Southcentral Railbelt Area, Alaska
Upper Susitna River Basin

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SUPPLEMENTAL FEASIBILITY REPORT

'DROELECTRIC POWER
nd related purposes

U.S. Department of the Army
Alaska District
Corps of Engineers

Main Report

Anchorage, Alaska

1979

SOUTHCENTRAL RAILBELT AREA, ALASKA
UPPER SUSITNA RIVER BASIN
SUPPLEMENTAL FEASIBILITY REPORT

HYDROELECTRIC POWER AND RELATED PURPOSES

Prepared by the
Alaska District, Corps of Engineers
Department of the Army

February 1979

Resources Development Act of 1976 enacted by the 94th Congress on 22 October 1976, states:

> The Secretary of the Army, acting through the Chief of Engineers, is authorized to undertake the Phase I design memorandum stage of advanced engineering and design of the project for hydroelectric power on the Susitna River, Alaska, in accordance with the recommendations of the Board of Engineers for Rivers and Harbors in its report dated June 24, 1976, at an estimated cost $25,000,000. This shall take effect upon submittal to the Secretary of the Army by the Chief of Engineers and notification to Congress of the approval of the Chief of Engineers.

Notification to Congress of the Chief of Engineers' approval has been forestalled because of Office of Management and Budget (OMB) reservations regarding economic justification. In a letter to the Secretary of the Army dated 9 September 1977, Eliot R. Cutler, OMB Associate Director for Natural Resources, Energy and Science stated, "...we strongly believe further information is needed to verify the benefit-cost status before the project proceeds to Phase I planning."

During 1978, additional geological explorations, engineering and environmental resource studies, and economic analyses were undertaken to address the concerns expressed by OMB. This Supplemental Feasibility Report presents the results of those additional investigations.

The report consists of three documents: a main report that responds specifically to the comments and suggestions offered by OMB and a two part supporting appendix that is comprised of Sections A through I. These correspond directly to the sections of Appendix 1 of the 1976 Interim Feasibility Report. This Supplemental Feasibility Report is not designed as a comprehensive document. Rather, only changes to the original report and new information pertinent to OMB's comments are presented here.

MAIN REPORT

TABLE OF CONTENTS

LIST OF PLATES

APPENDIX

SUMMARY

SCOPE OF INVESTIGATIONS

The purpose of this supplemental feasibility study was to reevaluate the economic justification of the proposed upper Susitna River basin hydropower development (see Plate 1). Both benefits and costs were reanalyzed in the process of responding to the concerns expressed by the Office of Management and Budget. Certain additional studies not specifically suggested by OMB, but required to insure comparability in the data, were also undertaken. Study efforts were directed at those aspects of feasibility to which the benefit and cost estimates are most sensitive.

Project costs are highly dependent upon site foundation conditions, and a significant amount of new geological information was gathered during the supplemental studies in 1978. Geological reconnaissance and mapping were conducted at the Watana damsite to identify and trace the surface expressions of discontinuities and shear zones, and also in the reservoir area to identify potential slide hazards. Core borings were made at the damsite to verify the depth of overburden materials and quality of bedrock. Potential borrow sources were explored to determine the extent and quality of available construction materials. Refraction seismograph studies were performed to supplement the data gained from the borings and test pits. Refer to Plate 2 for exploration locations as the Watana site.

Supplemental explorations at the Devil Canyon site where drilling had previously been conducted were limited to three seismic refraction lines, each approximately 1,100 feet long.

While foundation conditions play a key role in estimating project costs, those costs are also very dependent upon the contingency factors used. A feature-by-feature analysis was made to determine the appropriate contingency factor on the basis of cost histories of similar projects, experience in Alaskan construction, and analysis of the uncertainties associated with the design and material requirements of the various features.

A third element of the supplemental studies that impacted cost was the construction schedule. Mobilization, river diversion, and material placement requirements were closely examined along with the interdependencies among construction activities to determine the length of time required for construction.

The newly acquired geological information led to design modifications which, of course, also affected the cost estimates.

In addition to the factors influencing project costs, there are a number of determinants of project benefits that were also analyzed. First, the project's power capability was reexamined using an additional 3 years of historical streamflow data and an updated seasonal load curve. Load growth forecasts were revised using 3 additional years of historical data, more sophisticated population and economic activity forecasting tools, and more conservative economic development assumptions. A range of forecasts were made, reflecting the uncertainties involved in power demand projections.

