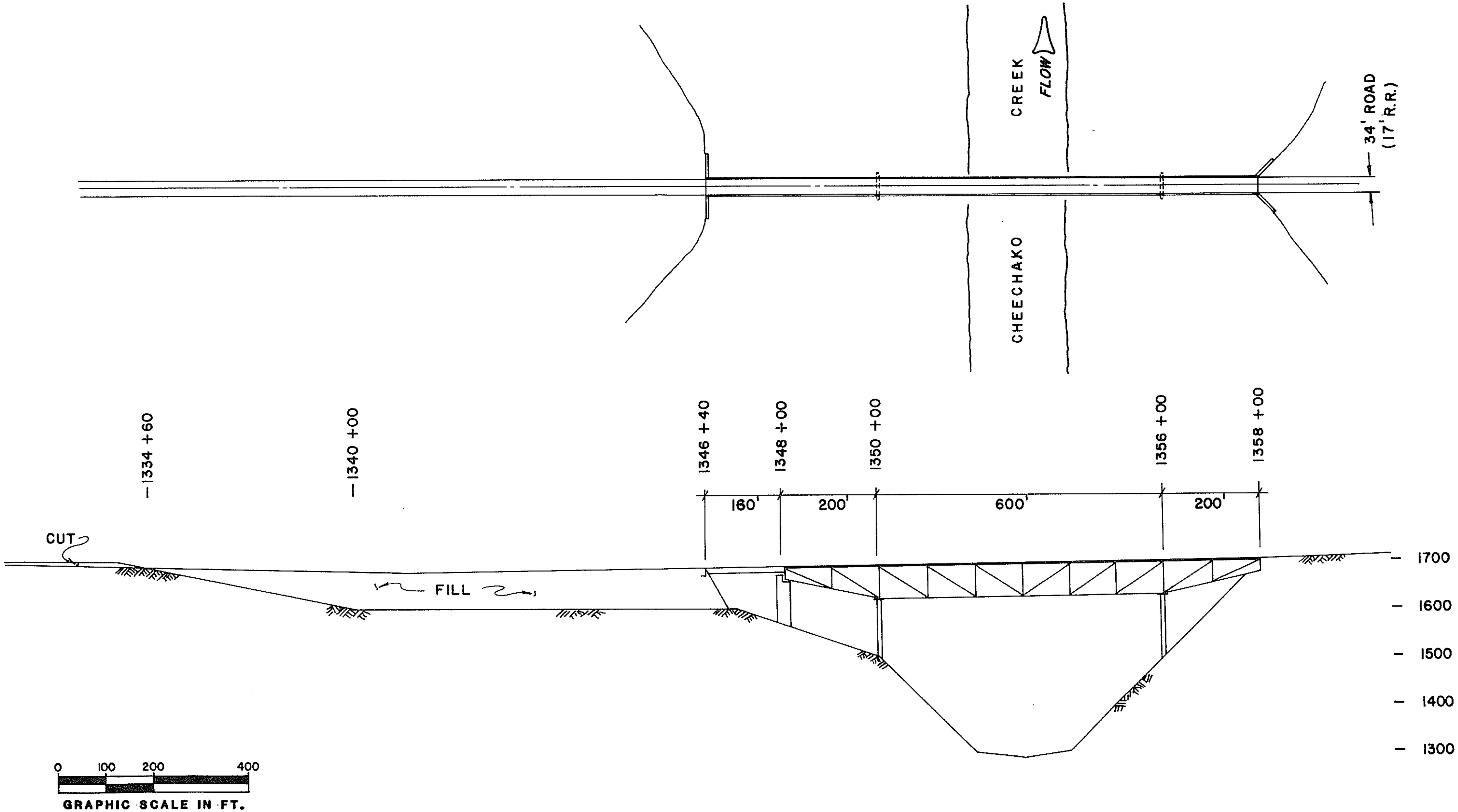
R&M CONSULTANTS, INC.

SUSITNA RIVER BRIDGE

PREPARED FOR:

ACRES

FIGURE F.5.2



1160 FT. STEEL DECK TRUSS BRIDGE

PREPARED BY:

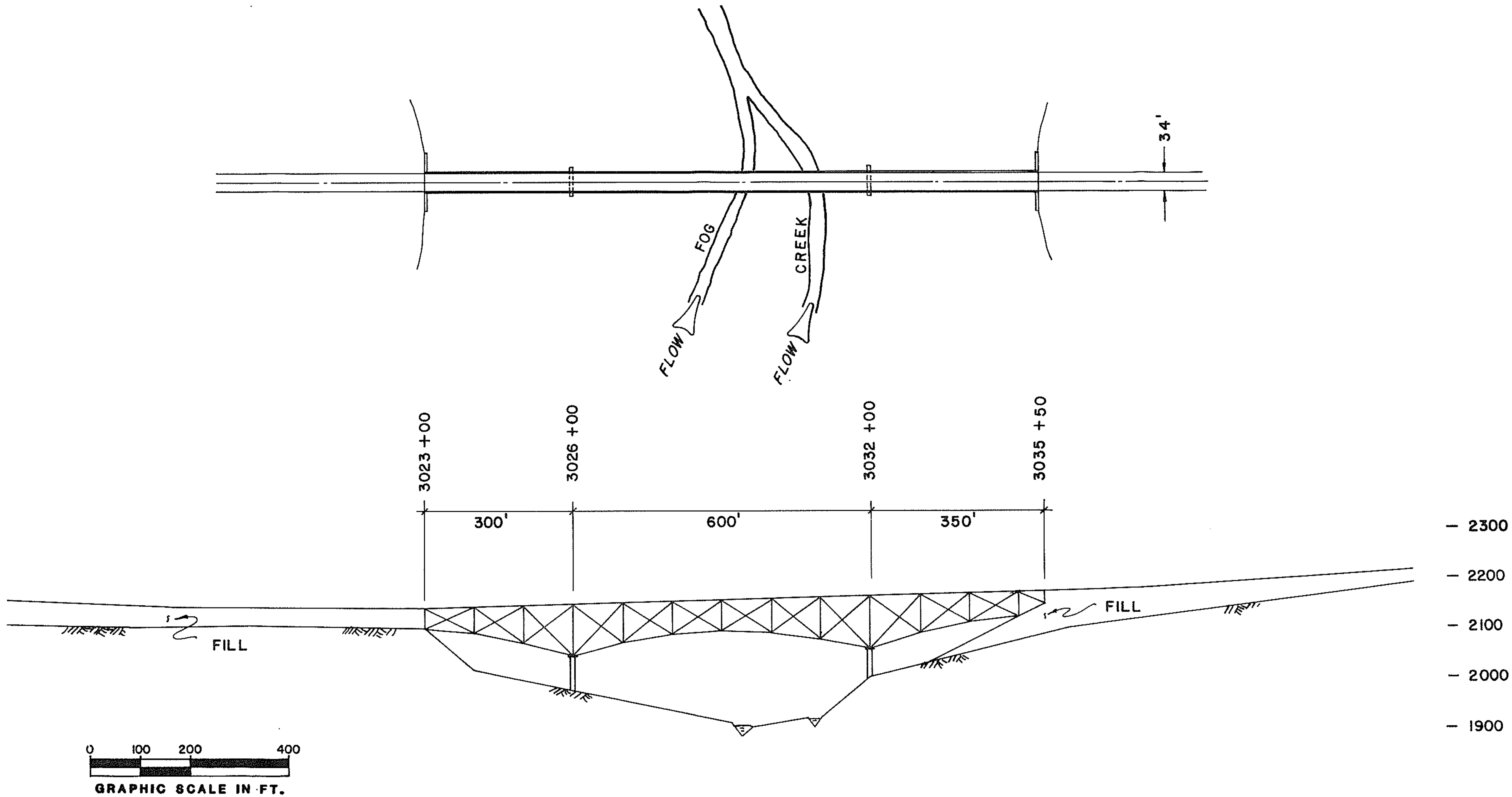
R&M CONSULTANTS, INC.

CHEECHAKO CREEK BRIDGE

PREPARED FOR:

ACRES

FIGURE F.5.3



1250 FT. STEEL DECK TRUSS BRIDGE

PREPARED BY:

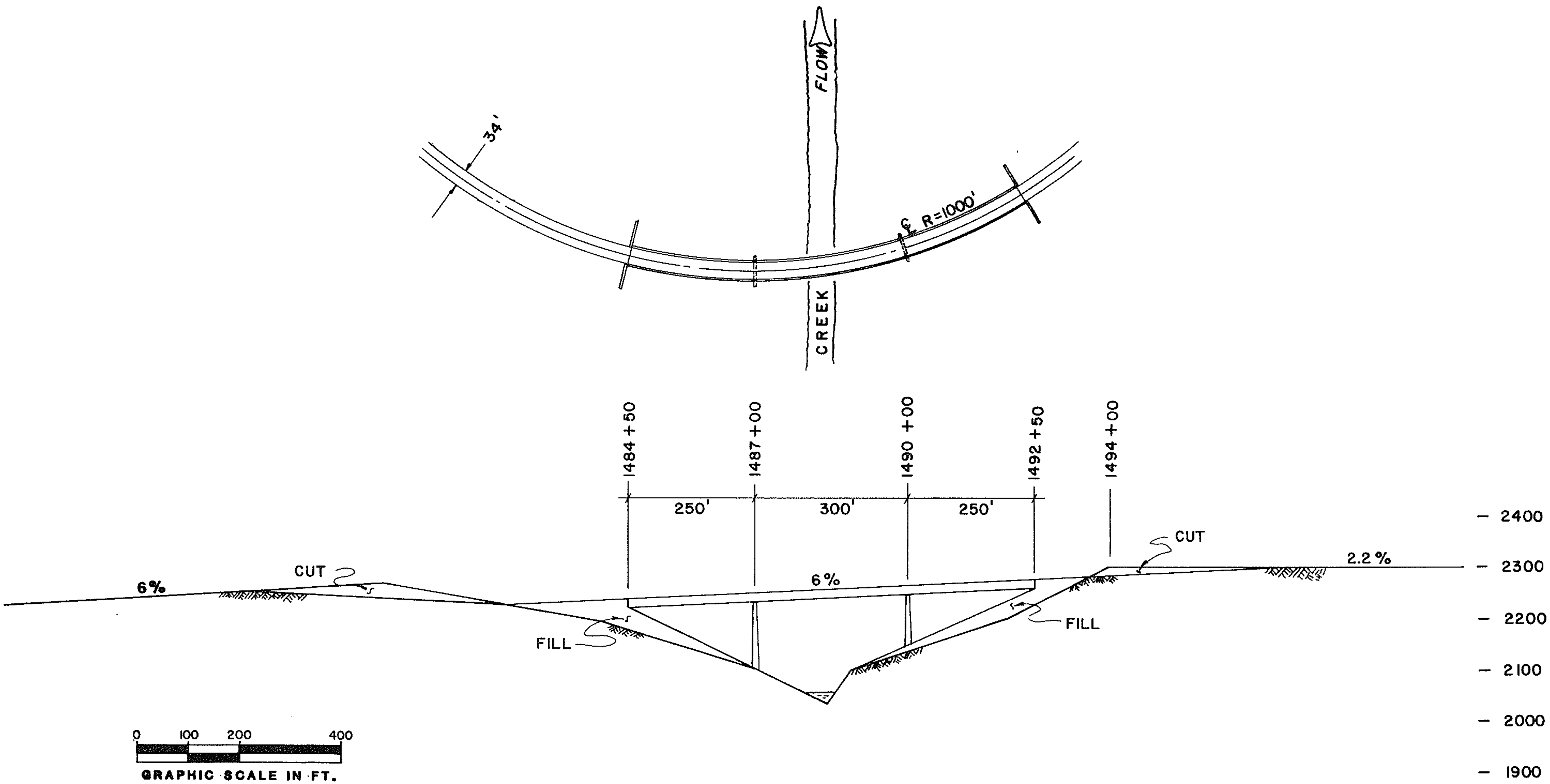
R&M CONSULTANTS, INC.

FOG CREEK BRIDGE

PREPARED FOR:

ACRES

FIGURE F.5.4



800 FT. STEEL BOX GIRDER BRIDGE

PREPARED BY:

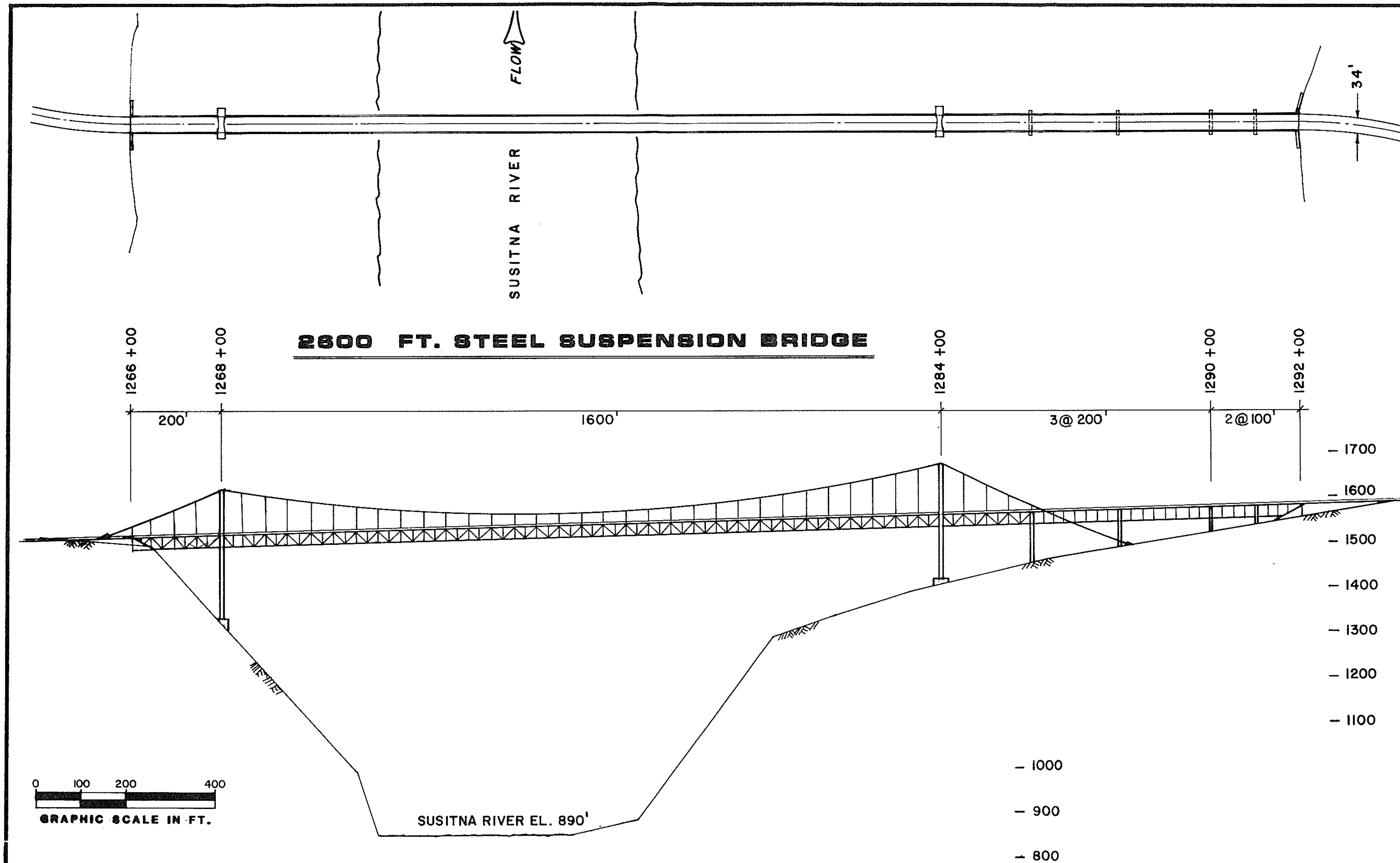
R&M CONSULTANTS, INC.

ROAD BRIDGE SOUTHEAST OF DEVIL CANYON

PREPARED FOR:

ACRES

FIGURE F.5.5



PREPARED BY:

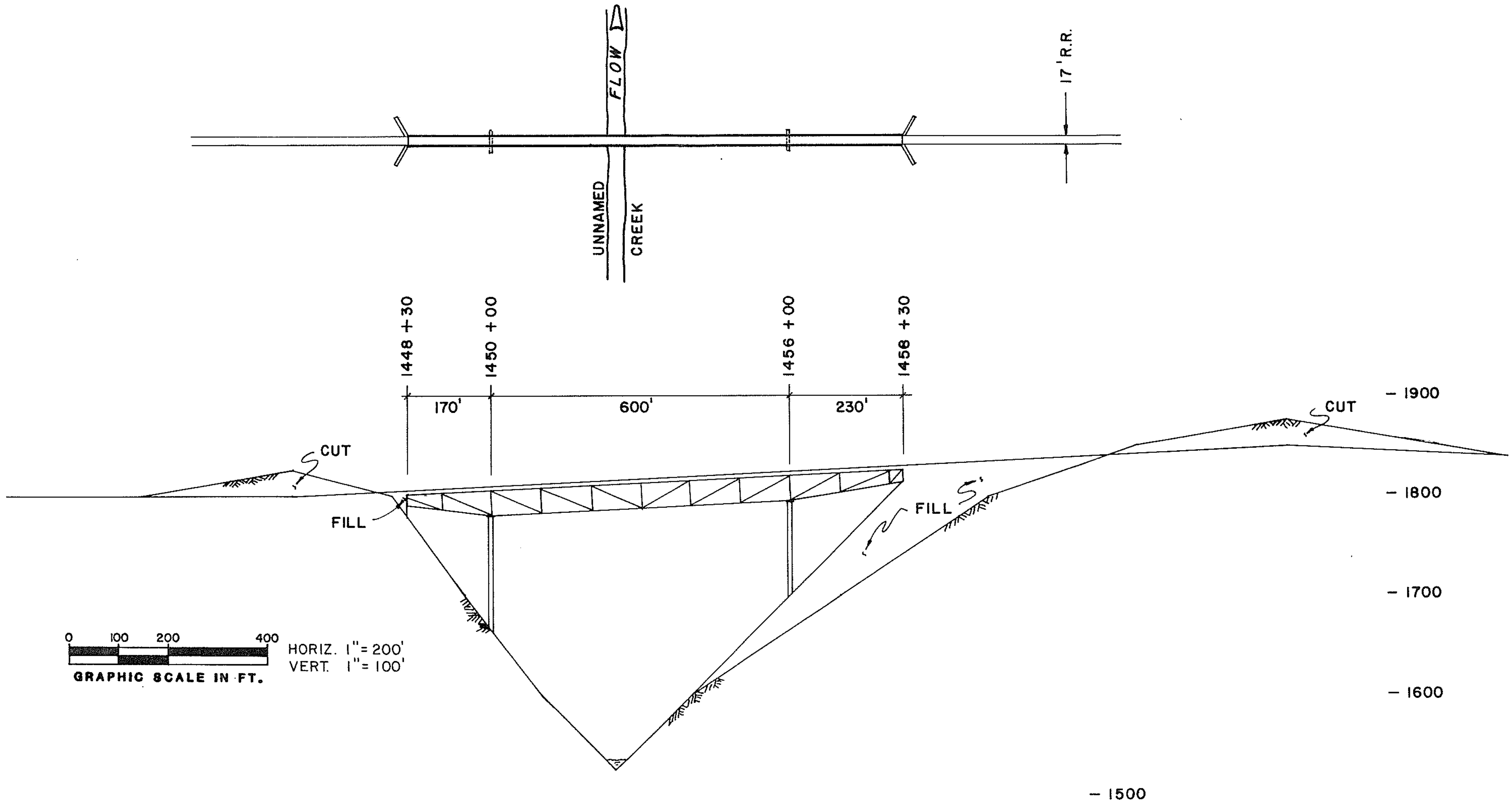
R&M CONSULTANTS, INC.

HIGH SUSITNA RIVER BRIDGE AT DEVIL CANYON

PREPARED FOR:

ACRES

FIGURE F.5.6



1000 FT. STEEL DECK TRUSS BRIDGE

PREPARED BY:

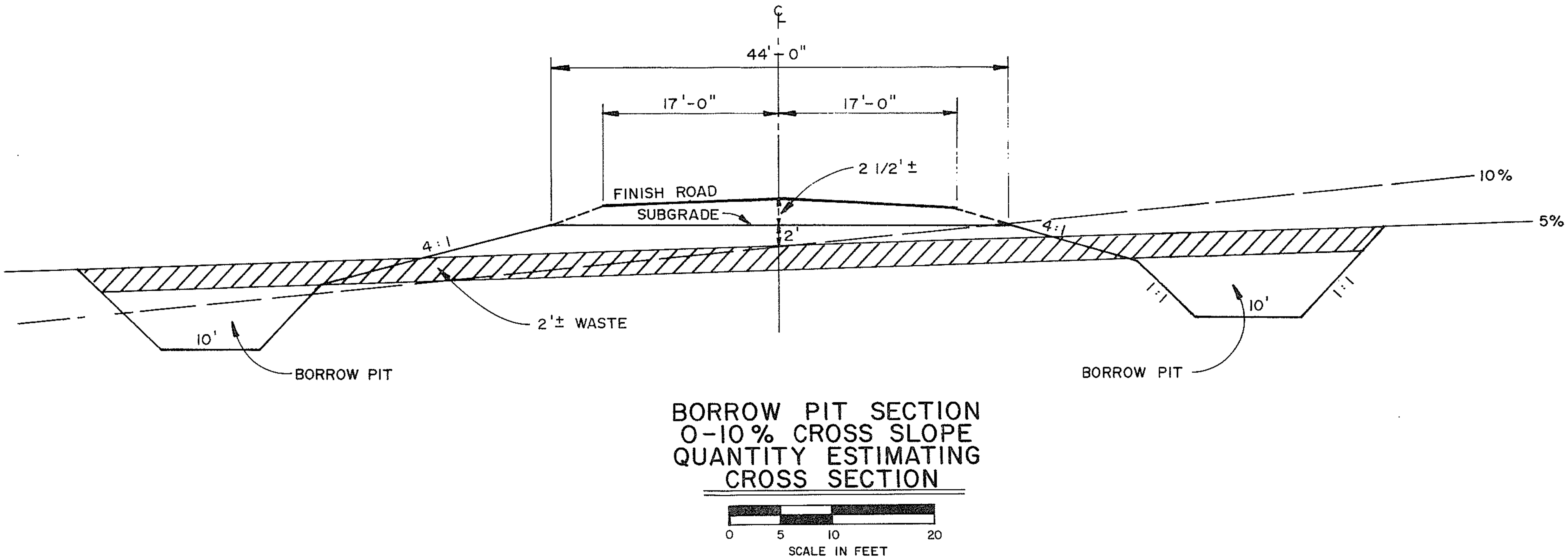
R&M CONSULTANTS, INC.