A load-resource analysis was developed and used to explore the sequence and timing of powerplant additions for the railbelt area and to determine how quickly Susitna power would be absorbed into the load.

Power benefit estimates were evaluated using 1978 cost estimates of thermal generation, the cost of which establishes the value of the hydropower project's output. The other categories of benefits, including load center interconnection, recreation, flood control, and employment, were also updated.

Finally, a comprehensive sensitivity analysis was conducted to ascertain those conditions under which the Susitna project would become uneconomic. This was augmented by a marketability analysis that estimates the cost of Susitna power relative to thermal generation under various load growth, timing and price level assumptions.

Other aspects of feasibility which were the subject of supplemental analyses included seismicity and environmental impact studies.

STUDY RESULTS

At the Watana damsite, the technical feasibility of constructing a dam in the general vicinity was reconfirmed. The rock at the damsite was found to be as good or better than previously assumed. Gravel borrow appears to be less abundant than anticipated, but large deposits of impervious material were located during the explorations. To take advantage of these findings, the dam design was altered by changing the gravel shells to rock shells and by widening the semipervious core (see Plates 3 and 4). Other modifications of the original Watana design included relocation of the spillway to take better advantage of rock lines, relocation of the diversion tunnel portals to place them in better rock, terraced rather than continuous rock cuts and other minor changes.

At Devil Canyon a gravity dam design was evaluated as an alternative to the original concrete thin arch concept (see Plates 5 and 6). The gravity structure, which is more costly but less sensitive to foundation problems, offers greater assurance that a dam can be built at the Devil Canyon site at a cost equal to or less than the estimated cost presented in the report. The less costly thin arch dam with separate spillway will be considered further if additional explorations during Phase I studies establish acceptable foundation conditions. By including in the economic analysis the higher cost of the gravity dam, the project's economic justification is presented on a more conservative basis.

The construction period for the entire project is now estimated at 14 years, with power-on-line for the initial phase occurring in 1994. The schedule allows 10 years for Watana construction and 8 years for Devil Canyon, with 4 years of concurrent construction. The transmission intertie could be available in 1991 to interconnect the Anchorage and Fairbanks load centers. This schedule is based on a construction start in October 1984.

The Susitna project is estimated to cost $2.59 billion at October 1978 prices. This includes $1.77 billion for Watana and the transmission facilities and $0.82 billion for the Devil Canyon phase. The 1978 combined project cost estimate amounts to a 70 percent increase over the cost estimate presented in the 1976 Interim Feasibility Report, which was based on January 1975 prices. Approximately 56 percent of this increase is due to price level changes over the 3-3/4 years between estimates. Another 15 percent is the result of using the cost of the alternate concrete gravity design at Devil Canyon. The remainder of the increase resulted from design changes and more detailed information on local construction materials.

When interest during construction is added, along with operation, maintenance and replacement costs, the average annual equivalent cost becomes $228 million, based on a discount rate of 6-7/8 percent.

The project's combined power output is estimated at 6.9 billion kilowatt hours average annual energy and 1,392 megawatts dependable capacity. Railbelt area power requirements are forecasted to grow to 12.7 billion kilowatt hours annual energy and 2,850 megawatts peak power by the year 2000 according to the medium range projection. Susitna power would need to be augmented by additional capacity from other powerplants, presumably coal-fired, within 9 years after initial power-on-line.

The estimated average annual benefits of the Susitna project amount to $324 million. This represents an increase of 119 percent over those presented in the 1976 report, which were based on a January 1975 price level.

By far the largest category of benefits is that which results from the sale of power. The value of the power is derived from the cost of producing it by means of the least cost nonhydro alternative which, in this case, is coal-fired generation. The cost of the thermal alternative was provided by the Federal Energy Regulatory Commission (FERC) and is based on 1978 price levels. The FERC composite Anchorage-Fairbanks capacity value of $186.58 per kilowatt-year represents a 107 percent increase over the comparable estimate provided by FERC (then the Federal Power Commission) in 1975. The 1978 composite energy value of 12.76 mills per kilowatt-hour amounts to a 144 percent increase over the comparable estimate of 1975. These higher estimates more than double the power benefit to an average annual equivalent of $289 million.