RAILROAD BRIDGE SOUTHEAST OF DEVIL CANYON

PREPARED FOR:

ACRES

FIGURE F.5.7



BORROW PIT SECTION
0-10% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

PREPARED BY:

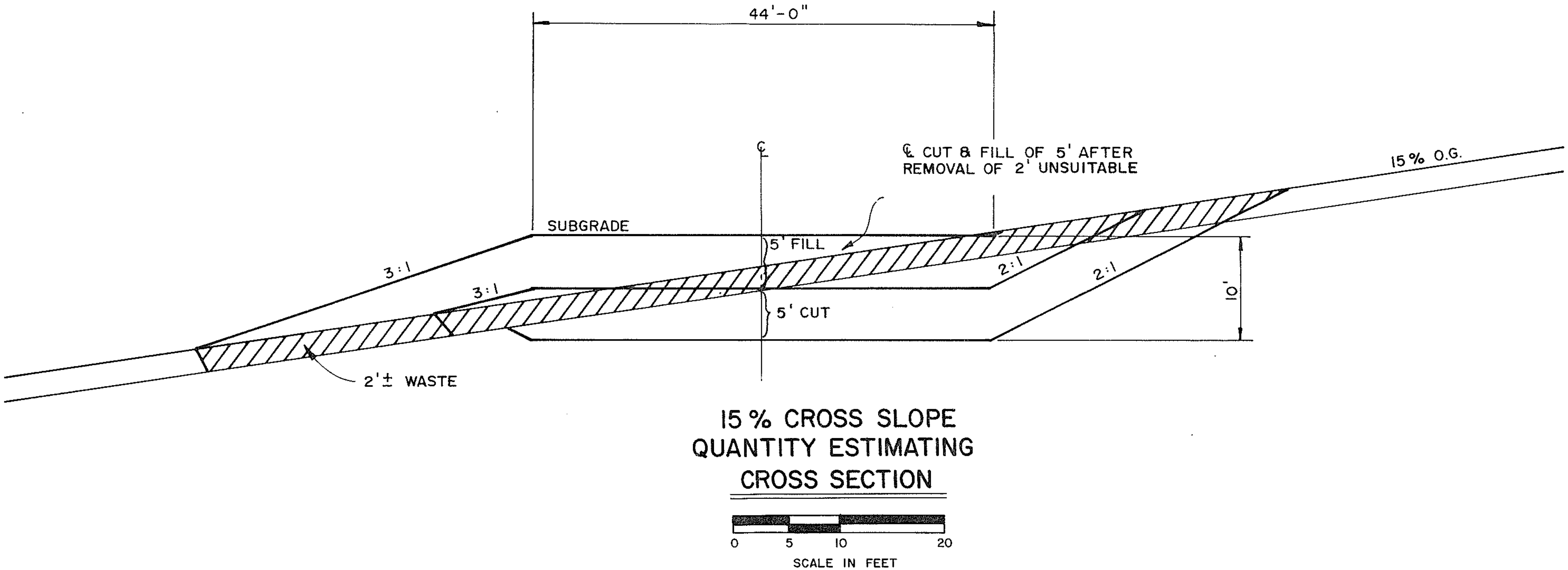
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION
0 - 10% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.1



PREPARED BY:

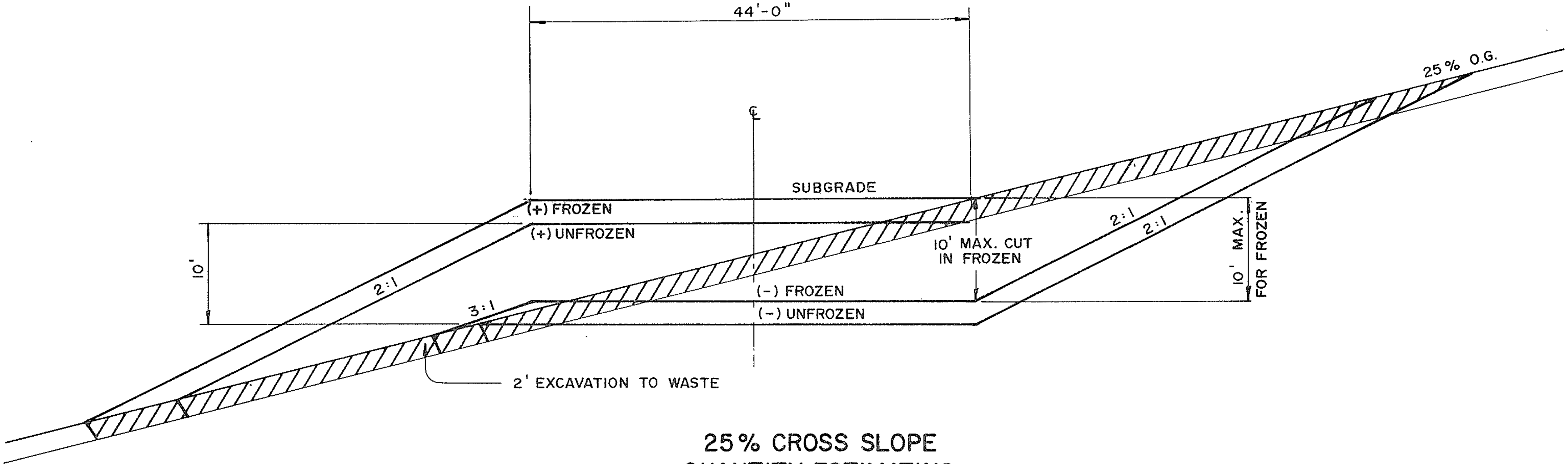
R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

TYPICAL ROAD SECTION
15% CROSS SLOPE

FIGURE F.6.2



25% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

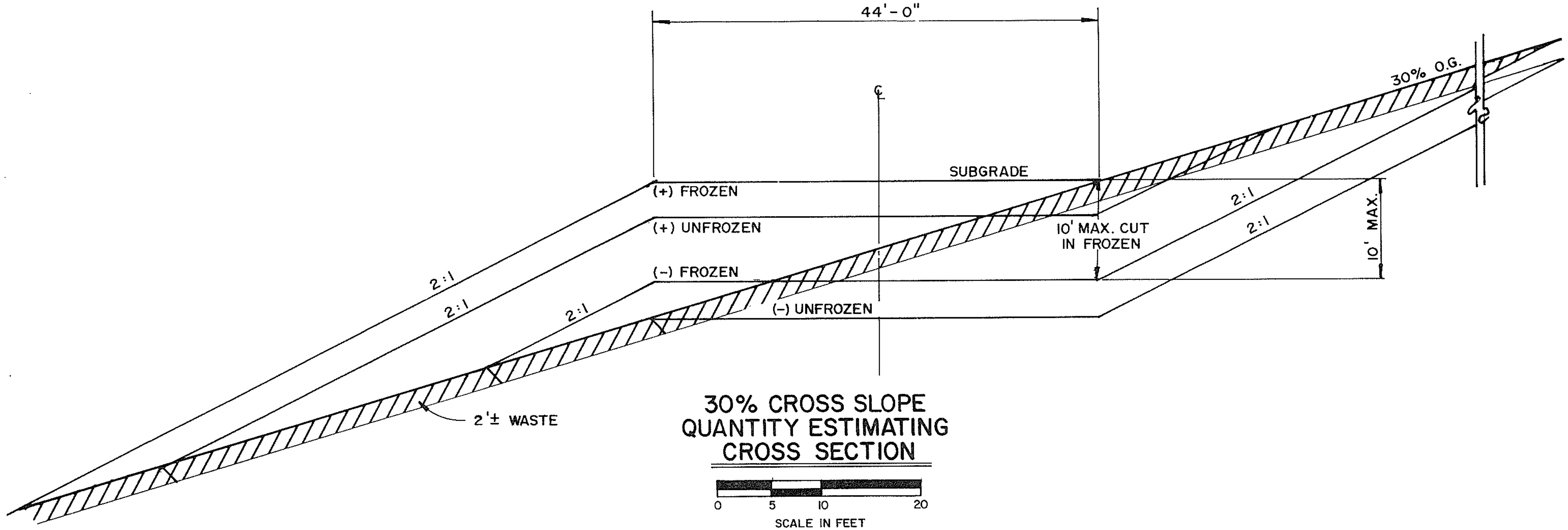
0 5 10 20
SCALE IN FEET

PREPARED BY:
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION
25% CROSS SLOPE

PREPARED FOR:
ACRES

FIGURE F.6.3



30% CROSS SLOPE QUANTITY ESTIMATING CROSS SECTION

0 5 10 20
SCALE IN FEET

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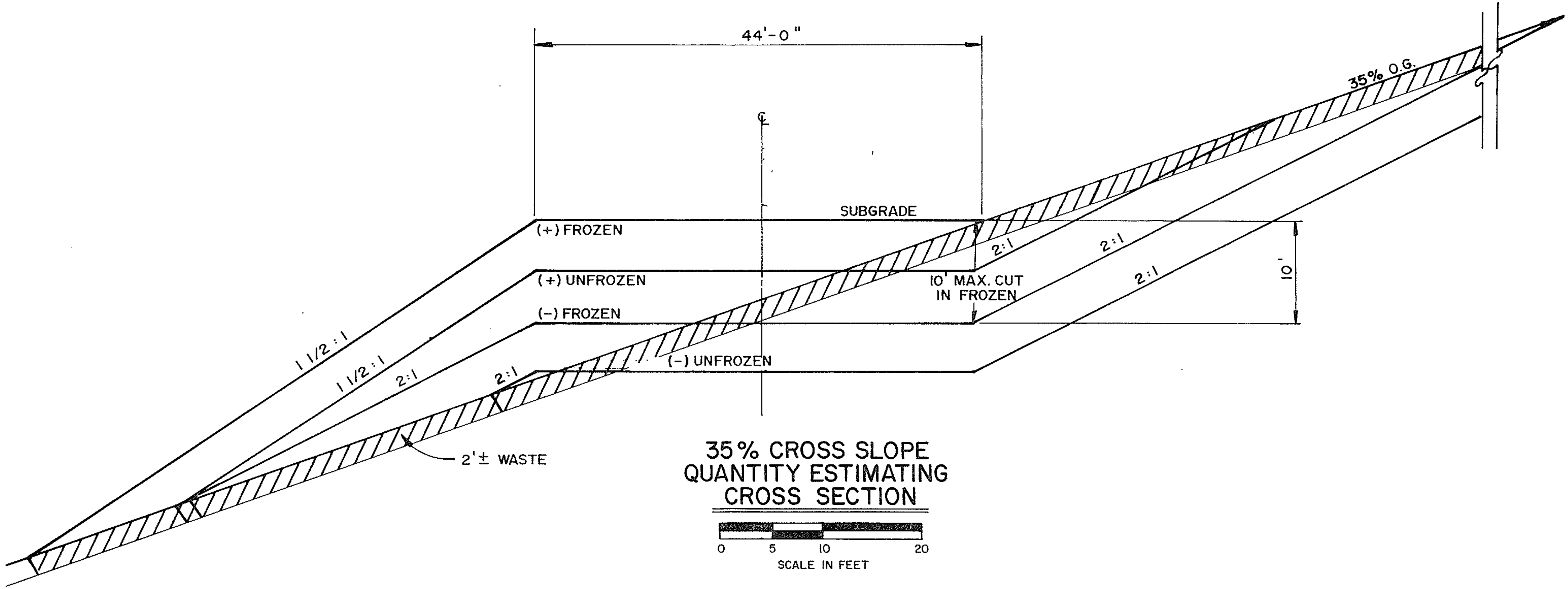
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION 30% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.4



35% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

PREPARED BY:

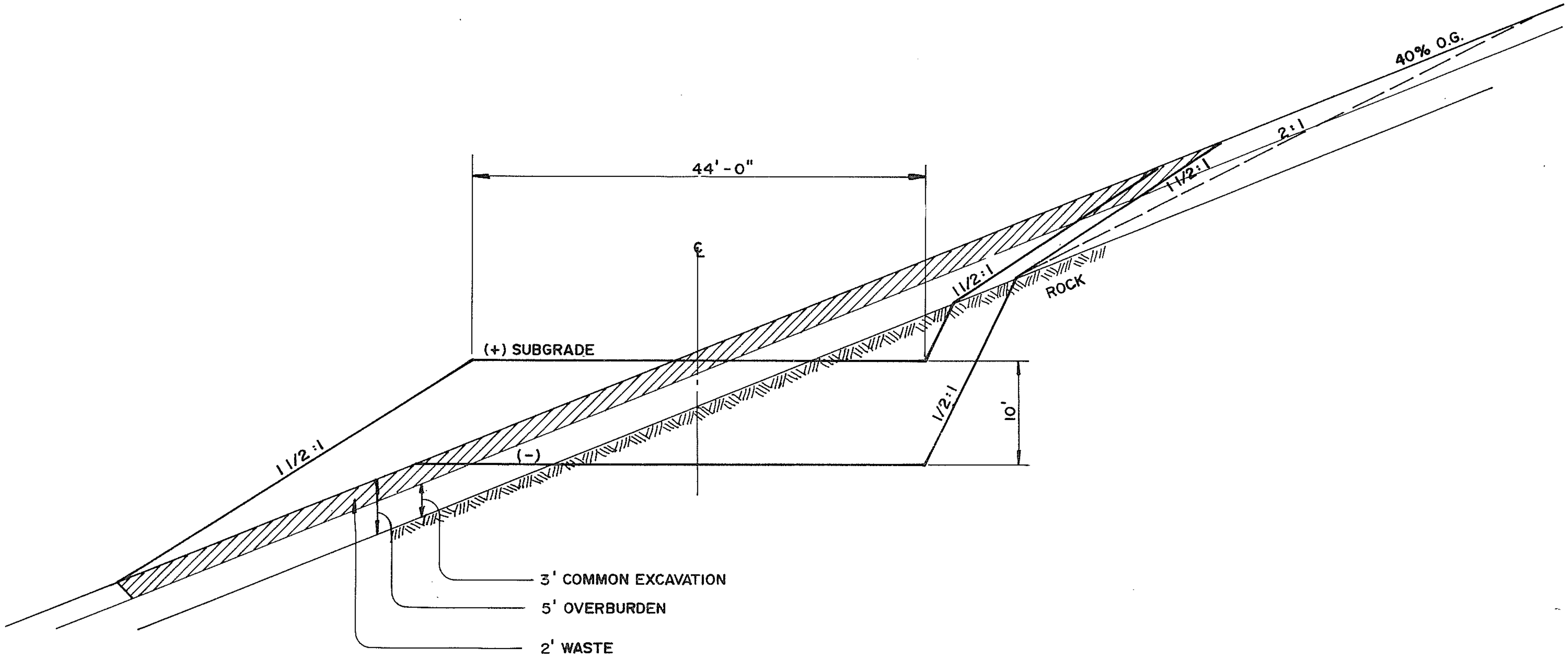
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION
35% CROSS SLOPE

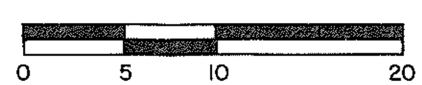
PREPARED FOR:

ACRES

FIGURE F.6.5



40% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION



SCALE IN FEET

PREPARED BY:

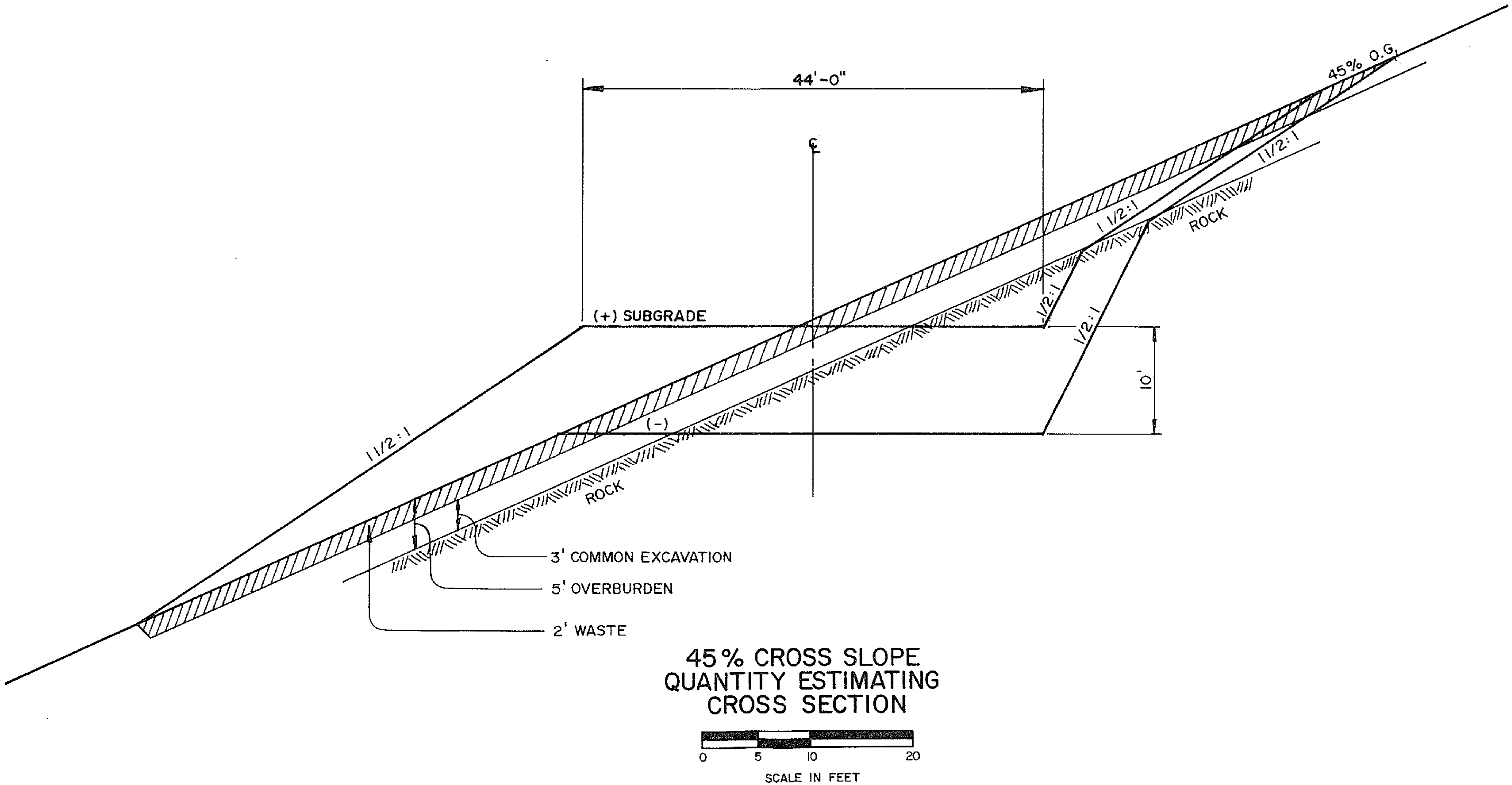
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION
40% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.6



45% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

PREPARED BY:

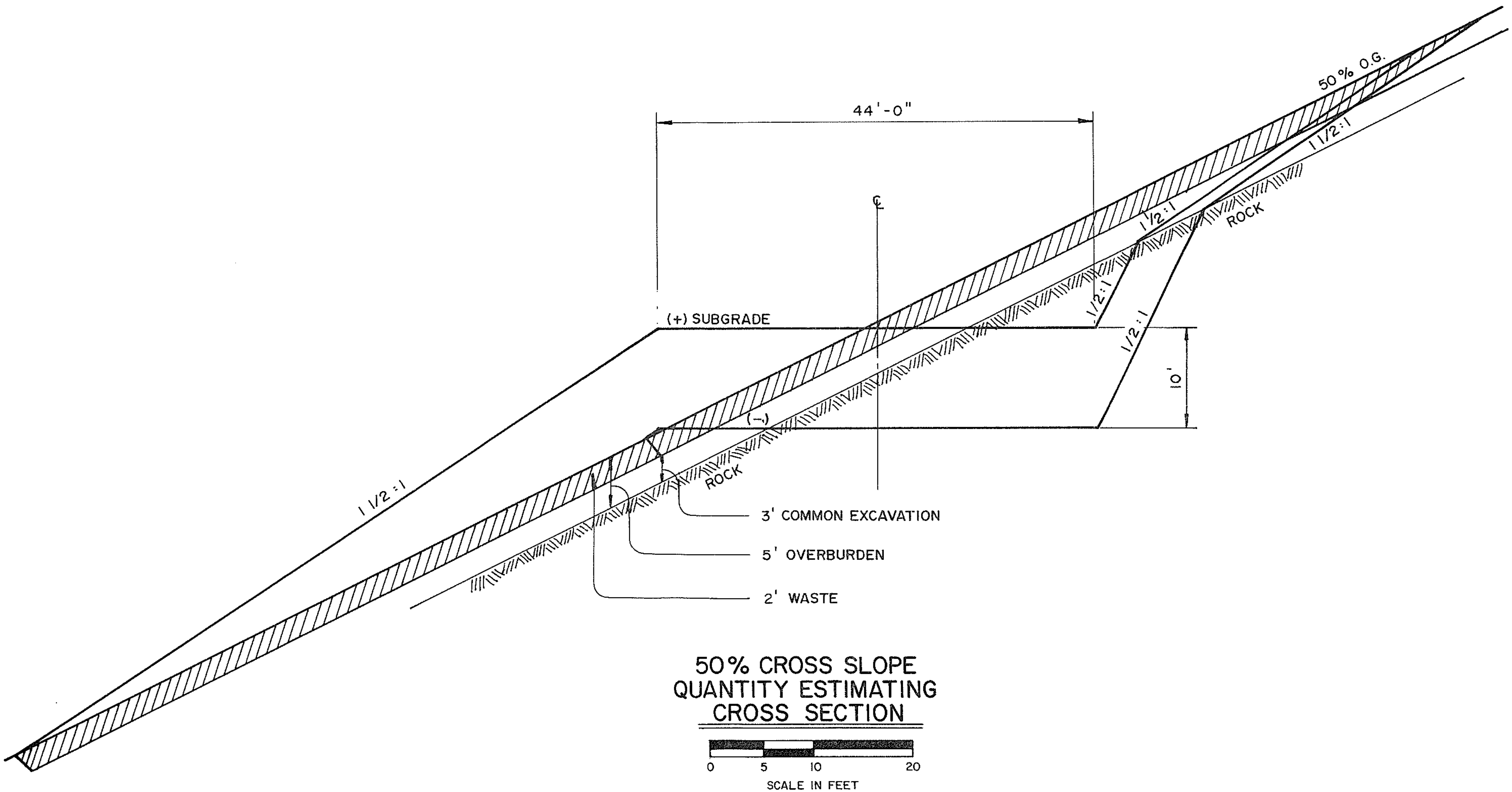
R&M CONSULTANTS, INC.

TYPICAL ROAD SECTION
45% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.7



50% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

PREPARED BY:

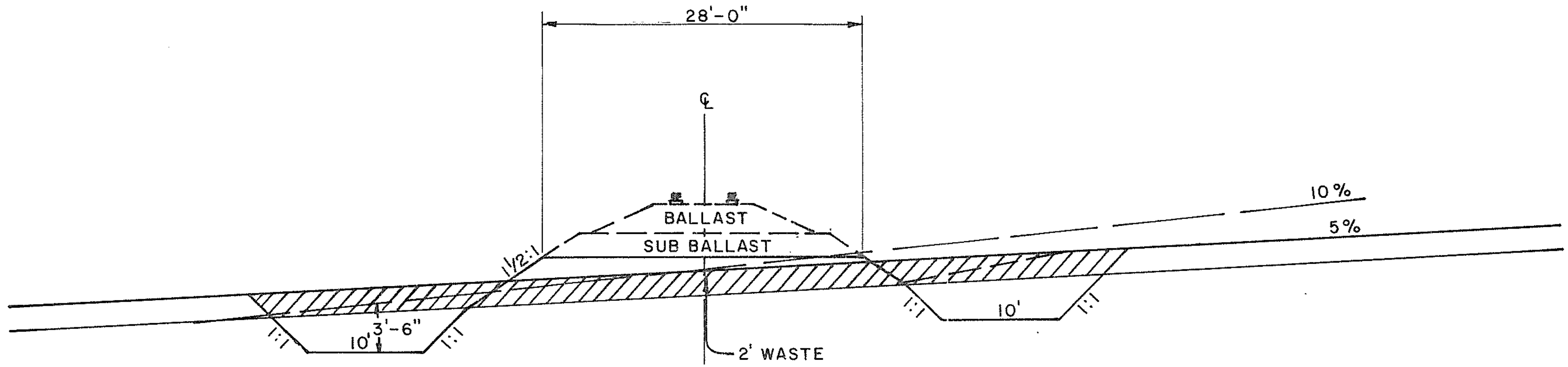
R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

TYPICAL ROAD SECTION
50% CROSS SLOPE

FIGURE F.6.8



BORROW PIT SECTION
0-10% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

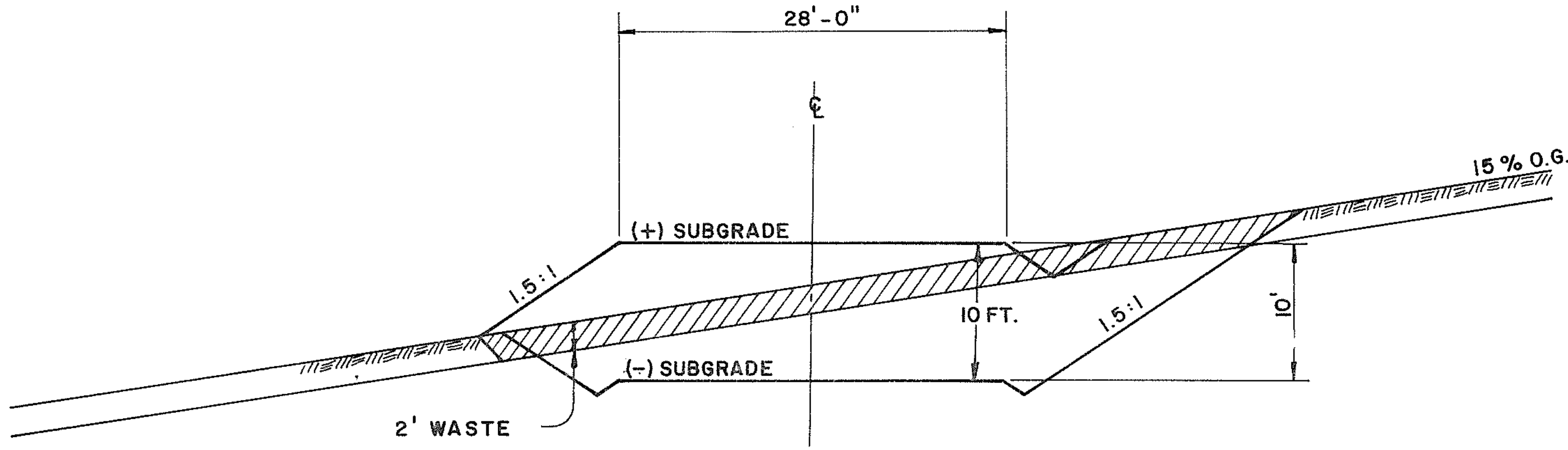
R&M CONSULTANTS, INC.

TYPICAL RAILROAD SECTION
0 - 10% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.9



15 % CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

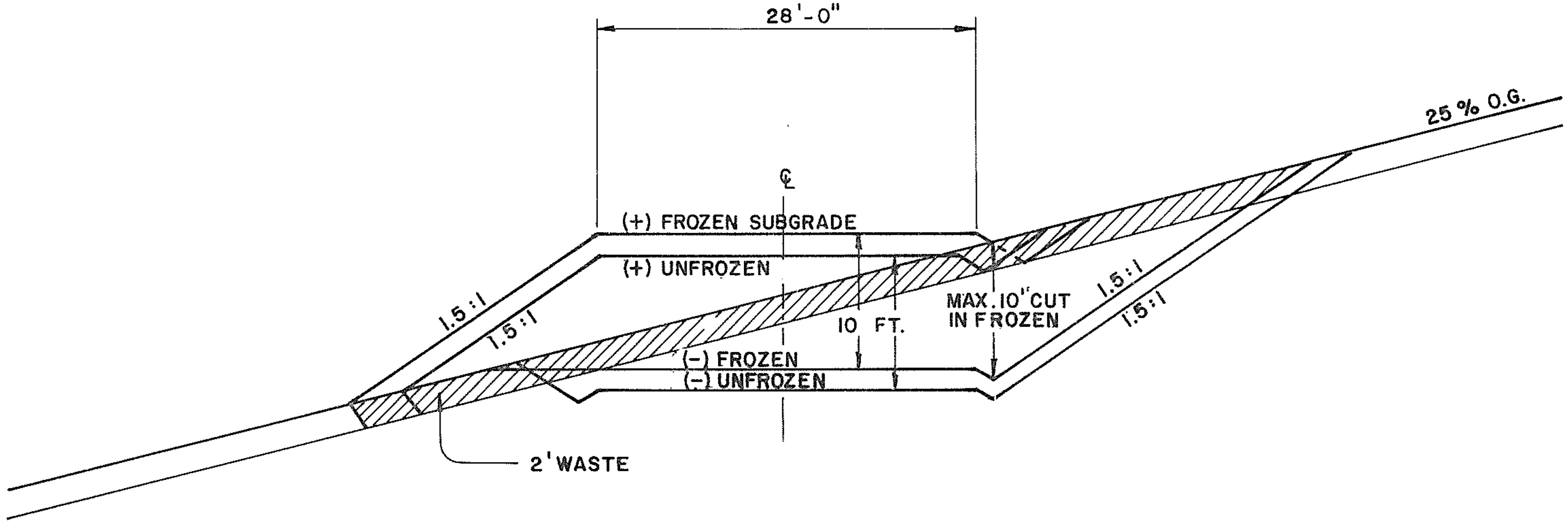
R&M CONSULTANTS, INC.

TYPICAL RAILROAD SECTION
15% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.10



25% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

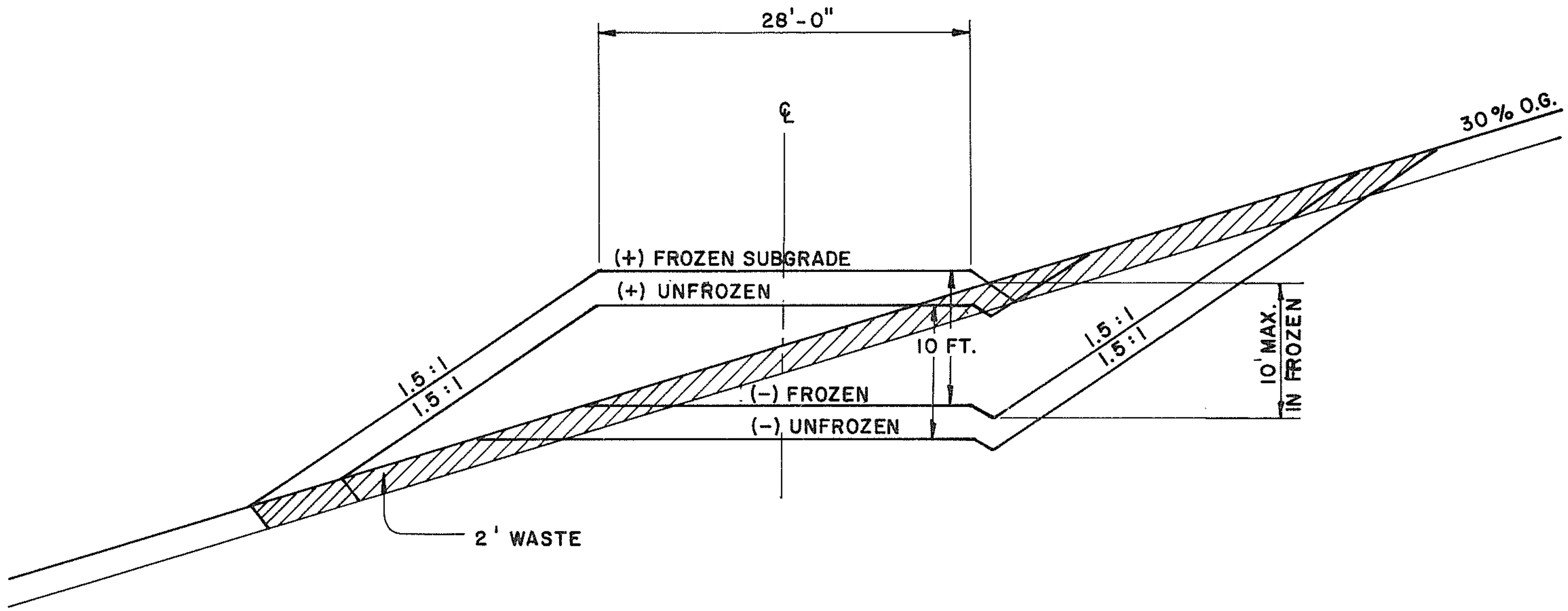
R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

TYPICAL RAILROAD SECTION
25% CROSS SLOPE

FIGURE F.6.11



30% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

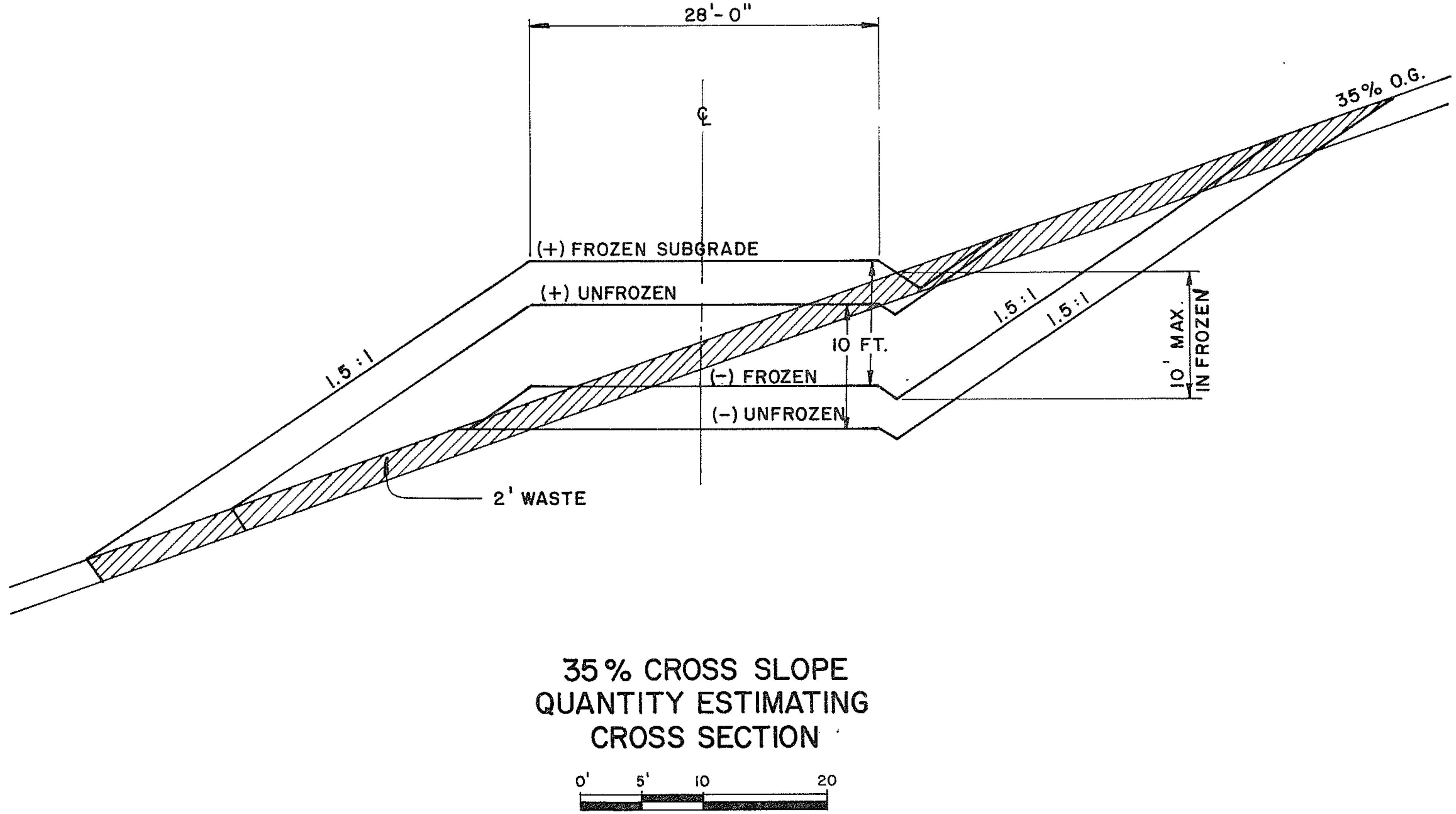
R&M CONSULTANTS, INC.

TYPICAL RAILROAD SECTION
30% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.12



35 % CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

PREPARED BY:

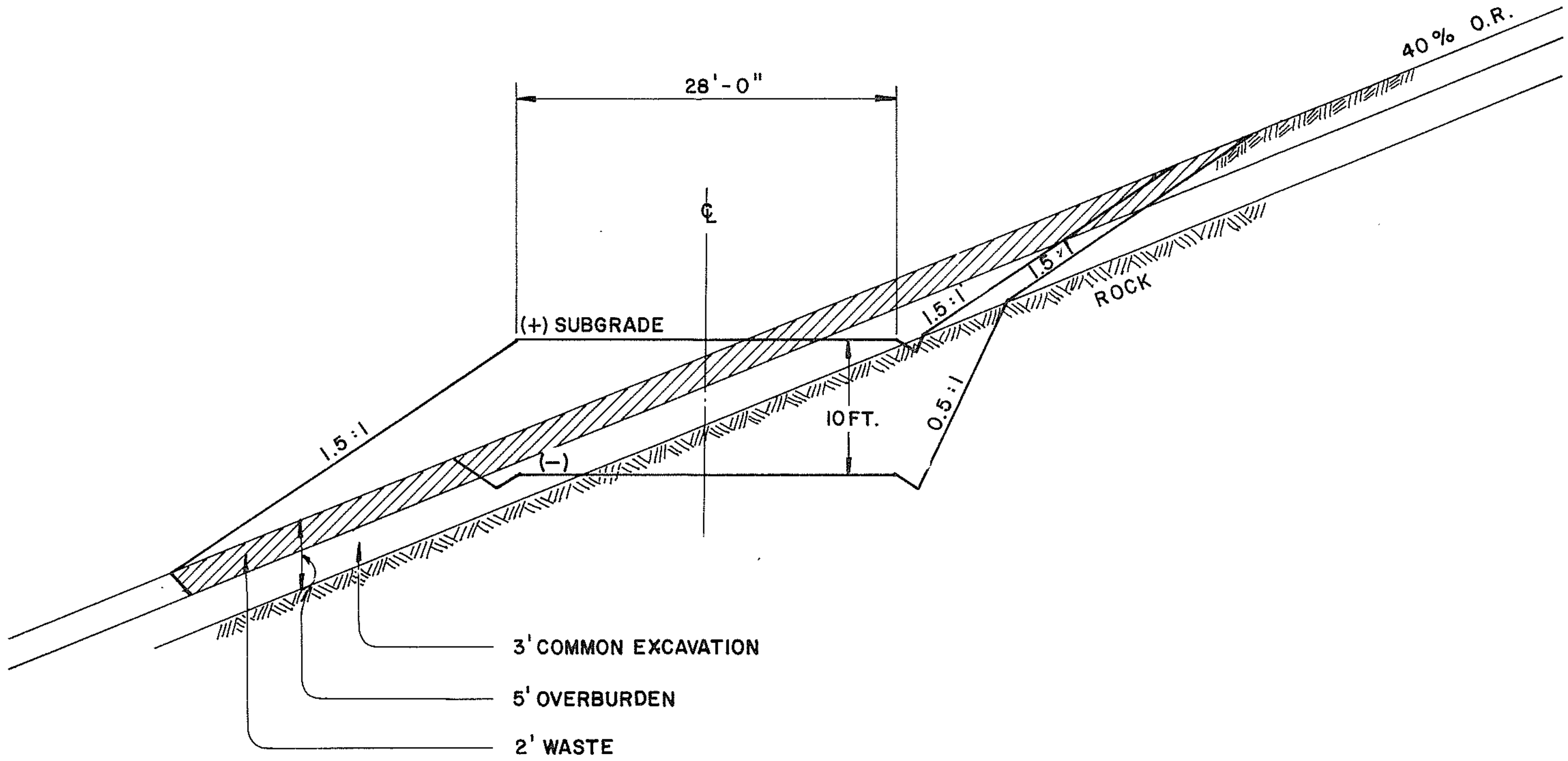
R&M CONSULTANTS, INC.