Besides those from the sale of power, there are power-related benefits derived from interconnection of the Anchorage and Fairbanks load centers. An interconnected system allows the sharing of capacity reserves so that fewer reserves are required in the system. Thus, interconnection offers benefits equal to the cost savings from not constructing additional capacity that would otherwise have been necessary. This benefit amounts to an average annual equivalent of $11 million.

Recreation benefits estimated at $300,000 annually are no change from the 1976 report. The benefits associated with flood control are estimated at $65,000 annually, an increase of 30 percent over the 1975 figure due solely to price changes associated with repair to damaged facilities.

The final benefit category, that attributable to the use of otherwise unemployed labor in project construction, is estimated at an average annual equivalent of $24 million. The 155 percent increase in this benefit over the original 1975 estimate is due to the higher cost of construction and more detailed analysis of labor requirements.

Under the base case set of assumptions, the proposed Susitna project offers annual net benefits of $95 million and a benefit-cost ratio of 1.42. The hydropower project's net benefits exceed those of the thermal alternative by $76 million annually. With an assumption of stable prices and medium load growth, the year 2000 average power system rates with the Susitna project are estimated at 5.5¢/kWh in Anchorage and 6.7¢/kWh in Fairbanks. This represents a 17 percent and 25 percent savings over the anticipated 6.6¢/kWh and 8.9¢/kWh rates without Susitna power.

In summary, the supplemental feasibility studies undertaken during 1978 have confirmed the adequacy of the Watana site for construction of the proposed facilities. The project design has been refined in light of the newly acquired geologic and foundation information. The need for additional power in the railbelt area has been verified, and additional environmental resource information has been added to the data base. The review of project costs and benefits has indicated that the Susitna project is economically justified under a broad range of possible futures. Finally, Susitna power has been shown to be marketable and less costly than any viable alternative.

The direction taken in the conduct of these supplemental feasibility studies was largely dictated by the concerns regarding project justification expressed by the Office of Management and Budget. The remainder of the main report responds to the specific questions raised by OMB. The Alaska Power Administration of the Department of Energy and Battelle Pacific Northwest Laboratories both contributed significantly to the analysis and to the formulation of the responses. Supplementary data and analysis in support of the responses are contained in the appendix.

WATANA SITE GEOLOGY AND TEST BORINGS

OMB COMMENT

> The cost estimates for Watana have been derived without benefit of any test borings at the Watana site. This is a departure from standard Corps practice, which calls for exploratory drilling at all sites before projects are proposed for authorization. Test borings would provide more reliable data on which to base cost estimates and on which to assess any potential seismic problems. The Watana site is located near the Susitna Fault and also within 50 miles of the Denali Fault - an area where major earthquakes have occurred in the past.

SCOPE OF GEOLOGICAL INVESTIGATIONS

Field Reconnaissance

Geologic reconnaissance and mapping of the reservoir area and damsite were conducted concurrently with subsurface investigations throughout the spring and early summer of 1978. Within the damsite area the primary purpose was to locate, identify, and trace the surface expressions of discontinuities and shear zones to aid in directing the drilling program and to provide a preliminary geologic map of the site. Within the reservoir area, the primary thrust of the reconnaissance was to identify by reason of shape, structure, or overburden mantle the slopes that could develop slumps or slides as a result of permafrost degradation or seismic action.

Borings and Test Pits

During 1978, explorations were conducted in the dam foundation and relict channel area. Core borings in the valley walls and floor were used to explore the quality and structure of the foundation rock and to obtain representative samples for testing. Borings in the relict channel area were used to define depth of overburden, the extent of permafrost, and the location of the water table as well as to examine the nature and condition of the materials by drilling.

Also during 1978, numerous test pits were dug in potential borrow areas utilizing tractor-mounted backhoes. Bulk sack samples were retrieved from each test pit for later testing. Shallow auger holes were also used to determine the extent of deposits and to verify the existence of quantities necessary for embankment construction.

Seismic Refraction Surveys

A seismic refraction exploration program consisting of 22,500 lineal feet of seismic refraction lines was completed by Dames and Moore, Consultants, in 1975. In the fall of 1978, an additional seismic refraction survey was completed by Shannon and Wilson, Consultants, which included 47,665 feet of seismic refraction lines. The survey confirmed the Dames and Moore findings of a buried relict channel and, in general, supported conclusions relating to rock quality in the abutments as interpreted from the recent core borings and geologic reconnaissance. The Shannon and Wilson study also confirmed the existence of large quantities of borrow materials on Tsusena Creek.