TYPICAL RAILROAD SECTION
35% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.13



40% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

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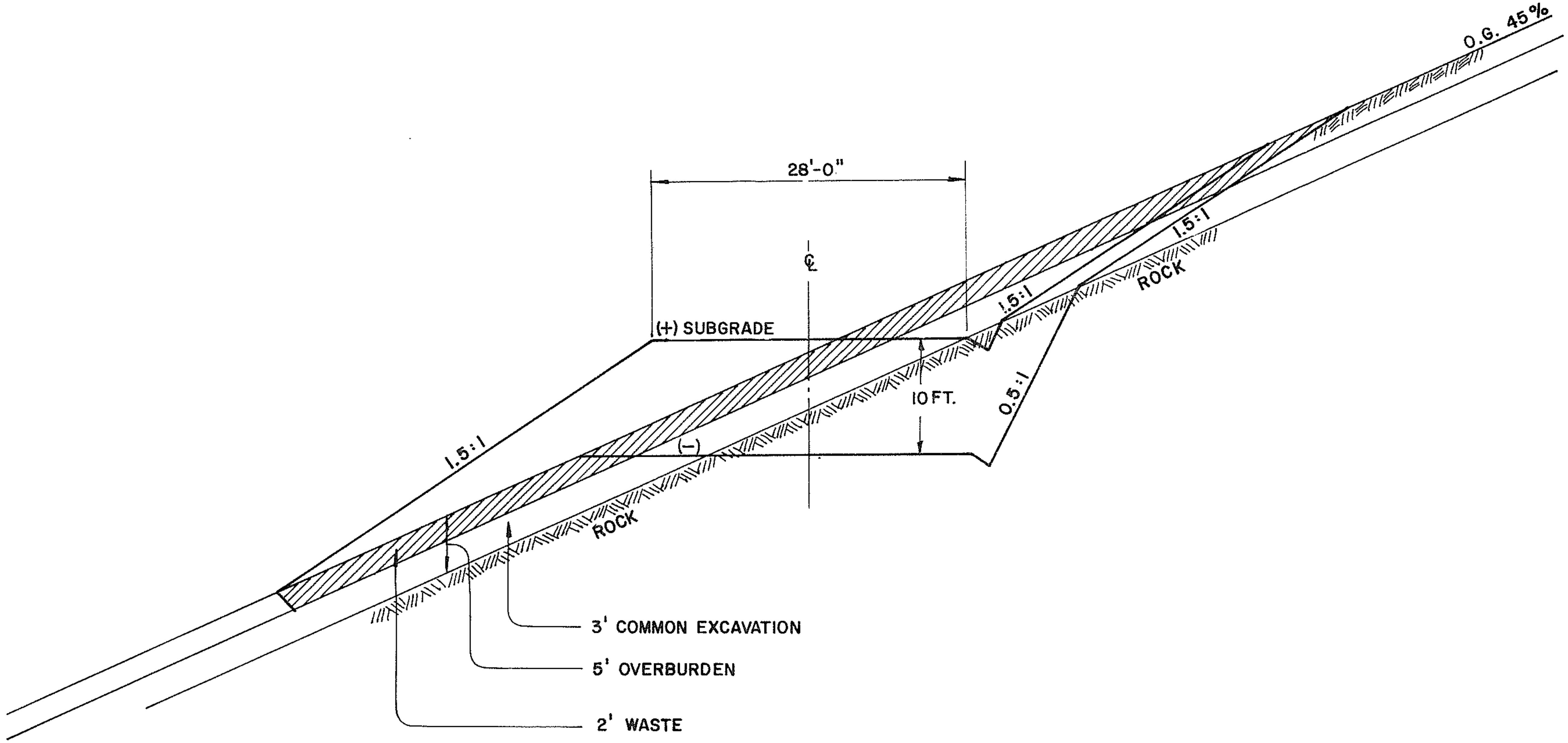
TYPICAL RAILROAD SECTION
40% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.14



45% CROSS SLOPE
QUANTITY ESTIMATING
CROSS SECTION

0 5 10 20
SCALE IN FEET

PREPARED BY:

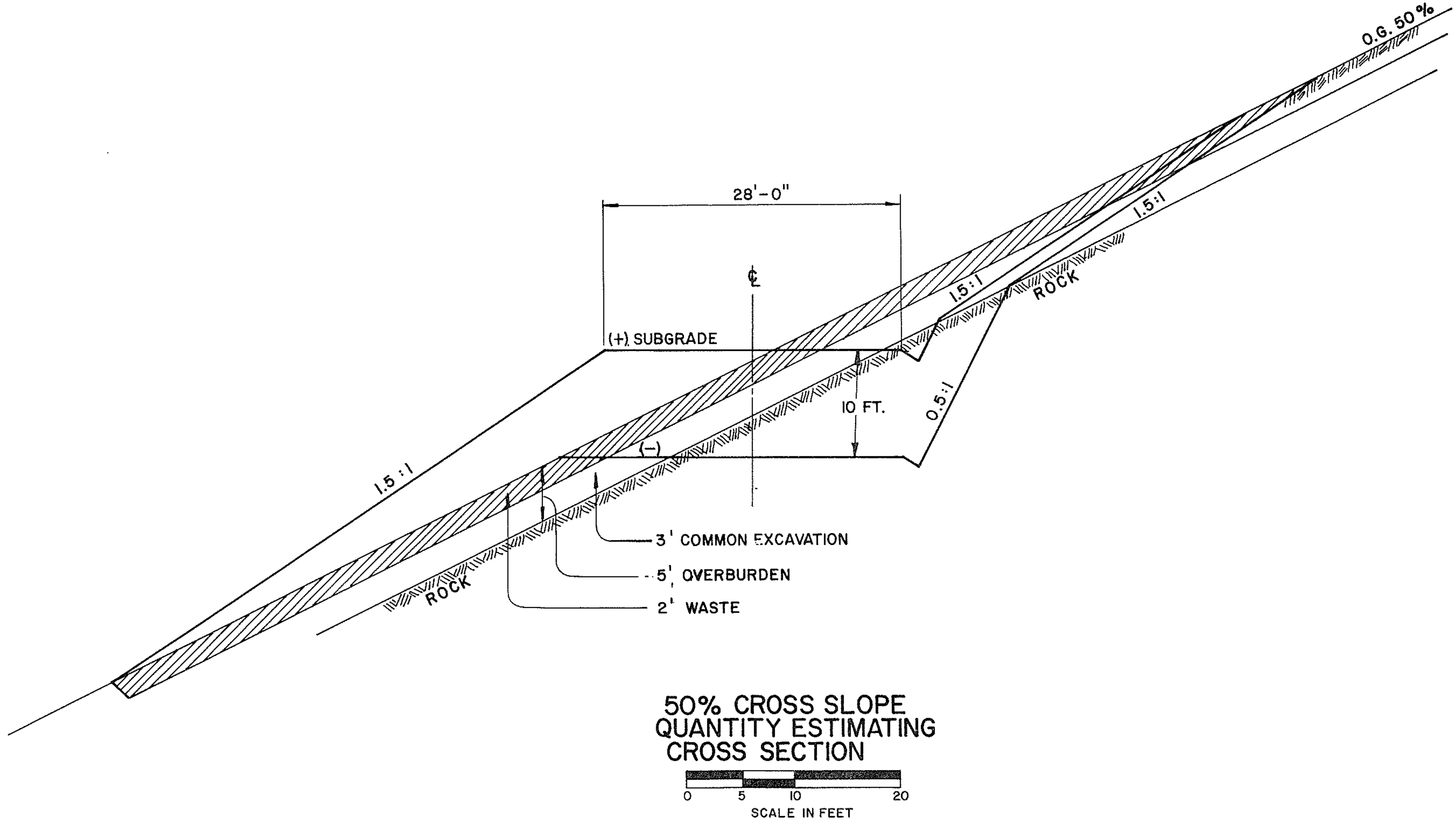
R&M
R&M CONSULTANTS, INC.

TYPICAL RAILROAD SECTION
45% CROSS SLOPE

PREPARED FOR:

ACRES

FIGURE F.6.15



PREPARED BY:

R&M CONSULTANTS, INC.

PREPARED FOR:

ACRES

TYPICAL RAILROAD SECTION
50% CROSS SLOPE

FIGURE F.6.16

Culvert sizes and lengths developed by this process are shown in Table F 7.1.

TABLE F-7.1
CULVERTS (in lineal feet)

Size DIA.	A-1 L.F.	A-2 L.F.	B-1 L.F.	B-2 L.F.	B-3 L.F.	C L.F.	R-1 L.F.	R-2 L.F.
18"	18,530	23,035	7,055	8,245	27,115	26,350	9,000	15,950
36"	300	0	100	200	200	100	200	200
42"	300	200	200	100	0	400	100	0
48"	100	0	0	0	100	600	0	100
54"	100	200	0	100	200	200	100	200
60"	400	400	100	100	100	300	100	100
72"	100	100	100	100	100	0	100	100
84"	0	100	0	0	100	200	0	100
96"	100	0	0	0	0	100	0	0
108"	0	200	0	0	0	200	0	0
120"	0	0	0	0	0	100	0	0
(1) 144"	0	100	0	0	0	0	0	0
(1) 168"	100	0	0	0	0	0	0	0

(1) Pipes larger than 120" will be either multiplate culvert or pipe arch similar to "Armco Super Span".

(2) 18" diameter pipes average 85' long under highway, 50' under railroad, larger pipes average 100 feet long.

F.8 - Construction Cost Estimates

The construction costs estimates outlined below include mobilization, construction camps, and construction surveys. The tabulated values for each plan, broken into pioneer road construction and maintenence, permanent road/rail and maintenence, and camps, are at the end of this appendix.

Disscussion of Bid Items

Clearing. Included is clearing and grubbing of vegetation to ten feet outside of excavation limits, and disposal of the material.

Waste Excavation. Removal and disposal of existing topsoil, muck, organics and other deliterious material.

Rock Excavation. Removal of material too hard to economically rip. Price includes placing in the fill or stock piling for later use in the structural section.

Common Excavation. All other excavation including removal and disposal or placement in fill.

Borrow. Where insufficient material is acquired for fill from common and rock excavation separate payment will be made to develope, excavate, and place material from borrow pits.

NFS Subbase. Non-frost susceptible granular material meeting standard specifications.

Grade "A" Base and D-1 Base. Granular, crushed material meeting standard specifications.

A.C. Sufacing. Bituminous concrete, including aggregate, asphalt binder, prime coat and tack coat.

Guardrail. Standard single rail guardrail.

Culverts. 18" cross culverts are figured per linear foot. Larger culverts (36" & over), for individual stream crossings are each multiplied by appropriate costs per foot, depending on diameter, and lumped into one sum. Costs includes placement, any special bedding requirements on materials, and head walls.

Fabric. Standard Mirafi or Typar filter fabric, to be placed over organics too deep to economically remove and replace.

Thaw Pipe. One thaw pipe per culvert. Price includes hangers, caps, standpipes, etc.

Topsoil and Seed. Topsoil will be manufactured from appropriate materials removed under waste excavation. Seed includes a hydroseed mixture of seed, fertilizer and lime.

Traffic Control Devices. Includes all standard signs and pavement markings, plus reflective paddle boards as delineators along the entire length of road.

Bridges. All highway bridges, regardless of type, are at present figured on the same per square foot basis. Rail bridges are also figured on a single price per square foot bases.

Rail Yard Control Devices. Includes all standard traffic devices for both the rail and the truck areas.

Subballast. Granular material meeting standard specifications.

Trackage. Includes rail, ties, and ballast. Switches are considered as equivalent to 200 feet of track for the purpose of this estimate.

Dock Lumber. Includes furnishing and installing 6 x 6 treated lumber to form two docks - one side loading and one end loading.

F.9 - Pioneer Road

The estimated quantities were broken into two phases - Pioneer Road (first two years) and permanent road (remaining five to thirteen years). For the purpose of this estimate, the following items were assumed.

1) The Pioneer Road is figured 15% longer than the final road, to account for turnouts and more winding alignment.

2) Top width of the road is 16 feet. The structure consists of cordorouy, as needed, unclassified fill, topped with 8 inches of D-1 base.

3) Cuts and fills of the Pioneer Road will, where ever possible, be in the same location as the permanent alignment. Borrow needs will be taken from side borrow in future permanent cuts. D-1 quantities in the Pioneer Road have been subtracted from the total permanent alignment quantities of borrow. Clearing, waste excavation, common excavation and rock excavation quantities necessary to build the Pioneer Road have been ommited from the permanent road quantities.

4) Minimum width sections of culverts will be installed, where ever possible, in there permanent location. The culverts will be lengthened when the permanent road is built. Similarily, where fabric is called for, only enough to cover the pioneer road foot print will be laid at first. The rest of the fabric is under the permanent road estimate.

5) Only one temporary bridge is included in the pioneer estimate - across the Susitna River at Devil Canyon. All other crossings will be constructed temporarily of banks of culverts covered with unclassified fill. Since route B-1 can be bypassed by direct service from Gold Creek, and since the B-1 segment can be accessed at several points along it length, no temporary bridges will be built at Indian River or Susitna River.

6) The permanent railhead will be constructed as quickly as possible as there is no "pioneer" alternative.

7) Guard rail, thaw pipes, topsoil and seed, and traffic control devices will be installed in the permanent road only.

8) A pioneer road will be built before construction of the rail road. The segments used for the pioneer roads are B-2 (for R-1) and B-3 (for R-2).

F.10 - Logistics Costs

The logistic costs are the costs directly associated with movement of freight. Table F.10-1 tabulates the railroad costs associated with Watana. Table F.10-2 tabulates the railroad costs associates with Devil Canyon. Table F.10-3 tabulates the truck haul costs for both dams. Table F.10-4 shows the combined logistic costs for all plans.

ROAD HAUL SEGMENT COSTS

F.10-3

Item	Tons	$/ton Mi. Rate	Gold Creek to Devil Canyon 12 Mi. (B-2)	Devil Canyon to Watana 36 Mi. (B-3)	Cantwell to Watana 65 Mi.	Devil Canyon to Watana 41 Mi. North (A-2)
All Watana	1,095,500	.2069	2,719,907	8,159,722	14,732,832	9,293,017
			15	16	17	18
All Devil	1,066,600	.2069	2,648,154	-	14,344,170	9,047,861
			19		21	22

WATANA LOGISTIC BREAKDOWN

Table F-10.1

		Rail Barge Whittier		Container Barge (Anchorage)		Rail Road					
	Tons	Cost $/ton	Cost	Cost $/ton	Cost	Cost $/ton Mi.	62 Mi. Whittier to Anchorage	149 Mi. Anchorage to Gold Creek	16 Mi. Gold Creek to Devil Canyon	42 Mi. Devil Canyon to Watana	56 Mi. Gold Creek to Cantwell
Const. Equimpment	16,000	120.00	$ 1,920,000	-	-	0.1878	186,298	447,715	48,077	126,202	168,269
Explosives	20,000	55.00	1,100,000	-	-	0.6267	777,108	1,867,566	200,544	526,428	701,904
Cement	350,000	55.00	19,250,000	-	-	0.1565	3,396,050	8,161,475	876,400	2,300,550	3,067,400
Rein. Steel	33,000	55.00	1,815,000	-	-	0.2577	527,254	1,267,111	136,066	357,172	476,230
Rock Bolts	12,500	55.00	687,500	-	-	0.2577	199,718	479,966	51,540	135,293	180,390
Steel Support	3,600	55.00	198,000	-	-	0.2577	57,519	138,230	14,843	38,964	51,952
Mech., str., elc. equip.	15,000	55.00	825,000	-	-	0.1262	117,366	282,057	30,288	79,506	106,008
Constr. Fuel	300,000	55.00	16,500,000	-	-	0.1450	2,697,000	6,481,500	696,000	1,827,000	2,436,000
Camp Fuel	51,000	55.00	2,805,000	-	-	0.1450	458,490	1,101,855	118,320	310,590	414,120
Tires & Parts	21,800	-	-	80.00	1,744,000	0.1878		610,012	65,505	171,950	229,266
Camp Supplies	74,600	-	-	80.00	5,968,000	0.1262		1,402,763	150,632	395,410	527,213
Village	1,400	-	-	80.00	112,000	0.1262		26,325	2,827	7,421	9,894
Contingency & Misc.	196,600	-	-	80.00	15,728,000	0.1262		3,696,827	396,975	1,042,059	1,389,412
	1,095,500		45,100,500		23,552,000		8,416,803	25,963,402	2,788,017	7,318,545	9,758,058
			1		2		3	4	5	6	7

DEVIL CANYON LOGISTIC BREAKDOWN

Table F10.2

		Rail Barge Whittier		Container Barge (Anchorage)		Rail Road				
	Tons	Cost $/ton	Cost	Cost $/ton	Cost	Cost $/ton Mi.	62 Mi. Whittier to Anchorage	149 Mi. Anchorage to Gold Creek	16 Mi. Gold Creek to Devil Canyon	56 Mi. Gold Creek to Cantwell
Const. Equimpment	5,000	120.00	$600,000	-	-	.1878	58,218	139,911	15,024	52,584
Explosive	3,000	55.00	165,000	-	-	.6267	116,566	280,135	30,082	105,286
Cement	650,000	55.00	35,750,000	-	-	.1565	6,306,950	15,157,025	1,627,600	5,696,600
Rein. Steel	22,000	55.00	1,210,000	-	-	.2577	351,503	844,741	90,710	314,486
Rock Bolts	3,000	55.00	165,000	-	-	.2577	47,932	115,192	12,370	43,294
Steel Support	2,200	55.00	121,000	-	-	.2577	35,150	84,474	9,071	31,749
Mics., str., elc. equip.	13,500	55.00	742,500	-	-	.1262	105,629	253,851	27,259	95,407
Constr. Fuel	68,000	55.00	3,740,000	-	-	.1450	611,320	1,469,140	157,760	552,160
Camp Fuel	30,000	55.00	1,650,000	-	-	.1450	269,700	648,150	69,600	243,600
Tires & Parts	18,700	-	-	80.00	1,496,000	.1878	-	523,267	59,190	196,664
Camp Supplies	44,000	-	-	80.00	3,520,000	.1262	-	827,367	88,845	310,957
Village	1,300	-	-	80.00	104,000	.1262	-	24,445	2,625	9,187
Contingency & Misc.	205,900	-	-	80.00	16,472,000	.1262	-	3,871,702	415,753	1,455,136
	1,066,600		$44,143,500		$21,592,000		7,902,968	24,239,400	2,602,889	9,110,110
			8		9		10	11	12	20

susi9/f2

LOGISTICS TOTALS

Table F-10.4

Plan 1:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek : 3, 4, 10, 11	66,522,573
	Truck to Dams: 15, 16, 19	13,527,783
	TOTAL	$214,438,356
Plan 2:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,522,573
	Rail to Dams: 12, 5, 6	12,709,451
	TOTAL	$213,620,024
Plan 3 & 7:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,523,573
	Rail to Cantwell: 7	9,758,058
	Truck to Watana from Cantwell: 17	14,732,832
	Truck to Devil from Gold Creek: 19	2,648,154
	TOTAL	$228,050,617
Plan 4 & 6:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,522,573
	Rail to Cantwell: 7	9,758,058
	Rail to Devil: 12	2,602,889
	Truck to Watana from Cantwell: 17	14,732,832
	TOTAL	$228,004,352
Plan 5 & 8:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,522,573
	Truck to Devil Canyon: 15, 19	5,368,061
	Northside Truck to Watana: 18	9,293,017
	TOTAL	$215,571,651
Plan 9:	Use: Water: 1, 2, 8, 9,	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,522,573
	Rail to Devil: 12, 5	5,390,906
	Northside Truck to Watana: 18	9,293,017
	TOTAL	$215,594,496
Plan 10:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Gold Creek: 3, 4, 10, 11	66,522,573
	Rail to Devil Canyon: 12, 5	5,390,906
	Truck to Watana: 16	8,159,722
	TOTAL	$214,461,201

LOCISTICS TOTALS (Continued)

Table F-10.4

Plan 11:	Use: Water: 1, 2, 8, 9	$134,388,000
	Rail to Cantwell: 3, 4, 7, 10, 11, 20	85,390,741
	Truck Via Denali to Dams: 17, 21, 22	38,124,863
	TOTAL	$257,903,604