The specific locations of the exploratory borings, test pits, and seismic refraction lines are shown on Plate 2.

FINDINGS AND DESIGN CHANGES

As a result of the additional field exploration and geologic studies in 1978, a more knowledgeable assessment of the proposed project can be made. Following is a summary of the items which reflect changes to the 1976 Interim Feasibility Report or reinforce its basic concepts.

Nothing was found during this phase of the study to cast doubt on the feasibility of a dam at the Watana site. All exploration and geologic studies reinforce the previous conclusion that a large earth and rockfill or concrete gravity dam could be built in this vicinity.

Explorations at the damsite indicate that the rock is as good or better than previously assumed. Foundation rock is considered adequate to support either an earth and rockfill or concrete gravity structure at this site.

The 1978 exploration program confirmed the existence of marginal permafrost in the area. Specific locations of permafrost were identified and a number of temperature measuring devices were installed. It was determined that this is a very "warm" permafrost, ranging in temperature from 0° C to -1° C. Permafrost was encountered in bedrock in the left abutment of the dam and its effects on the grouting in this area are discussed in the appendix. Permafrost was also encountered in the impervious borrow area; however, it is not considered to be a serious problem as it is quite warm and can be easily excavated.

The 1976 report envisioned rather large amounts of gravels available for construction of the shells of the dam and limited amounts of impervious core material. However, the recent explorations indicate that the reverse is true. Large quantities of gravel were not located, but large quantities of impervious core material were discovered near the damsite. Because of the apparent shortage of large quantities of gravel and the excess of impervious material, the dam section has been revised with gravel shells having been changed to rock shells. This change to rockfill has allowed the use of a steeper slope on the upstream face of the dam. A large portion of the rock will come from required excavation of the spillway and the remainder will come from excavation of underground facilities and access roads and from a large borrow source on the left abutment.

The core has been widened somewhat from that shown in the 1976 report and a zone of semipervious material, approximately of the same width as the core, has been added. This was done because of the large amounts of this material available and because our estimates show that it can be placed within the dam at a considerably lower cost than the rock shell material. The total thickness of these impervious or semipervious zones was determined by considering their effect on the total stability of the dam and the difficulties of placing materials which require careful moisture control in the arctic environment. Laboratory tests performed on these materials indicate that optimum moisture will be a critical factor in their compaction.

The foundation excavation has been increased in order to remove all gravels from beneath the embankment and strip the entire dam foundation to bedrock.

The 1976 report showed a vertical access shaft to the low-level drain system which passed through the embankment of the dam. This has been changed to a tunnel through the right abutment thereby eliminating any structures in the dam embankment.

A grout gallery has been added to the lower portions of the dam to facilitate grouting and to accommodate the process of thawing the permafrost rock for grouting.

The spillway shown in the 1976 report has been relocated to the southwest to insure rock cut for its entire length. The rock and overburden material from this large excavation will be utilized in the dam embankment. Also, the diverison tunnel portals have been shifted to insure their location in sound rock.

The 1976 report discusses a potential problem of seepage along a relict channel in the right abutment area. The 1978 exploration program verified the existence of this channel; however, studies indicate that it is not a problem and no remedial actions are necessary.

Ellis Krinitzsky of the Waterways Experiment Station and Ruben Kachadoorian and Henry J. Moore of the U.S. Geological Survey were contracted to perform seismic studies and evaluate the earthquake risk at these sites. Their work was divided into two phases: Kachadoorian and Moore performed the final reconnaissance of active faults and other geologic hazards, and Krinitzsky assessed the potential for earthquakes associated with such faulting. The resulting USGS report recognized that this is a highly seismic region; however, their reconnaissance of the proposed Devil Canyon and Watana damsites and reservoirs did not uncover evidence of recent or active faulting along any of the known or inferred faults. Their studies did not find any evidence of the Susitna Fault which was previously thought to exist a short distance west of the Watana damsite; therefore, they were not able to confirm the existence of such a fault. USGS also noted the areas where slides might be expected to occur along the valley walls under the influence of saturation and thawing permafrost. Krinitzsky's work assessed the possible occurrence of earthquakes at the damsites and the motions that are likely to be associated with earthquake activity. His findings indicate that the design of the proposed dams to withstand such motion is within the state of the art for seismic design.