COST ESTIMATE
BREAKDOWN TABLES

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
	.1 Roads				
	.11 Pioneer Roads				
	.111 Chulitna to Gold Creek B-1 Road (13.26 Mi)				
	Clearing	118	AC	$ 5,760.00	$ 679,680.00
	Waste Excavation	270,190	CY	4.80	1,296,912.00
	Common Excavation	173,864	CY	4.20	730,228.80
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	2,820	LF	28.80	81,216.00
	36" + Culverts	-	LS	20,496.00	20,496.00
	D-1 Base Material	71,556	TON	21.60	1,545,609.60
	Fabric	5,465	SY	3.00	16,395.00
				TOTAL	$4,370,537.40
	Maintenence	27	Mile-Year	$4,000.00	$108,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	TON	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.113	Devil Canyon to Watana -South B-3 Road (36.46 Mi)				
	Clearing	271	AC	$5,760.00	$1,560,960.00
	Waste Excavation	585,666	CY	4.80	2,811,196.80
	Common Excavation	255,812	CY	4.20	1,074,410.40
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	10,850	LF	28.80	312,480.00
	36" + Culverts	-	LS	124,752.00	124,752.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	196,778	TON	21.60	4,250,404.80
	Fabric	27,408	SY	3.00	82,224.00
				TOTAL	$10,216,428.00
	Maintenence	73	Mile-Years	$4,000.00	$292,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.121	Chulitna to Gold Creek Road B-1, (13.26 Mi)				
	Clearing	92	AC	$ 5,760.00	$ 529,920.00
	Waste Excavation	305,290	CY	4.80	1,465,392.00
	Common Excavation	396,316	CY	4.20	1,664,527.20
	Rock Excavation	35,850	CY	14.40	516,240.00
	Borrow	95,896	CY	6.00	575,376.00
	NFS Subbase Material	136,500	CY	8.40	1,146,600.00
	Grade "A" Base Material	74,480	CY	16.80	1,251,264.00
	D-1 Base Material	31,080	TON	21.60	671,328.00
	A.C. Surfacing	28,462	TON	79.20	2,254,190.40
	Guardrail	9,800	LF	43.20	423,360.00
	18" Culverts	4,240	LF	28.80	122,112.00
	36" + Culverts	-	LS	30,744.00	30,744.00
	Fabric	13,379	SY	3.00	40,137.00
	Thaw Pipes	7,555	LF	43.20	326,376.00
	Topsoil & Seed	130	AC	3,600.00	468,000.00
	Traffic Control Devices	13	MI	18,000.00	234,000.00
	Bridges	90,440	SF	180.00	16,279,200.00
				TOTAL	$27,998,766.60
	Maintenence	173	Mile-Years	$10,000.00	$1,730,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.122	Gold Creek to Devil Canyon Road B-2, (12.31 Mi)				
	Clearing	28	AC	$ 5,760.00	$ 161,280.00
	Waste Excavation	97,892	CY	4.80	469,881.60
	Common Excavation	44,772	CY	4.20	188,042.40
	Rock Excavation	23,625	CY	14.40	340,200.00
	Borrow	416,311	CY	6.00	2,497,866.00
	NFS Subbase Material	126,750	CY	8.40	1,064,700.00
	Grade "A" Base Material	69,160	CY	16.80	1,161,888.00
	D-1 Base Material	28,860	TON	21.60	623,376.00
	A.C. Surfacing	26,429	TON	79.20	2,093,176.80
	Guardrail	6,700	LF	43.20	289,440.00
	18" Culverts	4,950	LF	28.80	142,560.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	5,585	SY	3.00	16,755.00
	Thaw Pipes	8,845	LF	43.20	382,104.00
	Topsoil & Seed	86	AC	3,600.00	309,600.00
	Traffic Control Devices	12	MI	18,000.00	216,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$9,989,125.80
	Maintenence	160	Mile-Years	$12,000.00	$1,920,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.123	Devil Canyon to Watana - South, Road B-3, (36.46 Mi) .				
	Clearing	360	AC	$ 5,760.00	$ 2,073,600.00
	Waste Excavation	1,164,494	CY	4.80	5,589,571.20
	Common Excavation	1,308,618	CY	4.20	5,496,195.60
	Rock Excavation	246,750	CY	14.40	3,553,200.00
	Borrow	15,693	CY	6.00	94,158.00
	NFS Subbase Material	375,375	CY	8.40	3,153,150.00
	Grade "A" Base Material	204,820	CY	16.80	3,440,976.00
	D-1 Base Material	85,470	TON	21.60	1,846,152.00
	A.C. Surfacing	78,271	TON	79.20	6,199,063.20
	Guardrail	8,300	LF	43.20	358,560.00
	18" Culverts	16,270	LF	28.80	468,576.00
	36" + Culverts	-	LS	57,888.00	57,888.00
	Fabric	69,133	SY	3.00	207,399.00
	Thaw Pipes	27,915	LF	43.20	1,205,928.00
	Topsoil & Seed	410	AC	3,600.00	1,476,000.00
	Traffic Control Devices	36	MI	18,000.00	648,000.00
	Bridges	109,140	SF	180.00	19,645,200.00
				TOTAL	$55,513,617.00
	Maintenence	219	Mile-Years	$13,000.00	$2,847,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.22	Railheads				
.222	Railhead at Gold Creek				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	LF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	15	Year	$28,600.00	$429,900.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
1.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$342,000.00	342,000.00
	Catering & Operation Support	40,890	Manday	39.50	1,615,155.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	1,752,000.00	1,752,000.00
	Catering & Operation Support	228,550	Manday	39.10	8,936,305.00
	TOTAL PROJECT COST				$139,144,508.20

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
2.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	TON	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Year	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
2.336	ROAD & RAIL FACILITIES				
.116	Devil Canyon to Watana B-3 Road (36.46 Mi)				
	Clearing	271	AC	$ 5,760.00	$ 1,560,960.00
	Waste Excavation	585,666	CY	4.80	2,811,196.80
	Common Excavation	255,812	CY	4.20	1,074,410.40
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	10,850	LF	28.80	312,480.00
	36" + Culverts	-	LS	174,576.00	174,576.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	196,778	TON	21.60	4,250,404.80
	Fabric	27,408	SY	3.00	82,224.00
				TOTAL	$10,266,252.00
	Maintenence	73	Mile-Year	$4,000.00	$292,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
2.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.21	Permanent Rail Road (Including Railhead)				
.211	Gold Creek to Devil Canyon Rail R-1, (16.29 Mi)				
	Clearing	68	AC	$ 5,760.00	$ 391,680.00
	Waste Excavation	129,482	CY	4.80	621,513.60
	Common Excavation	549,157	CY	4.20	2,306,459.40
	Rock Excavation	2,200	CY	14.40	31,680.00
	Borrow	79,611	CY	6.00	477,666.00
	Subballast	192,467	CY	8.60	1,655,216.20
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	1,390	LF	28.80	40,032.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	300	SY	3.00	900.00
	Thaw Pipes	10,100	LF	43.20	436,320.00
	Topsoil & Seed	116	AC	3,600.00	417,600.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Bridges	0	SF	360.00	0.00
	Trackage	110,300	LF	140.00	15,442,000.00
				TOTAL	$22,171,723.20
	Maintenence				
	Rail	212	Mile-Years	$5,000.00	$1,060,000.00
	Railhead - Devil Canyon	7	Years	$28,600.00	$200,200.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
2.336	ROAD & RAIL FACILITIES				
.212	Devil Canyon to Watana Rail R-2, (41.57 Mi)				
	Clearing	215	AC	$ 5,760.00	$ 1,238,400.00
	Waste Excavation	655,074	CY	4.80	3,144,355.20
	Common Excavation	971,388	CY	4.20	4,079,829.60
	Rock Excavation	168,960	CY	14.40	2,433,024.00
	Borrow	0	CY	6.00	0.00
	Subballast	447,096	CY	8.60	3,845,025.60
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	12,490	LF	28.80	359,712.00
	36" + Culverts	-	LS	132,624.00	132,624.00
	Fabric	37,970	SY	3.00	113,910.00
	Thaw Pipes	16,750	LF	43.20	723,600.00
	Topsoil & Seed	335	AC	3,600.00	1,206,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Bridges	36,720	SF	360.00	13,219,200.00
	Trackage	248,000	LF	140.00	34,720,000.00
				TOTAL	$65,534,080.40
	Maintenence				
	Rail	249	Mile-Years	7,000.00	1,743,000.00
	Railhead	8	Years	28,600.00	228,800.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
2.63	CAMP				
.1	Camp				
.11	Pioneer Road Camp				
	Camp Facilities	-	LS	$267,00.00	$ 267,000.00
	Catering & Operation Support	31,750	Manday	39.60	1,257,300.00
.12	Access Road/Railhead Camp				
	Camp Facilities	-	LS	645,000.00	645,000.00
	Catering & Operation Support	207,800	Manday	39.10	8,124,980.00
	TOTAL PROJECT COSTS				$116,882,329.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.111	Chulitna to Gold Creek B-1 Road (13.26 Mi)				
	Clearing	118	AC	$ 5,760.00	$ 679,680.00
	Waste Excavation	270,190	CY	4.80	1,296,912.00
	Common Excavation	173,864	CY	4.20	730,228.80
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	2,820	LF	28.80	81,216.00
	36" + Culverts	-	LS	20,496.00	20,496.00
	D-1 Base Material	71,556	TON	21.60	1,545,609.60
	Fabric	5,465	SY	3.00	16,395.00
				TOTAL	$4,370,537.40
	Maintenence	27	Mile-Year	$4,000.00	$108,000.00

ITEM		DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES					
	.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
		Clearing	113	AC	$ 5,760.00	$ 650,880.00
		Waste Excavation	324,998	CY	4.80	1,559,990.40
		Commom Excavation	291,163	CY	4.20	1,222,884.60
		Rock Excavation	0	CY	14.40	0.00
		Borrow	0	CY	6.00	0.00
		18" Culverts	3,460	LF	28.80	99,648.00
		36" + Culverts	-	LS	13,824.00	13,824.00
		Bridges	0	SF	0.00	0.00
		D-1 Base Material	66,444	TON	21.60	1,435,190.40
		Fabric	3,192	SY	3.00	9,576.00
					TOTAL	$4,991,993.40
		Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.115	Denali to Watana				
	C Road (44.32 Mi)				
	Clearing	0	AC	$5,760.00	$0.00
	Waste Excavation	0	CY	4.80	0.00
	Common Excavation	0	CY	4.20	0.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	0	LF	28.80	0.00
	36" + Culverts	0	LS	0.00	0.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	0	TON	21.60	0.00
	Fabric	0	SY	3.00	0.00
				TOTAL	$0.00
	Maintenence	0	Mile-Years	$0.00	$0.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.121	Chulitna to Gold Creek Road B-1, (13.26 Mi))				
	Clearing	92	AC	$ 5,760.00	$ 529,920.00
	Waste Excavation	305,290	CY	4.80	1,465,392.00
	Common Excavation	396,316	CY	4.20	1,664,527.20
	Rock Excavation	35,850	CY	14.40	516,240.00
	Borrow	95,896	CY	6.00	575,376.00
	NFS Subbase Material	136,500	CY	8.40	1,146,600.00
	Grade "A" Base Material	74,480	CY	16.80	1,251,264.00
	D-1 Base Material	31,080	TON	21.60	671,328.00
	A.C. Surfacing	28,462	TON	79.20	2,254,190.40
	Guardrail	9,800	LF	43.20	423,360.00
	18" Culverts	4,240	LF	28.80	122,112.00
	36" + Culverts	-	LS	30,744.00	30,744.00
	Fabric	13,379	SY	3.00	40,137.00
	Thaw Pipes	7,555	LF	43.20	326,376.00
	Topsoil & Seed	130	AC	3,600.00	468,000.00
	Traffic Control Devices	13	MI	18,000.00	234,000.00
	Bridges	90,440	SF	180.00	16,279,200.00
				TOTAL	$27,998,766.60
	Maintenence	66	Mile-Years	$10,000.00	$660,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.122	Gold Creek to Devil Canyon - Road B-2, (12.31 Mi)				
	Clearing	28	AC	$ 5,760.00	$ 161,280.00
	Waste Excavation	97,892	CY	4.80	469,881.60
	Common Excavation	44,772	CY	4.20	188,042.40
	Rock Excavation	23,625	CY	14.40	340,200.00
	Borrow	416,311	CY	6.00	2,497,866.00
	NFS Subbase Material	126,750	CY	8.40	1,064,700.00
	Grade "A" Base Material	69,160	CY	16.80	1,161,888.00
	D-1 Base Material	28,860	TON	21.60	623,376.00
	A.C. Surfacing	26,429	TON	79.20	2,093,176.80
	Guardrail	6,700	LF	43.20	289,440.00
	18" Culverts	4,950	LF	28.80	142,560.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	5,585	SY	3.00	16,755.00
	Thaw Pipes	8,845	LF	43.20	382,104.00
	Topsoil & Seed	86	AC	3,600.00	309,600.00
	Traffic Control Devices	12	MI	18,000.00	216,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$9,989,125.80
	Maintenence	62	Mile-Years	12,000.00	744,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.125	Denali to Watana Road C, (44.32 Mi) (Plus 21.00 Mi)				
	Clearing	800	AC	$ 5,760.00	$ 4,608,000.00
	Waste Excavation	2,245,400	CY	4.80	10,777,920.00
	Common Excavation	2,450,800	CY	4.20	10,293,360.00
	Rock Excavation	41,800	CY	14.40	601,920.00
	Borrow	20,000	CY	6.00	120,000.00
	NFS Subbase Material	470,000	CY	8.40	3,948,000.00
	Grade "A" Base Material	300,000	CY	16.80	5,040,000.00
	D-1 Base Material	162,500	TON	21.60	3,510,000.00
	A.C. Surfacing	148,813	TON	79.20	11,785,989.60
	Guardrail	4,200	LF	43.20	181,440.00
	18" Culverts	30,350	LF	28.80	874,080.00
	36" + Culverts	-	LS	468,120.00	468,120.00
	Fabric	12,907	SY	3.00	38,721.00
	Thaw Pipes	28,750	LF	43.20	1,242,000.00
	Topsoil & Seed	514	AC	3,600.00	1,850,400.00
	Traffic Control Devices	69	MI	18,000.00	1,242,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$56,581,950.60
	Maintenence	523	Mile-Years	$8,000.00	$4,184,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
	.2 Rail Facilities				
	.22 Railheads				
	.221 Railhead - Cantwell				
	Clearing	25	AC	$ 5,760.00	$ 144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Bse	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	CF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	7	Years	28,600.00	$200,200.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.336	ROAD & RAIL FACILITIES				
.222	Railhead - Gold Creek				
	Clearing	25	AC	$ 5,760.00	$ 144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	CF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	8	Years	28,600.00	$228,800.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
3.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$ 162,000.00	$ 162,000.00
	Catering & Operation Support	19,590	Manday	39.40	771,846.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	1,251,000.00	1,251,000.00
	Catering & Operation Support	240,630	Manday	39.10	9,408,633.00
	TOTAL PROJECT COST				$133,734,212.80

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	Ton	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Year	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.336	ROAD & RAIL FACILITIES				
.1	Roads				
.115	Denali to Watana C Road (44.32 Mi)				
	Clearing	0	AC	$ 5,760.00	$0.00
	Waste Excavation	0	CY	4.80	0.00
	Common Excavation	0	CY	4.20	0.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	0	LF	28.80	0.00
	36" + Culverts	0	LS	0.00	0.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	0	TON	21.60	0.00
	Fabric	0	SY	3.00	0.00
				TOTAL	$0.00
	Maintenence	0	Mile-Years		$0.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.125	Denali to Watana Rail Road C, (44.32 Mi) (Plus 21.00 Mi)				
	Clearing	800	AC	$ 5,760.00	$ 4,608,000.00
	Waste Excavation	2,245,400	CY	4.80	10,777,920.00
	Common Excavation	2,450,800	CY	4.20	10,293,360.00
	Rock Excavation	41,800	CY	14.40	601,920.00
	Borrow	20,000	CY	6.00	120,000.00
	NFS Subbase Material	470,000	CY	8.40	3,948,000.00
	Grade "A" Base Material	300,000	CY	16.80	5,040,000.00
	D-1 Base Material	162,500	TON	21.60	3,510,000.00
	A.C. Surfacing	148,813	TON	79.20	11,785,989.60
	Guardrail	4,200	LF	43.20	181,440.00
	18" Culverts	30,350	LF	28.80	874,080.00
	36" + Culverts	-	LS	468,120.00	468,120.00
	Fabric	12,907	SY	3.00	38,721.00
	Thaw Pipes	28,750	LF	43.20	1,242,000.00
	Topsoil & Seed	514	AC	3,600.00	1,850,400.00
	Traffic Control Devices	69	MI	18,000.00	1,242,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$56,581,950.60
	Maintenence	523	Mile-Year	$8,000.00	$4,184,000.00

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ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.336	ROAD & RAIL FACILITIES				
	.2 Rail Facilities				
	.21 Permanent Railroad (Include Railhead)				
	.211 Gold Creek to Devil Canyon Rail R-1, (16.29 Mi)				
	Clearing	68	AC	$ 5,760.00	$ 391,680.00
	Waste Excavation	129,482	CY	4.80	621,513.60
	Common Excavation	549,157	CY	4.20	2,306,459.40
	Rock Excavation	2,200	CY	14.40	31,680.00
	Borrow	79,611	CY	6.00	477,666.00
	Subballast	192,467	CY	8.60	1,655,216.20
	Grade A Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	1,390	LF	28.80	40,032.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	300	SY	3.00	900.00
	Thaw Pipes	10,100	LF	43.20	436,320.00
	Topsoil & Seed	116	AC	3,600.00	417,600.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Bridges	0	SF	360.00	0.00
	Trackage	110,300	LF	140.00	15,442,000.00
				TOTAL	$22,171,723.20
	Maintenence				
	Rail	81	Mile-years	$5,000.00	$405,000.00
	Railhead	7	Years	$28,600.00	$200,200.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.336	ROAD & RAIL FACILITIES				
.22	Railheads				
.221	Railhead - Cantwell				
	Clearing	25	AC	$ 5,760.00	$ 144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	CF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	8	Years	28,600.00	$228,800.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
4.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$ 87,000.00	$ 87,000.00
	Catering & Operation Support	10,450	Manday	39.40	$411,730.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	819,000.00	819,000.00
	Catering & Operation Support	195,910	Manday	39.10	7,660,081.00
	TOTAL PROJECT COST				$103,833,158.20

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
	.1 Roads				
	.11 Pioneer Roads				
	.111 Chulitna to Gold Creek B-1 Road (13.26 Mi)				
	Clearing	118	AC	$ 5,760.00	$ 679,680.00
	Waste Excavation	270,190	CY	4.80	1,296,912.00
	Common Excavation	173,864	CY	4.20	730,228.80
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	2,820	LF	28.80	81,216.00
	36" + Culverts	-	LS	20,496.00	20,496.00
	D-1 Base Material	71,556	Ton	21.60	1,545,609.60
	Fabric	5,465	SY	3.00	16,395.00
				TOTAL	$4,370,537.40
	Maintenence	27	Mile-Year	$4,000.00	$108,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	TON	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.114	Devil Canyon to Watana -North A-2 Road (41.25 Mi)				
	Clearing	369	AC	$5,760.00	$2,125,440.00
	Waste Excavation	855,321	CY	4.80	4,105,540.80
	Common Excavation	619,500	CY	4.20	2,601,900.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	9,200	LF	28.80	264,960.00
	36" + Culverts	-	LS	114,960.00	114,960.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	222,640	TON	21.60	4,809,024.00
	Fabric	14,946	SY	3.00	44,838.00
				TOTAL	$14,066,662.80
	Maintenence	83	Mile-Years	$4,000.00	$332,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
	.118 Devil Canyon Low Level Crossing H Road (7.88 Mi)				
	Clearing	170	AC	$ 5,760.00	$ 979,200.00
	Waste Excavation	498,845	CY	4.80	2,394,456.00
	Common Excavation	549,417	CY	4.20	2,307,551.40
	Rock Excavation	749,641	CY	14.40	10,794,830.40
	Borrow	0	CY	6.00	0.00
	18" Culverts	5,100	LF	28.80	146,880.00
	36" + Culverts	-	LS	0.00	0.00
	Bridges	12,480	SF	180.00	2,246,400.00
	D-1 Base Material	36,966	TON	21.60	798,465.60
	Fabric	0	SY	3.00	0.00
				TOTAL	$19,667,783.40
	Maintenence	118	Mile-Years	$5,000.00	$590,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.121	Chulitna to Gold Creek Road B-1, (13,26 Mi)				
	Clearing	92	AC	$ 5,760.00	$ 529,920.00
	Waste Excavation	305,290	CY	4.80	1,465,392.00
	Common Excavation	396,316	CY	4.20	1,664,527.20
	Rock Excavation	35,850	CY	14.40	516,240.00
	Borrow	95,896	CY	6.00	575,376.00
	NFS Subbase Material	136,500	CY	8.40	1,146,600.00
	Grade "A" Base Material	74,480	CY	16.80	1,251,264.00
	D-1 Base Material	31,080	TON	21.60	671,328.00
	A.C. Surfacing	28,462	TON	79.20	2,254,190.40
	Guardrail	9,800	LF	43.20	423,360.00
	18" Culverts	4,240	LF	28.80	122,112.00
	36" + Culverts	-	LS	30,744.00	30,744.00
	Fabric	13,379	SY	3.00	40,137.00
	Thaw Pipes	7,555	LF	43.20	326,376.00
	Topsoil & Seed	130	AC	3,600.00	468,000.00
	Traffic Control Devices	13	MI	18,000.00	234,000.00
	Bridges	90,440	SF	180.00	16,279,200.00
			TOTAL		$27,998,766.60
	Maintenence	173	Mile-Years	10,000.00	1,730,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.122	Gold Creek to Devil Canyon Road B-2, (12.31 Mi)				
	Clearing	28	AC	$ 5,760.00	$ 161,280.00
	Waste Excavation	97,892	CY	4.80	469,881.60
	Common Excavation	44,772	CY	4.20	188,042.40
	Rock Excavation	23,625	CY	14.40	340,200.00
	Borrow	416,311	CY	6.00	2,497,886.00
	NFS Subbase Material	126,750	CY	8.40	1,064,700.00
	Grade "A" Base Material	69,160	CY	16.80	1,161,888.00
	D-1 Base Material	28,860	TON	21.60	623,376.00
	A.C. Surfacing	26,429	TON	79.20	2,093,176.80
	Guardrail	6,700	LF	43.20	289,440.00
	18" Culverts	4,950	LF	28.80	142,560.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	5,585	SY	3.00	16,755.00
	Thaw Pipes	8,845	LF	43.20	382,104.00
	Topsoil & Seed	86	AC	3,600.00	309,600.00
	Traffic Control Devices	12	MI	18,000.00	216,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$9,989,125.80
	Maintenence	160	Mile-Years	12,000.00	1,920,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.124	Devil Canyon to Watana - North Road A-2, (41.25 Mi)				
	Clearing	207	AC	$ 5,760.00	$ 1,192,320.00
	Waste Excavation	681,179	CY	4.80	3,269,659.20
	Common Excavation	984,473	CY	4.20	4,134,786.60
	Rock Excavation	146,527	CY	14.40	2,109,988.80
	Borrow	73,145	CY	6.00	438,870.00
	NFS Subbase Material	424,710	CY	8.40	3,567,564.00
	Grade "A" Base Material	231,739	CY	16.80	3,893,215.20
	D-1 Base Material	96,704	TON	21.60	2,088,806.40
	A.C. Surfacing	88,557	TON	79.20	7,013,714.40
	Guardrail	6,050	LF	43.20	261,360.00
	18" Culverts	13,840	LF	28.80	398,592.00
	36" + Culverts	-	LS	179,040.00	179,040.00
	Fabric	34,874	SY	3.00	104,622.00
	Thaw Pipes	24,435	LF	43.20	1,055,592.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$31,619,730.60
	Maintenence	248	Mile-Years	$10,00.00	$2,480,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.128	Devil Canyon Trans-Dam Crossing, Road D, (7.26 Mi)				
	Clearing	45	AC	$ 5,760.00	$ 259,200.00
	Waste Excavation	132,300	CY	4.80	635,040.00
	Common Excavation	114,500	CY	4.20	480,900.00
	Rock Excavation	12,200	CY	14.40	175,680.00
	Borrow	90,200	CY	6.00	541,200.00
	NFS Subbase Material	27,960	CY	8.40	234,864.00
	Grade "A" Base Material	15,260	CY	16.80	256,368.00
	D-1 Base Material	6,370	TON	21.60	137,592.00
	A.C. Surfacing	5,830	TON	79.20	461,736.00
	Guardrail	2,640	LF	43.20	114,048.00
	18" Culverts	1,785	LF	28.80	51,408.00
	36" + Culverts	-	LS	0.00	0.00
	Fabric	0	SY	3.00	0.00
	Thaw Pipes	1,785	LF	43.20	77,112.00
	Topsoil & Seed	29	AC	3,600.00	104,400.00
	Traffic Control Devices	3	MI	18,000.00	54,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$3,583,548.00
	Maintenence	7	Mile-Years	$13,000.00	$91,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.21	Railhead				
.222	Railhead at Gold Creek				
	Clearing	25	AC	$ 5,760.00	$ 144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	CF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	15	Years	$28,600.00	$429,900.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
5.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	1	LS	$750,000.00	$ 750,000.00
	Catering & Operation Support	90,570	Manday	39.20	3,550,344.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	1	LS	1,059,000.00	1,059,000.00
	Catering & Operation Support	175,350	Manday	39.10	6,856,185.00
	TOTAL PROJECT COSTS				$142,276,257.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Chulitna to Gold Creek B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges		SF	0.00	0.00
	D-1 Base Material	66,444	Ton	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Year	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
	.115 Denali to Watana C Road (44.32 Mi)				
	Clearing	0	AC	$5,760.00	$0.00
	Waste Excavation	0	CY	4.80	0.00
	Common Excavation	0	CY	4.20	0.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	0	LF	28.80	0.00
	36" + Culverts	0	LS	0.00	0.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	0	TON	21.60	0.00
	Fabric	0	SY	3.00	0.00
				TOTAL	$0.00
	Maintenence	0	Mile-Years	$0.00	$0.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.125	Denali to Watana - Road C, (44.32 Mi)				
	Clearing	800	AC	$ 5,760.00	$ 4,608,000.00
	Waste Excavation	2,245,400	CY	4.80	10,777,920.00
	Common Excavation	2,450,800	CY	4.20	10,293,360.00
	Rock Excavation	41,800	CY	14.40	601,920.00
	Borrow	20,000	CY	6.00	120,000.00
	NFS Subbase Material	470,000	CY	8.40	3,948,000.00
	Grade "A" Base Material	300,000	CY	16.80	5,040,000.00
	D-1 Base Material	162,500	TON	21.60	3,510,000.00
	A.C. Surfacing	148,813	TON	79.20	11,785,989.60
	Guardrail	4,200	LF	43.20	181,440.00
	18" Culverts	30,350	LF	28.80	174,080.00
	36" + Culverts	-	LS	468,120.00	468,120.00
	Fabric	12,907	SY	3.00	38,721.00
	Thaw Pipes	28,750	LF	43.20	1,242,000.00
	Topsoil & Seed	514	AC	3,600.00	1,850,400.00
	Traffic Control Devices	69	MI	18,000.00	1,242,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$56,581,950.60
	Maintenence	523	Mile-Years	$8,000.00	$4,184,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
.13	Maintenance Road				
.131	Devil Canyon to Watana - North, Road A-2, (41.25 Mi)				
	Clearing	576	AC	$ 5,760.00	$ 3,317,760.00
	Waste Excavation	1,536,500	CY	4.80	7,375,200.00
	Common Excavation	1,603,000	CY	4.20	6,732,600.00
	Rock Excavation	146,500	CY	14.40	2,109,600.00
	Borrow	156,700	CY	6.00	940,200.00
	NFS Subbase Material	424,700	CY	8.40	3,567,480.00
	Grade "A" Base Material	231,700	CY	16.80	3,892,560.00
	D-1 Base Material	96,700	TON	21.60	2,088,720.00
	A.C. Surfacing	88,600	TON	79.20	7,017,120.00
	Guardrail	6,050	LF	43.20	261,360.00
	18" Culverts	23,000	LF	28.80	662,400.00
	36" + Culverts	-	LS	407,520.00	407,520.00
	Fabric	49,800	SY	3.00	149,400.00
	Thaw Pipes	24,400	LF	43.20	1,054,080.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$41,487,600.00
	Maintenence	289	Mile-Years	$10,000.00	$2,890,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.21	Permanent Railroad (Includes railhead)				
.211	Gold Creek to Devil Canyon Rail R-1, (16.29 Mi)				
	Clearing	68	AC	$ 5,760.00	$ 391,680.00
	Waste Excavation	129,482	CY	4.80	621,513.60
	Common Excavation	549,157	CY	4.20	2,306,459.40
	Rock Excavation	2,200	CY	14.40	31,680.00
	Borrow	79,611	CY	6.00	477,666.00
	Subballast	192,467	CY	8.60	1,655,216.20
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	1,390	LF	28.80	40,032.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	300	SY	3.00	900.00
	Thaw Pipes	10,100	LF	43.20	436,320.00
	Topsoil & Seed	116	AC	3,600.00	417,600.00
	Rail Yard Traffic Control Devices	-	LS	720.00	720.00
	Bridges	0	SF	360.00	0.00
	Trackage	110,300	LF	140.00	15,442,000.00
				TOTAL	$21,171,723.20
	Maintenence				
	Rail	81	Mile-Years	$5,000.00	$405,000.00
	Railhead	7	Year	$28,600.00	$200,200.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.336	ROAD & RAIL FACILITIES				
.22	Railheads				
.221	Railhead - Cantwell				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,800.00
	Trackage	19,700	CF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	8	Years	$28,600.00	$228,800.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
6.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$ 87,000.00	$ 87,000.00
	Catering & Operation Support	10,450	Manday	39.40	411,730.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	1	LS	1,215,000.00	1,215,000.00
	Catering & Operation Support	291,700	Manday	39.10	11,405,470.00
	TOTAL PROJECT COSTS				$151,352,147.20

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
	.1 Roads				
	.11 Pioneer Roads				
	.111 Chulitna to Gold Creek B-1 Road (13.26 Mi)				
	Clearing	118	AC	$ 5,760.00	$ 679,680.00
	Waste Excavation	270,190	CY	4.80	1,296,912.00
	Common Excavation	173,864	CY	4.20	730,228.80
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	2,820	LF	28.80	81,216.00
	36" + Culverts	-	LS	20,496.00	20,496.00
	D-1 Base Material	71,556	Ton	21.60	1,545,609.60
	Fabric	5,465	SY	3.00	16,395.00
				TOTAL	$4,370,537.40
	Maintenence	27	Mile-Year	$4,000.00	$108,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	TON	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.115	Denali to Watana				
	C Road (44.32 Mi)				
	Clearing	0	AC	$5,760.00	$0.00
	Waste Excavation	0	CY	4.80	0.00
	Common Excavation	0	CY	4.20	0.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	0	LF	28.80	0.00
	36" + Culverts	0	LS	0.00	0.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	0	TON	21.60	0.00
	Fabric	0	SY	3.00	0.00
				TOTAL	$0.00
	Maintenence	0	Mile	$0.00	$0.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads & Bridges				
.121	Chulitna to Gold Creek, Road B-1, (13.26 Mi)				
	Clearing	92	AC	$ 5,760.00	$ 529,920.00
	Waste Excavation	305,290	CY	4.80	1,465,392.00
	Common Excavation	396,316	CY	4.20	1,664,527.20
	Rock Excavation	35,850	CY	14.40	516,240.00
	Borrow	95,896	CY	6.00	575,376.00
	NFS Subbase Material	136,500	CY	8.40	1,146,600.00
	Grade "A" Base Material	74,480	CY	16.80	1,251,264.00
	D-1 Base Material	31,080	TON	21.60	671,328.00
	A.C. Surfacing	28,462	TON	79.20	2,254,190.40
	Guardrail	9,800	LF	43.20	423,360.00
	18" Culverts	4,240	LF	28.80	122,112.00
	36" + Culverts	-	LS	30,744.00	30,744.00
	Fabric	13,379	SY	3.00	40,137.00
	Thaw Pipes	7,555	LF	43.20	326,376.00
	Topsoil & Seed	130	AC	3,600.00	468,000.00
	Traffic Control Devices	13	MI	18,000.00	234,000.00
	Bridges	90,440	SF	180.00	16,279,200.00
				TOTAL	$27,998,766.60
	Maintenence	66	Mile-Years	$10,000.00	$660,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.122	Gold Creek to Devil Canyon Road B-2, (12.31 Mi)				
	Clearing	28	AC	$ 5,760.00	$ 161,280.00
	Waste Excavation	97,892	CY	4.80	469,881.60
	Common Excavation	44,772	CY	4.20	188,042.40
	Rock Excavation	23,625	CY	14.40	340,200.00
	Borrow	416,311	CY	6.00	2,497,866.00
	NFS Subbase Material	126,750	CY	8.40	1,064,700.00
	Grade "A" Base Material	69,160	CY	16.80	1,161,888.00
	D-1 Base Material	28,860	TON	21.60	623,376.00
	A.C. Surfacing	26,429	TON	79.20	2,093,176.80
	Guardrail	6,700	LF	43.20	289,440.00
	18" Culverts	4,950	LF	28.80	142,560.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	5,585	SY	3.00	16,755.00
	Thaw Pipes	8,845	LF	43.20	382,104.00
	Topsoil & Seed	86	AC	3,600.00	309,600.00
	Traffic Control Devices	12	MI	18,000.00	216,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$9,989,125.80
	Maintenence	62	Mile-Years	$12,000.00	$744,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
	.125 Devil Canyon to Watana Road C, (44.32 Mi)				
	Clearing	800	AC	$ 5,760.00	$ 4,608,000.00
	Waste Excavation	2,245,400	CY	4.80	10,777,920.00
	Common Excavation	2,450,800	CY	4.20	10,293,360.00
	Rock Excavation	41,800	CY	14.40	601,920.00
	Borrow	20,000	CY	6.00	120,000.00
	NFS Subbase Material	470,000	CY	8.40	3,948,000.00
	Grade "A" Base Material	300,000	CY	16.80	5,040,000.00
	D-1 Base Material	162,500	TON	21.60	3,510,000.00
	A.C. Surfacing	148,813	TON	79.20	11,785,989.60
	Guardrail	4,200	LF	43.20	181,440.00
	18" Culverts	30,350	LF	28.80	874,080.00
	36" + Culverts	-	LS	468,120.00	468,120.00
	Fabric	12,907	SY	3.00	38,721.00
	Thaw Pipes	28,750	LF	43.20	1,242,000.00
	Topsoil & Seed	514	AC	3,600.00	1,850,400.00
	Traffic Control Devices	69	MI	18,000.00	1,242,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$56,581,950.60
	Maintenence	523	Mile-Years	$8,000.00	$4,184,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.13	Maintenance Road				
.131	Devil Canyon to Watana - North Side, Road A-2, (41.25 Mi)				
	Clearing	576	AC	$ 5,760.00	$ 3,317,760.00
	Waste Excavation	1,536,500	CY	4.80	7,375,200.00
	Common Excavation	1,603,000	CY	4.20	6,732,600.00
	Rock Excavation	146,500	CY	14.40	2,109,600.00
	Borrow	156,700	CY	6.00	940,200.00
	NFS Subbase Material	424,700	CY	8.40	3,567,480.00
	Grade "A" Base Material	231,700	CY	16.80	3,892,560.00
	D-1 Base Material	96,700	TON	21.60	2,088,720.00
	A.C. Surfacing	88,600	TON	79.20	7,017,120.00
	Guardrail	6,050	LF	43.20	261,360.00
	18" Culverts	23,000	LF	28.80	662,400.00
	36" + Culverts	-	LS	407,520.00	407,520.00
	Fabric	49,800	SY	3.00	149,400.00
	Thaw Pipes	24,400	LF	43.20	1,054,080.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$41,487,600.00
	Maintenence	289	Mile-Years	$10,000.00	$2,890,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.22	Railhead				
.221	Railhead - Cantwell				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	LF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	8	Year	$28,600.00	$228,800.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.336	ROAD & RAIL FACILITIES				
.222	Railhead - Gold Creek				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	LF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	7	Years	$28,600.00	$200,200.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
7.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$162,000.00	$ 162,000.00
	Catering & Operation Support	19,590	Manday	39.40	771,846.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	1,647,000.00	1,647,000.00
	Catering & Operation Support	336,420	Manday	39.10	13,154,022.00
	TOTAL PROJECT COSTS				$182,253,201.80

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	Ton	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.114	Devil Canyon to Watana - North A-2 Road (41.25 Mi)				
	Clearing	369	AC	$ 5,760.00	$2,125,440.00
	Waste Excavation	855,321	CY	4.80	4,105,540.80
	Common Excavation	619,500	CY	4.20	2,601,900.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	9,200	LF	28.80	264,960.00
	36" + Culverts	-	LS	114,960.00	114,960.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	222,640	TON	21.60	4,809,024.00
	Fabric	14,946	SY	3.00	44,838.00
				TOTAL	$14,066,662.80
	Maintenence	83	Mile-Years	$4,000.00	$332,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.118	Devil Canyon Low Level Crossing H Road (7.88 Mi)				
	Clearing	170	AC	$ 5,760.00	$ 979,200.00
	Waste Excavation	498,845	CY	4.80	2,394,456.00
	Common Excavation	549,417	CY	4.20	2,307,551.40
	Rock Excavation	749,641	CY	14.40	10,794,830.40
	Borrow	0	CY	6.00	0.00
	18" Culverts	5,100	LF	28.80	146,880.00
	36" + Culverts	-	LS	0.00	0.00
	Bridges	12,480	SF	180.00	2,246,400.00
	D-1 Base Material	36,966	TON	21.60	798,465.60
	Fabric	0	SY	3.00	0.00
				TOTAL	$19,667,783.40
	Maintenence	118	Mile-Years	$5,000.00	$590,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.12	Permanent Road				
.122	Gold Creek to Devil Canyon, Road B-2, (12.31 Mi)				
	Clearing	28	AC	$ 5,760.00	$ 161,280.00
	Waste Excavation	97,892	CY	4.80	469,881.60
	Common Excavation	44,772	CY	4.20	188,042.40
	Rock Excavation	23,625	CY	14.40	340,200.00
	Borrow	416,311	CY	6.00	2,497,866.00
	NFS Subbase Material	126,750	CY	8.40	1,064,700.00
	Grade "A" Base Material	69,160	CY	16.80	1,161,888.00
	D-1 Base Material	28,860	TON	21.60	623,376.00
	A.C. Surfacing	26,429	TON	79.20	2,093,176.80
	Guardrail	6,700	LF	43.20	289,440.00
	18" Culverts	4,950	LF	28.80	142,560.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	5,585	SY	3.00	16,755.00
	Thaw Pipes	8,845	LF	43.20	382,104.00
	Topsoil & Seed	86	AC	3,600.00	309,600.00
	Traffic Control Devices	12	MI	18,000.00	216,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$9,989,125.80
	Maintenence	160	Mile-Years	$2,000.00	$1,920,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD, RAIL & AIR FACILITIES				
.124	Devil Canyon to Watana - North, Road A-2, (41.25 Mi)				
	Clearing	207	AC	$ 5,760.00	$ 1,192,320.00
	Waste Excavation	681,179	CY	4.80	3,269,659.20
	Common Excavation	984,473	CY	4.20	4,134,786.60
	Rock Excavation	146,527	CY	14.40	2,109,988.80
	Borrow	73,145	CY	6.00	438,870.00
	NFS Subbase Material	424,710	CY	8.40	3,567,564.00
	Grade "A" Base Material	231,739	CY	16.80	3,893,215.20
	D-1 Base Material	96,704	TON	21.60	2,088,806.40
	A.C. Surfacing	88,557	TON	79.20	7,013,714.40
	Guardrail	6,500	LF	43.20	261,360.00
	18" Culverts	13,840	LF	28.80	398,592.00
	36" + Culverts	-	LS	179,040.00	179,040.00
	Fabric	34,874	SY	3.00	104,622.00
	Thaw Pipes	24,435	LF	43.20	1,055,592.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$31,619,730.60
	Maintenence	248	Mile-Years	$10,000.00	$2,480,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.128	Devil Canyon Trans-Dam Crossing, Road D, (7.26 Mi)				
	Clearing	45	AC	$ 5,760.00	$ 259,200.00
	Waste Excavation	132,300	CY	4.80	635,040.00
	Common Excavation	114,500	CY	4.20	480,900.00
	Rock Excavation	12,200	CY	14.40	175,680.00
	Borrow	90,200	CY	6.00	541,200.00
	NFS Subbase Material	27,960	CY	8.40	234,864.00
	Grade "A" Base Material	15,260	CY	16.80	256,368.00
	D-1 Base Material	6,370	TON	21.60	137,592.00
	A.C. Surfacing	5,830	TON	79.20	461,736.00
	Guardrail	2,640	LF	43.20	114,048.00
	18" Culverts	1,785	LF	28.80	51,408.00
	36" + Culverts	-	LS	0.00	0.00
	Fabric	0	SY	3.00	0.00
	Thaw Pipes	1,785	LF	43.20	77,112.00
	Topsoil & Seed	29	AC	3,600.00	104,400.00
	Traffic Control Devices	3	MI	18,000.00	54,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$3,583,548.00
	Maintenence	7	Mile-Year	$13,00.00	$91,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.22	Railhead				
.222	Railhead - Gold Creek				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	LF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	15	Year	$28,600.00	$429,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
8.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$675,000.00	$675,000.00
	Catering & Operation Support	81,430	Manday	39.20	3,192,056.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	567,000.00	567,000.00
	Catering & Operation Support	116,290	Manday	39.10	4,546,939.00
	TOTAL PROJECT COST				$104,833,519.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	TON	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
.114	Devil Canyon to Watana - North, Road A-2, (36.46 Mi)				
	Clearing	369	AC	$ 5,760.00	$ 2,125,440.00
	Waste Excavation	855,321	CY	4.80	4,105,540.80
	Common Excavation	619,500	CY	4.20	2,601,900.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	9,200	LF	28.80	264,960.00
	36" + Culverts	-	LS	114,960.00	114,960.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	222,640	TON	21.60	4,809,024.00
	Fabric	14,946	SY	3.00	44,838.00
				TOTAL	$14,066,662.80
	Maintenence	83	Mile-Years	$4,000.00	$332,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
	.118 Devil Canyon Low Level Crossing H Road (7.88 Mi)				
	Clearing	170	AC	$ 5,760.00	$ 979,200.00
	Waste Excavation	498,845	CY	4.80	2,394,456.00
	Common Excavation	549,417	CY	4.20	2,307,551.40
	Rock Excavation	749,641	CY	14.40	10,794,830.40
	Borrow	0	CY	6.00	0.00
	18" Culverts	5,100	LF	28.80	146,880.00
	36" + Culverts	-	LS	0.00	0.00
	Bridges	12,480	SF	180.00	2,246,400.00
	D-1 Base Material	36,966	Ton	21.60	798,465.60
	Fabric	0	SY	3.00	0.00
				TOTAL	$19,667,783.40
	Maintenence	118	Mile-Years	$5,000.00	$590,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads				
.124	Devil Canyon to Watana - North, Road A-2, (41.25 Mi)				
	Clearing	207	AC	$ 5,760.00	$ 1,192,320.00
	Waste Excavation	681,179	CY	4.80	3,269,659.20
	Common Excavation	984,473	CY	4.20	4,134,786.60
	Rock Excavation	146,527	CY	14.40	2,109,988.80
	Borrow	73,145	CY	6.00	438,870.00
	NFS Subbase Material	424,710	CY	8.40	3,567,564.00
	Grade "A" Base Material	231,739	CY	16.80	3,893,215.20
	D-1 Base Material	96,704	TON	21.60	2,088,806.40
	A.C. Surfacing	88,557	TON	79.20	7,013,714.40
	Guardrail	6,050	LF	43.20	261,360.00
	18" Culverts	13,840	LF	28.80	398,592.00
	36" + Culverts	-	LS	179,040.00	179,040.00
	Fabric	34,874	SY	3.00	104,622.00
	Thaw Pipes	24,435	LF	43.20	1,055,592.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$31,619,730.60
	Maintenence	248	Mile-Years	$10,000.00	$2,480,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
.128	Devil Canyon Trans Dam Crossing, Road D, (7.26 Mi)				
	Clearing	45	AC	$ 5,760.00	$ 259,200.00
	Waste Excavation	132,300	CY	4.80	635,040.00
	Common Excavation	114,500	CY	4.20	480,900.00
	Rock Excavation	12,200	CY	14.40	175,680.00
	Borrow	90,200	CY	6.00	541,200.00
	NFS Subbase Material	27,960	CY	8.40	234,864.00
	Grade "A" Base Material	15,260	CY	16.80	256,368.00
	D-1 Base Material	6,370	TON	21.60	137,592.00
	A.C. Surfacing	5,830	TON	79.20	461,736.00
	Guardrail	2,640	LF	43.20	114,048.00
	18" Culverts	1,785	LF	28.80	51,765.00
	36" + Culverts	-	LS	0.00	0.00
	Fabric	0	SY	3.00	0.00
	Thaw Pipes	1,785	LF	43.20	77,112.00
	Topsoil & Seed	29	AC	3,600.00	104,400.00
	Traffic Control Devices	3	MI	18,000.00	54,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$3,583,548.00
	Maintenence	7	Mile-Year	$13,00.00	$91,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.21	Permanent Rail Road (Included Railhead)				
.211	Gold Creek to Devil Canyon, Rail R-1, (16.29 Mi)				
	Clearing	68	AC	$ 5,760.00	$ 391,680.00
	Waste Excavation	129,482	CY	4.80	621,513.60
	Common Excavation	549,157	CY	4.20	2,306,459.40
	Rock Excavation	2,200	CY	14.40	31,680.00
	Borrow	79,611	CY	6.00	477,666.00
	Subballast	192,467	CY	8.60	1,655,216.20
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	1,390	LF	28.80	40,032.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	300	SY	3.00	900.00
	Thaw Pipes	10,100	LF	43.20	436,320.00
	Topsoil & Seed	116	AC	3,600.00	417,600.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Bridges	0	SF	360.00	0.00
	Trackage	110,300	LF	140.00	15,442,000.00
				TOTAL	$21,171,723.20
	Maintenence				
	Rail	212	Mile-Years	$5,000.00	$106,000.00
	Railhead - Devil Canyon	15	Years	$28,600.00	$429,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
9.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$675,000.00	$ 675,000.00
	Catering & Operation Support	81,430	Manday	39.20	3,192,056.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	$627,000.00	$ 627,000.00
	Catering & Operation Support	130,630	Manday	39.10	5,107,633.00
	TOTAL PROJECT COSTS				$108,831,130.40

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
10.336	ROAD & RAIL FACILITIES				
.1	Roads				
.11	Pioneer Roads				
.112	Gold Creek to Devil Canyon B-2 Road (12.31 Mi)				
	Clearing	113	AC	$ 5,760.00	$ 650,880.00
	Waste Excavation	324,998	CY	4.80	1,559,990.40
	Common Excavation	291,163	CY	4.20	1,222,884.60
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	3,460	LF	28.80	99,648.00
	36" + Culverts	-	LS	13,824.00	13,824.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	66,444	Ton	21.60	1,435,190.40
	Fabric	3,192	SY	3.00	9,576.00
				TOTAL	$4,991,993.40
	Maintenence	25	Mile-Years	$4,000.00	$100,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
10.336	ROAD & RAIL FACILITIES				
.113	Gold Creek to Watana -South B-3 Road (36.46 Mi)				
	Clearing	271	AC	$5,760.00	$1,560,960.00
	Waste Excavation	585,666	CY	4.80	2,811,196.80
	Common Excavation	255,812	CY	4.20	1,074,410.40
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	10,850	LF	28.80	312,480.00
	36" + Culverts	-	LS	124,752.00	124,752.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	196,778	Ton	21.60	4,250,404.80
	Fabric	27,408	SY	3.00	82,224.00
				TOTAL	$10,216,428.00
	Maintenence	73	Mile-Years	$4,000.00	$292,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
10.336	ROAD & RAIL FACILITIES				
.12	Permanent Raods				
.123	Devil Canyon to Watana - South, Road B-3, (36.46 Mi)				
	Clearing	360	AC	$ 5,760.00	$ 2,073,600.00
	Waste Excavation	1,164,494	CY	4.80	5,589,571.20
	Common Excavation	1,308,618	CY	4.20	5,496,195.60
	Rock Excavation	246,750	CY	14.40	3,553,200.00
	Borrow	15,693	CY	6.00	94,158.00
	NFS Subbase Material	375,375	CY	8.40	3,153,150.00
	Grade "A" Base Material	204,820	CY	16.80	3,440,976.00
	D-1 Base Material	85,470	TON	21.60	1,846,152.00
	A.C. Surfacing	78,271	TON	79.20	6,199,063.20
	Guardrail	8,300	LF	43.20	358,560.00
	18" Culverts	16,270	LF	28.80	468,576.00
	36" + Culverts	-	LS	57,888.00	57,888.00
	Fabric	69,133	SY	3.00	207,399.00
	Thaw Pipes	27,915	LF	43.20	1,205,928.00
	Topsoil & Seed	410	AC	3,600.00	1,476,000.00
	Traffic Control Devices	36	MI	18,000.00	648,000.00
	Bridges	109,140	SF	180.00	19,645,200.00
				TOTAL	$55,513,617.00
	Maintenence	219	Mile-Years	$13,000.00	$2,847,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
10.336	ROAD RAIL FACILITIES				
.2	Rail Facilities				
.21	Permanent Rail Road (Include Railhead)				
.211	Gold Creek to Devil Canyon Rail R-1, (16.29 Mi)				
	Clearing	68	AC	$ 5,760.00	$ 391,680.00
	Waste Excavation	129,482	CY	4.80	621,513.60
	Common Excavation	549,157	CY	4.20	2,306,459.40
	Rock Excavation	2,200	CY	14.40	31,680.00
	Borrow	79,611	CY	6.00	477,666.00
	Subballast	192,467	CY	8.60	1,655,216.20
	Grade "A" Base Material	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	TON	21.60	51,840.00
	A.C. Surfacing	2,200	TON	79.20	174,240.00
	Dock Lumber	16	MBF	580.00	9,280.00
	18" Culverts	1,390	LF	28.80	40,032.00
	36" + Culverts	-	LS	32,256.00	32,256.00
	Fabric	300	SY	3.00	900.00
	Thaw Pipes	10,100	LF	43.20	436,320.00
	Topsoil & Seed	116	AC	3,600.00	417,600.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Bridges	0	SF	360.00	0.00
	Trackage	110,300	LF	140.00	15,442,000.00
				TOTAL	$22,171,723.20
	Maintenence				
	Rail	212	Mile-Years	$5,000.00	$1,060,000.00
	Railhead - Devil Canyon	15	Years	$28,600.00	$429,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
10.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$267,000.00	$ 267,000.00
	Catering & Operation Support	31,750	Manday	39.60	1,257,300.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	582,000.00	582,000.00
	Catering & Operation Support	183,830	Manday	39.10	7,187,753.00
	TOTAL PROJECT COST				$106,915,814.60

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.336	ROAD & RAIL FACILITIES				
.11	Pioneer Roads				
.114	Gold Creek to Watana -South A-2 Road (41.25 Mi)				
	Clearing	369	AC	$5,760.00	$2,125,440.00
	Waste Excavation	855,321	CY	4.80	4,105,540.80
	Common Excavation	619,500	CY	4.20	2,601,900.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	9,200	LF	28.80	264,960.00
	36" + Culverts	-	LS	114,960.00	114,960.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	222,640	TON	21.60	4,809,024.00
	Fabric	14,946	SY	3.00	44,838.00
				TOTAL	$14,066,662.80
	Maintenence	83	Mile-Years	$4,000.00	$332,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.336	ROAD & RAIL FACILITIES				
.115	Denali to Watana				
	C Road (44.32 Mi)				
	Clearing	0	AC	$5,760.00	$0.00
	Waste Excavation	0	CY	4.80	0.00
	Common Excavation	0	CY	4.20	0.00
	Rock Excavation	0	CY	14.40	0.00
	Borrow	0	CY	6.00	0.00
	18" Culverts	0	LF	28.80	0.00
	36" + Culverts	0	LS	0.00	0.00
	Bridges	0	SF	0.00	0.00
	D-1 Base Material	0	TON	21.60	0.00
	Fabric	0	SY	3.00	0.00
				TOTAL	$0.00
	Maintenence	0	Mile-Years	$0.00	$0.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.336	ROAD & RAIL FACILITIES				
.12	Permanent Roads & Bridges				
.124	Watana to Devil Canyon - North, Road A-2, (41.25 Mi)				
	Clearing	207	AC	$ 5,760.00	$ 1,192,320.00
	Waste Excavation	681,179	CY	4.80	3,269,659.20
	Common Excavation	984,473	CY	4.20	4,134,786.60
	Rock Excavation	146,527	CY	14.40	2,109,988.80
	Borrow	73,145	CY	6.00	438,870.00
	NFS Subbase Material	424,710	CY	8.40	3,567,564.00
	Grade "A" Base Material	231,739	CY	16.80	3,893,215.20
	D-1 Base Material	96,704	TON	21.60	2,088,806.40
	A.C. Surfacing	88,557	TON	79.20	7,013,714.40
	Guardrail	6,050	LF	43.20	261,360.00
	18" Culverts	13,840	LF	28.80	398,592.00
	36" + Culverts	-	LS	179,040.00	179,040.00
	Fabric	34,874	SY	3.00	104,622.00
	Thaw Pipes	24,435	LF	43.20	1,055,592.00
	Topsoil & Seed	326	AC	3,600.00	1,173,600.00
	Traffic Control Devices	41	MI	18,000.00	738,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$31,619,730.60
	Maintenence	206	Mile-Years	$10,000.00	$2,060,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.336	ROAD & RAIL FACILITIES				
.125	Denali to Watana Road C, (44.32 Mi) (Plus 21.00 Mi)				
	Clearing	800	AC	$ 5,760.00	$ 4,608,000.00
	Waste Excavation	2,245,400	CY	4.80	10,777,920.00
	Common Excavation	2,450,800	CY	4.20	10,293,360.00
	Rock Excavation	41,800	CY	14.40	601,920.00
	Borrow	20,000	CY	6.00	120,000.00
	NFS Subbase Material	470,000	CY	8.40	3,948,000.00
	Grade "A" Base Material	300,000	CY	16.80	5,040,000.00
	D-1 Base Material	162,500	TON	21.60	3,510,000.00
	A.C. Surfacing	148,813	TON	79.20	11,785,989.60
	Guardrail	4,200	LF	43.20	181,440.00
	18" Culverts	30,350	LF	28.80	874,080.00
	36" + Culverts	-	LS	468,120.00	468,120.00
	Fabric	12,907	SY	3.00	38,721.00
	Thaw Pipes	28,750	LF	43.20	1,242,000.00
	Topsoil & Seed	514	AC	3,600.00	1,850,400.00
	Traffic Control Devices	69	MI	18,000.00	1,242,000.00
	Bridges	0	SF	180.00	0.00
				TOTAL	$56,581,950.60
	Maintenence	980	Mile-Years	$8,000.00	$7,840,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.336	ROAD & RAIL FACILITIES				
.2	Rail Facilities				
.22	Railheads				
.221	Railhead - Cantwell				
	Clearing	25	AC	$ 5,760.00	$144,000.00
	Waste Excavation	78,000	CY	4.80	374,400.00
	Common Excavation	505,000	CY	4.20	2,121,000.00
	Grade A Base	4,900	CY	16.80	82,320.00
	D-1 Base Material	2,400	CY	21.60	51,840.00
	A.C. Surfacing	2,200	Ton	79.20	174,240.00
	Topsoil & Seed	15	AC	3,600.00	54,000.00
	Rail Yard Control Devices	-	LS	720.00	720.00
	Subballast	25,800	CY	8.60	221,880.00
	Trackage	19,700	LF	140.00	2,758,000.00
	Dock Lumber	16	MBF	580.00	9,280.00
				TOTAL	$5,991,680.00
	Maintenence	15	Year	$28,600.00	$429,000.00

ITEM	DESCRIPTION	QUANTITY	UNITS	PRICE	AMOUNT
11.63	CAMP				
	.1 Camp				
	.11 Pioneer Road Camp				
	Camp Facilities	-	LS	$243,000.00	$ 243,000.00
	Catering & Operation Support	29,430	Manday	39.40	1,159,542.00
	.12 Access Road/Railhead Camp				
	Camp Facilities	-	LS	912,000.00	912,000.00
	Catering & Operation Support	217,580	Manday	39.10	8,507,378.00
	TOTAL PROJECT COSTS				$129,742,944.00

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Cost Item	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
Pioneer Construction	$ 19,578,958.80	$ 15,258,245.40	$ 9,362,530.80	$ 4,991,993.40	$ 43,096,977.00	$ 4,991,993.40
Perm. Construction	99,493,189.40	87,705,803.60	106,553,203.00	84,745,353.80	79,182,851.00	125,232,953.80
CONSTRUCTION TOTAL	$119,072,148.20	$102,964,049.00	$115,915,733.80	$89,737,347.20	$122,279,828.00	$130,224,947.20
Ranking	8	5	7	1	9	10
Pioneer Maintenence	$ 500,000.00	$ 392,000.00	$ 208,000.00	$ 100,000.00	$1,130,000.00	$ 100,000.00
Perm. Maintenence	6,926,900.00	3,232,000.00	6,017,000.00	5,018,000.00	6,650,900.00	7,908,000.00
MAINTENENCE TOTAL	$7,426,900.00	$3,624,000.00	$6,225,000.00	$5,118,000.00	$7,780,900.00	$8,008,000.00
	7	1	6	4	8	9
Pioneer Camp	$ 1,957,155.00	$ 1,524,300.00	$ 933,846.00	$ 498,730.00	$ 4,300,344.00	$ 498,730.00
Perm Camp	10,688,305.00	8,769,980.00	10,659,633.00	8,479,081.00	7,915,185.00	12,620,470.00
CAMP TOTAL	$12,645,460.00	$10,294,280.00	$11,593,479.00	$8,977,811.00	$12,215,529.00	$13,119,200.00
SUB TOTAL	$139,144,508.20	$116,882,329.00	$133,734,212.80	$103,833,158.20	$142,276,257.00	$151,352,147.20
Logistics	$214,438,356.00	$213,620,024.00	$228,050,617.00	$228,004,352.00	$215,571,651.00	$228,004,352.00
Ranking	2	1	9 - 10	7 - 8	4 - 5	7 - 8
PLAN TOTAL	$353,582,864.20	$330,502,353.00	$361,784,829.80	$331,837,510.20	$357,847,908.00	$379,356,499.20
Ranking	6	4	8	5	7	9

Continued on next page

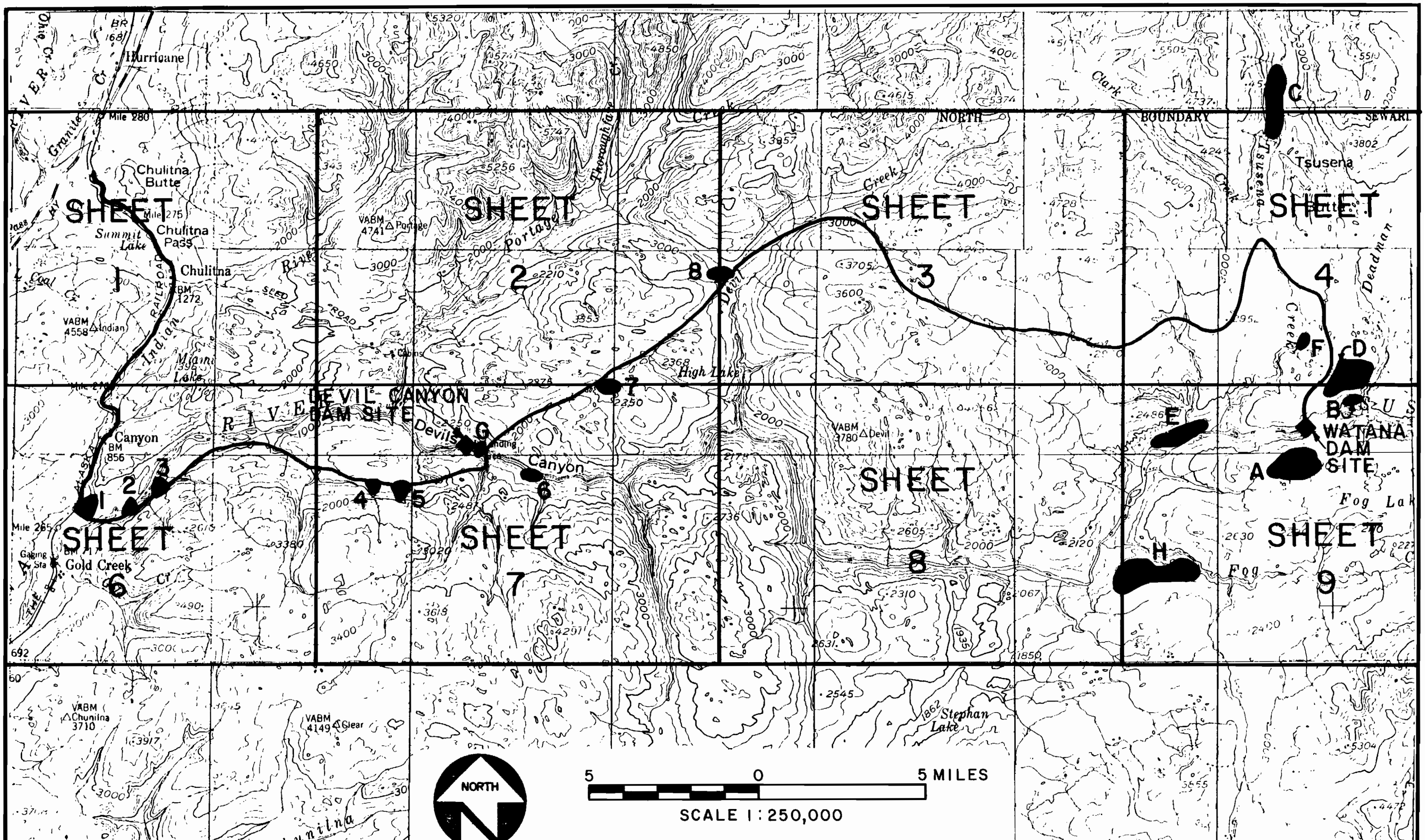
Cost Item	Plan 7	Plan 8	Plan 9	Plan 10	Plan 11
Pioneer Construction	$ 9,362,530.80	$ 38,726,439.60	$ 38,726,439.60	$ 15,208,421.40	$ 14,066,662.80
Perm. Construction	148,040,803.00	51,184,084.40	56,375,001.80	77,685,340.20	94,193,361.20
CONSTRUCTION TOTAL	$157,403,333.80	$ 89,910,524.00	$95,101,441.40	$92,893,761.60	$108,260,024.00
Ranking	11	2	4	3	6
Pioneer Maintenence	$ 208,000.00	$1,022,000.00	$1,022,000.00	$ 392,000.00	$ 332,000.00
Perm. Maintenence	8,907,000.00	4,920,000.00	3,106,000.00	4,336,000.00	10,329,000.00
MAINTENENCE TOTAL	$9,115,000.00	$5,942,000.00	$4,128,000.00	$4,728,000.00	$10,661,000.00
	10	5	2	3	11
Pioneer Camp	$ 933,846.00	$ 3,867,056.00	$ 3,867,056.00	$ 1,524,300.00	$ 1,402,542.00
Perm. Camp	14,801,022.00	5,113,939.00	5,734,633.00	7,769,753.00	9,419,378.00
CAMP TOTAL	$15,734,868.00	$8,980,995.00	$9,601,689.00	$9,294,053.00	$10,821,920.00
SUB TOTAL	$182,253,201.80	$104,833,519.00	$108,831,130.40	$106,915,814.60	$129,742,944.00
Logistics	$228,050,617.00	$215,571,651.00	$215,594,496.00	$214,461,201.00	$257,903,604.00
Ranking	9 - 10	4 - 5	6	3	11
PLAN TOTAL	$410,303,818.80	$320,405,170.00	$324,425,626.40	$321,377,015.60	$387,646,548.00
Ranking	11	1	3	2	10

APPENDIX G

BORROW PITS

Appendix G- Borrow Pits

This appendix contains the two letters from Terrestrial Environmental Specialists concerning the selected borrow pit areas. Both dam and road borrow is discussed. Portions of the maps accompanying the letters were reproduced. For reference, a map showing the borrow pits in relation to the whole project is included. More detailed drawings of each pit can be found on the Segment Maps in Appendix B.



PREPARED BY:

R&M CONSULTANTS, INC.

BORROW PIT LOCATIONS

PREPARED FOR:

ACRES

FIGURE G-1

Terrestrial
Environmental
Specialists, inc.
R.D. 1 BOX 388 PHOENIX, N.Y. 13135 (315)695-7228

November 5, 1981
218.858

Mr. Norm Gutcher
R&M Consultants, Inc.
P.O. Box 6087
5024 Cordova Street
Anchorage, Alaska 99503

Dear Norm:

Enclosed please find a copy of a map indicating access route borrow areas. We have given these areas identifying numbers, superimposed them onto vegetation habitat type maps, and have commented, where appropriate, on the use of particular areas. These comments are included on the attached table. One general comment we have is that since most of these borrow areas are in forested habitat, provision must be made to clear, and then properly dispose of, woody vegetation. Also enclosed is a copy of a letter and map sent by Joe McMullen to Lance Duncan of Acres. Joe's letter addresses environmental sensitivity of lettered borrow areas for the dam sites. You might find some of the information contained therein useful.

If I can be of any further help, or if you identify any other potential borrow areas, please contact me.

Sincerely,

Cathie

Cathie A. Baumgartner
Environmental Study Deputy
Director

CAB/vl
Enc.
cc: M. Grubb

Borrow Areas - Access Corridors

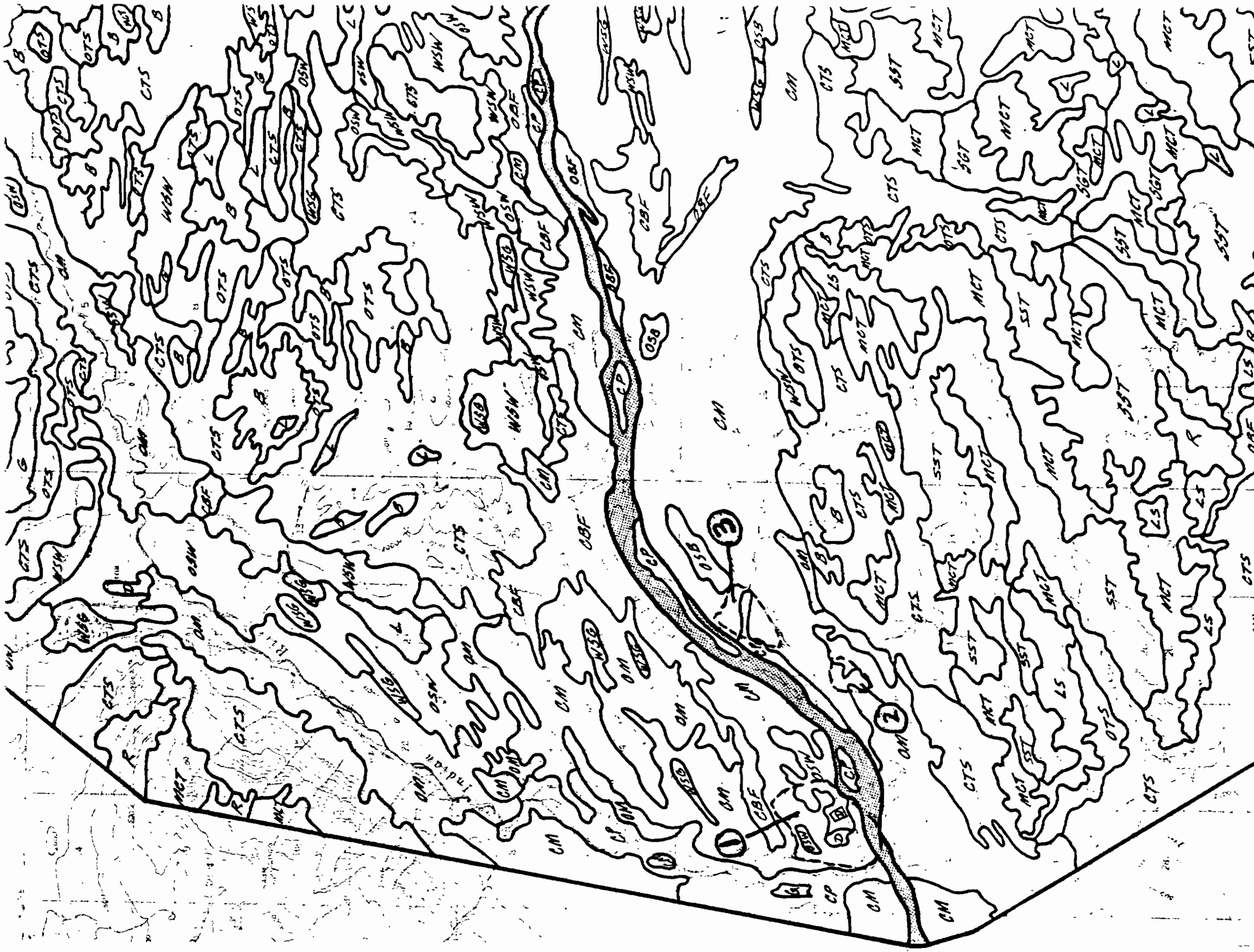
Area[a]	Township	Sections	General Location	Vegetation Types -	Value[b]	Comments
1	T31N,R2W Seward Meridian	(9 & 10)	Near confluence of Indian & Susitna rivers	Closed Mixed Forest Open White Spruce Disturbed	.88 .94 --	Private lands - Indian River Remote Parcel disposal area, therefore probable conflict with present and future land use; contact Ak. DNR, Division of Forest, Land, and Water Management (Land Management Section) to determine exactly where parcels have been staked Two identified vegetation types, both have relatively high wildlife value
2	T31N,R2W	(11)	East of confluence of Indian and Susitna rivers, south of Susitna and north of Gold Creek	Closed Mixed Forest Open Mixed Forest	.88 .95	Community types have similar, relatively high wildlife values; stay away from creek bank and bed if possible Potential erosion problem because of slope
3	T31N,R2W	(2)	Along Corridor 2, northeast of confluence of Indian and Susitna rivers	Closed Mixed Forest Closed Balsam Poplar	.88 .62	Stay away from creek bed and bank - closed poplar not really valuable habitat per se but is found along stream banks
4	T31N,R1W	(2 & 11)	Along Corridor 2, west of Devil Canyon dam site	Closed Mixed Forest Open Black Spruce Wet Sedge Grass Rock	.88 .82 1.00 .44	If possible, stay as far away from wet sedge grass habitat (NE corner of borrow area) as possible Native Claim (Knik)

(a) Numbered areas refer to accompanying maps. Lettered areas refer to previously identified borrow areas for dam sites.

(b) Weighted Relative Values - See Access Route Environmental Report (TES - October 1981).

Area[(a)]	Township	Sections	General Location	Vegetation Types -	Value[(b)]	Comments
5	T31N,R1W	(1 & 12)	Along Corridor 2, west of Devil Canyon dam site	Closed Mixed Forest	.88	All same habitat - medium to high in wildlife value, makes no difference where borrowed from Native Claim (CIRI)
6	T31N,R1E	(3)	South shore of Susitna River, east of Devil Canyon	Woodland Black Spruce Closed Birch Forest Open Black Spruce	.76 .66 .82	Makes no difference - will be under water anyway Native Claim (Knik)
7	T32N,R1E	(24)	Northeast of Devil Canyon dam site	Open Tall Shrub Birch Shrub	.77 .80	Stay as far away from the lake as possible, birch shrub occurs on SW half of area - good winter browse for moose
8	T32N,R2E	(3 & 4)	Northeast of Devil Canyon, just west of Devil Creek	Birch Shrub - .80 Low Shrub - .88		Stay as far away as possible from small creek on western border of borrow area, i.e., start to borrow from east side Almost entire area is birch shrub which provides good winter browse for moose
A	T31N,R5E	(3, 4 & 5)	North of Fog Lakes, south of Watana dam site	Woodland Black Spruce Mat & Cushion Tundra Low Shrub Willow Shrub Open Black Spruce		See letter - McMullen to Duncan November 3, 1981
B	T32N,R5E	(26 & 27)	Near Watana dam site north of Susitna River	Closed Mixed Forest Closed Birch Forest Woodland Black Spruce		See letter - McMullen to Duncan November 3, 1981
C	T33N,R5E T22S,R5W (Fairbanks Meridian)	(17)	North of Tsusena Butte along Tsusena Creek	Woodland White Spruce Low Shrub Birch Shrub Open Tall Shrub		See letter - McMullen to Duncan November 3, 1981

Area (a)	Township	Sections	General Location	Vegetation Types - Value (b)	Comments
D	T32N,R5E	(22, 23, 26 & 27)	North of Watana camp and dam site	Birch Shrub Low Shrub Closed Birch Forest Closed Mixed Forest Open Mixed Forest	See letter - McMullen to Duncan November 3, 1981
E	T32N,R4E	(35 & 36)	Along north shore of Susitna River west of Watana dam site	Woodland White Spruce Closed Mixed Forest Open White Spruce	See letter - McMullen to Duncan November 3, 1981
F	T32N,R5E	(16)	South of Tsusena Butte	Birch Shrub Closed Mixed Forest Low Shrub	See letter - McMullen to Duncan November 3, 1981
G	T32N,R1E	(32 & 33)	At Devil Canyon dam site	Closed Mixed Forest	See letter - McMullen to Duncan November 3, 1981
H	T31N,R4E	(21, 22, 23, & 24)	North of Corridor 2, south of Fog Creek, southwest of Watana dam site	Open Black Spruce Closed Mixed Forest Woodland Black Spruce Low Shrub	See letter - McMullen to Duncan November 3, 1981



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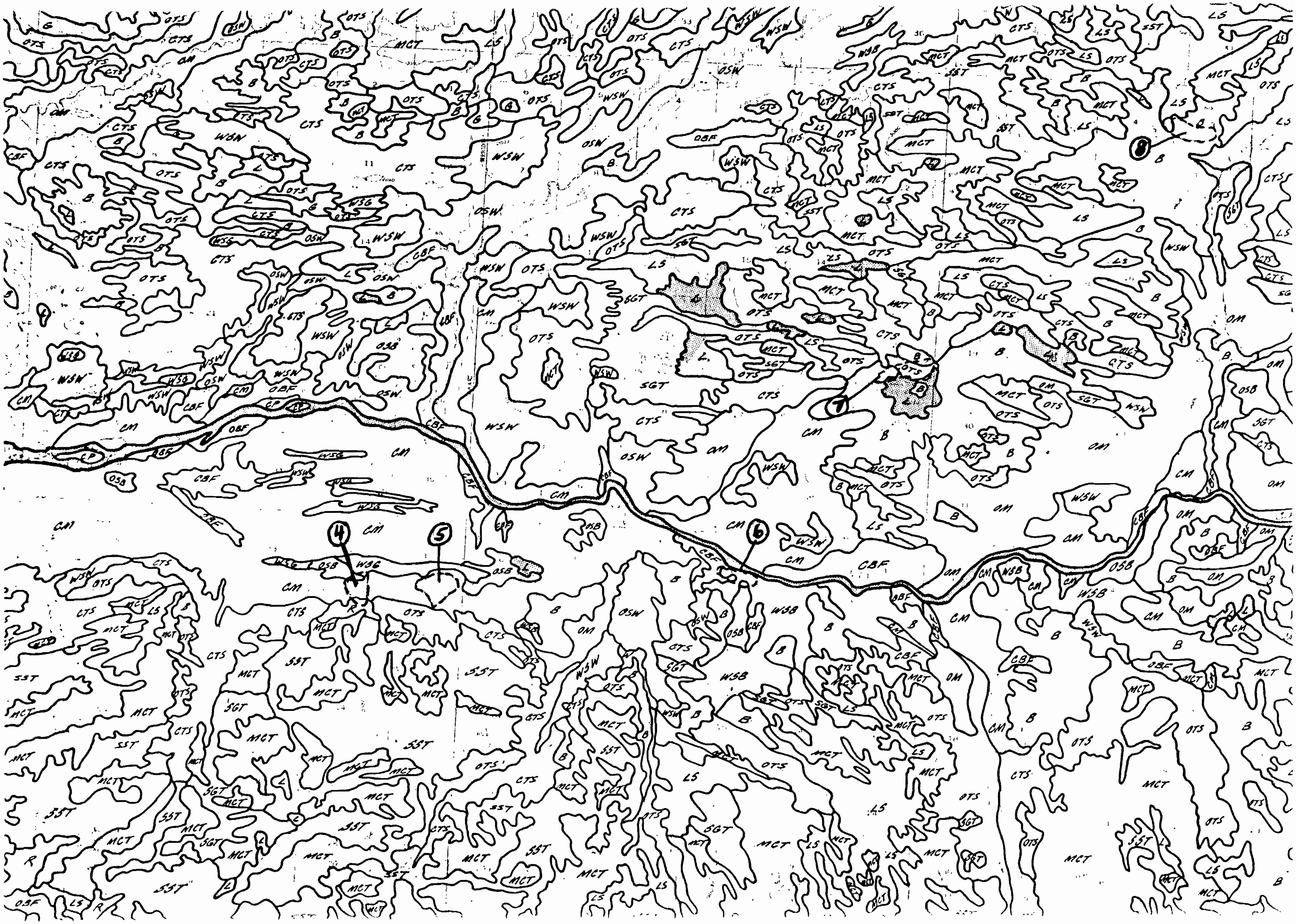
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Terrestrial Environmental Specialists, inc.
R.D. 1 BOX 388 PHOENIX, N.Y. 13135 (315)695-7228

November 3, 1981
218.851

Project Manager
Susitna Hydroelectric Project
Acres American, Inc.
Liberty Bank Building
Main at Court
Buffalo, New York 14202

Attention: Lance Ducan

Dear Lance:

As we discussed on October 21, 1981, please find enclosed a preliminary relative sensitivity map for the borrow areas presently under consideration. If there are additional borrow areas whose locations have not been forwarded to us, please let us know.

We tried to take the different facets of the environmental studies into consideration for the production of this sensitivity map. The information varied in specificity among disciplines. We could be fairly accurate for wildlife and vegetation, since we have fairly good vegetation/habitat maps. Information for fisheries, cultural resources, land use, recreation, and aesthetics was also considered. Keep in mind that the sensitivity map is a relative rating that was prepared to aid Acres in their selection of one portion of a borrow area over another. There are probably no environmental concerns in any of the borrow areas that would absolutely preclude their development (e.g. endangered species). The development of an area of high sensitivity will simply result in a greater environmental impact and more mitigation costs than the development of an area of medium or low sensitivity. In addition to the map, we have collected some preliminary general thoughts and specific comments for each borrow area.

The general comments are as follows. We have assumed that all disturbed areas will be reclaimed. For reclamation, it is very important to stockpile the topsoil and return it to the surface following development. Fertilization and seeding will probably also be required. The reclamation should begin as soon as the development of an area is completed. If a given area is to be developed in different stages (i.e. at different times), then it would be best to stockpile the topsoil on the next area to be developed; and begin reclamation and return the topsoil to the area currently being developed when the development is complete. In general it is probably best to develop areas in a manner that will limit the surface area to be disturbed. This will limit the impacts, especially on wildlife, vegetation, and cultural resources. We assume the floor of the developed area will be reclaimed and available for use by wildlife. The one drawback to going deep but limiting surface area may be in the area of visual exposure (aesthetics). Those areas that are along the reservoir would probably be best developed so that disturbance will be within the impoundment zone. This type of development may remove more land from terrestrial habitat, but it will "hide" the disturbed area from view, at least at full pool elevation. Since the pool elevation of the Watana impoundment will fluctuate quite a bit, this type of development will work best for borrow areas within the Devil Canyon impoundment. I do not know if you are considering Native Claims in your evaluation of borrow areas, but all of the borrow areas, with the exception of C, F and the northern half of D are within Native Claimed land.

The preliminary comments specific to particular borrow areas are as follows:

<u>Borrow Area A</u>

This area is close to the Watana Dam Site, therefore, its development would keep the disturbance in proximity to other construction activities. The area has a relatively low sensitivity for most environmental concerns, especially the elevated central portion which is covered by mat and cushion tundra. However, visual exposure to existing areas of recreational use (Fog Lakes) and areas of potential future use (Watana impoundment and construction village) would be high if this borrow area is developed. If the south-side access route (and/or south-side camp and village sites) is selected, the visual exposure of this borrow area will be an especially important consideration. During our telephone conversation we discussed the development of this area as a pit with one open side and high walls on three sides. This would probably be best, with the only drawback being visual exposure. For aesthetic purposes it would be best to face the open side away from view, or attempt to screen the opening from view, perhaps by contouring the open side.

<u>Borrow Area B</u>

This relatively small area will be adjacent to other construction activities and largely within the Watana Reservoir. There does not appear to be any major environmental problem with its development.

Borrow Area C

There are several environmental concerns associated with this borrow area. This borrow area is located north of Tsusena Butte and will require the development of some type of road to connect it to the Watana Dam Site. The development of such a road will result in direct impacts associated with habitat removal and indirect impacts associated with the opening of a previously inaccessible area to easy access. The bottom land within borrow area C contains a large amount of willow shrub, which provides good winter browse for moose. The development of borrow area C would potentially influence the fish resources of Tsusena Creek. Finally, there are nine known archeological sites within this borrow area.

Borrow Area D

Borrow area D will be close to other construction and camp activities. Its location will help limit the impacts on wildlife. However, because of its location it will be visible from the Watana Dam vicinity, permanent village, and possibly the access route. As a result, care should be taken in the reclamation of this area.

Borrow Area E

It appears that borrow area E will be largely within the Devil Canyon impoundment zone. Because of its location, this borrow area does not appear to have any major environmental drawbacks, except for the area near the mouth of Tsusena Creek. If possible, development should be limited in that area, especially if other activities will not disturb this area.

Borrow Area F

This area is north of the Watana Dam Site. Depending on the route selected this area may be adjacent to an access route. There do not appear to be any major environmental concerns for this area, although the western edge along Tsusena Creek is probably relatively more sensitive because of potential influences on the Creek. The borrow area will be within a potential high visual exposure zone.

Borrow Area G

This area is within the Devil Canyon impoundment on the south side of the river just upstream of the Devil Canyon Dam Site. Its development will not result in any additional environmental impacts.

Borrow Area H

As was borrow area C, this borrow area is distant from the Watana Dam vicinity. Direct and indirect impacts associated with road development to this area will occur, although the area would be accessible if a southern access route was selected. Raptor nesting habitat on the cliffs along Fog Creek may be disturbed if this area is developed. There is potential for the disturbance of Fog Creek if this area is developed. Also, the northeastern corner contains some known archeological sites.

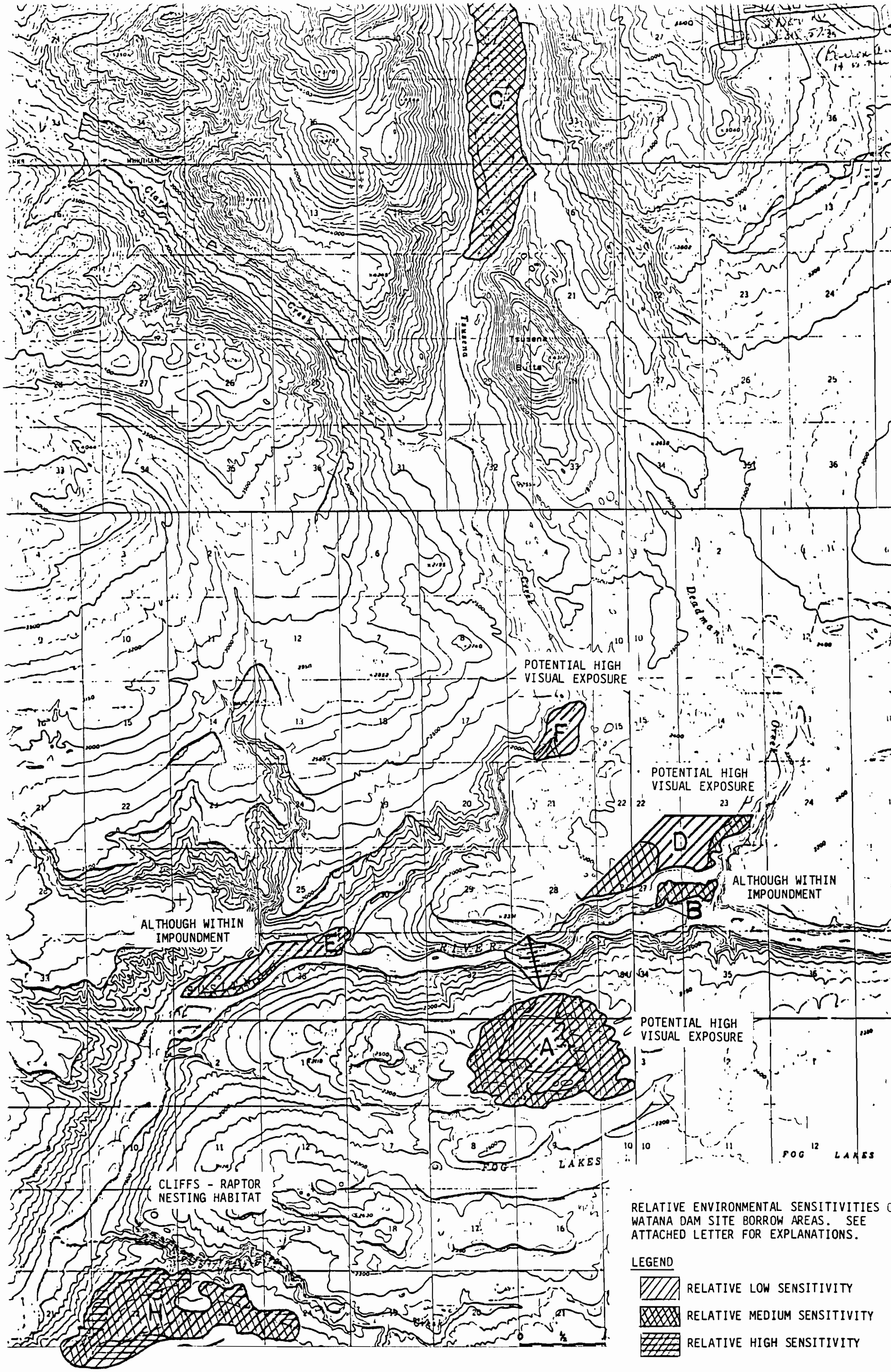
I hope that the enclosed information will aid Acres in the selection and development of borrow areas. If you have any questions concerning any aspect of the information presented, please do not hesitate to contact us.

Sincerely,

Joe

Joseph M. McMullen
Plant Ecology Group Leader

JMM/vl
cc: K. Young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CLIFFS - RAPTOR NESTING HABITAT
Tsusena Butte
Deadman Creek
FOG LAKES
RELATIVE ENVIRONMENTAL SENSITIVITIES O
WATANA DAM SITE BORROW AREAS. SEE
ATTACHED LETTER FOR EXPLANATIONS.
LEGEND
RELATIVE LOW SENSITIVITY
RELATIVE MEDIUM SENSITIVITY
RELATIVE HIGH SENSITIVITY