CONTINGENCY ESTIMATES

OMB COMMENT

> A standard 20 percent contingency factor was used in arriving at cost estimates. A contingency of 30 percent could result in reducing the benefit-cost-ratio to 1. A larger contingency factor could reduce the ratio below unity. The recently completed Snettisham project in Alaska cost 36 percent more than original estimates, after correction for inflation.
>
> A review of the 20 percent contingency factor should be undertaken, in light of the best existing information on comparable projects and project locations.

Contingency factors have been reviewed and adjusted. The review included incorporation of the new 1978 foundation, material, and topographic information. Instead of utilizing a single contingency factor for the project as a whole, each major feature was examined individually to derive a contingency that reflects the uncertainties associated with the design and cost of that specific feature. The total estimated contingencies for the Watana project are approximately $246 million or 18 percent of the estimated total construction cost. Individual factors range from 15 percent for the relatively well defined earth and rockfill main dam to 20 percent for many of the other features.

The contingencies used for the Devil Canyon project were adjusted in two ways. First, a fundamental change in the design concept was made. To insure that the cost estimates in this supplemental feasibility study were sufficient to cover the possibility of unexpected foundation conditions at the Devil Canyon site, a concrete gravity dam design was analyzed. The concrete gravity structure requires less ideal foundation conditions than does the concrete thin arch structure recommended in the 1976 report. While the concrete arch design is still deemed engineeringly feasible on the basis of the available Devil Canyon geological explorations, the less sensitive and more costly concrete gravity structure has been used as the basis of the 1978 cost estimate. In this way, sufficient cost is included in the estimate to allow construction of either the concrete thin arch if favorable site conditions are found during preconstruction planning or the concrete gravity structure if less favorable conditions are found to exist. Thus, economic feasibility has been presented using the most conservative set of conditions.

In addition to the more conservative gravity design at Devil Canyon, normal contingency factors were also applied. The total contingencies for the Devil Canyon gravity dam estimate are about $121 million or 17 percent of total construction costs.

With the 1978 estimates of Susitna project benefits and costs, a 68 percent contingency factor would be required to have costs exceed benefits under the base case set of assumptions.

The Snettisham Hydroelectric Project that provides power to the Juneau area was mentioned by OMB as an example of cost overruns. The reported 36 percent cost increase over original estimates is not entirely correct since the 36 percent factor included additional construction not contemplated in the original cost estimate. The original estimate was for a project that included only the Long Lake phase of development with associated camp facilities and transmission system. The planned Crater Lake phase of development was added in fiscal year 1973, but construction has been deferred. The actual cost overrun as of 1978 is 22 percent. More than half of this 22 percent overrun from original cost estimates was accounted for by the temporary repairs and subsequent permanent relocation of a failed portion of the transmission line. Environmental considerations had dictated its original location in an area of extreme winds and ice conditions not previously encountered on any transmission line in North America.

AREA REDEVELOPMENT BENEFITS

OMB COMMENT

> These benefits are a correction for the use of otherwise unemployed labor during construction. Though standard procedures permit this benefit category for power projects, it would seem that such benefits should not be accepted in the Susitna report because private development for power purposes would produce equivalent benefits.
>
> An evaluation of the validity of the use of ARA benefits in the Susitna report should be made.

Project costs are considered to be an adverse effect on the national economy because resources required for construction would normally be diverted from other uses. The value of resources in their alternative uses is therefore the true economic cost of the project. If some resources used in the proposed plan would otherwise be unemployed, these resources would not be diverted from production of other goods and services and, hence, are not an economic cost to the national economy. Procedurally, the credit for using unemployed labor is conventionally tabulated as an addition to benefits rather than a deduction from costs.

The basis for determination of employment benefits as with benefits associated with all other project purposes, is a comparison of conditions <u>with</u> and <u>without</u> a plan to provide the planning objective. The <u>with</u> condition is the plan under consideration, namely the provision of additional power. The <u>without</u> condition is without provision of additional power. The relevant without condition for purposes of benefit evaluation is not an alternative solution to the planning objective even though in the absence of the recommended project, an alternative will be provided. Therefore, the entire applicable employment benefit is credited to each project considered in the plan formulation process. If, alternatively, wage payments of otherwise unemployed labor is credited as a savings in economic costs, it is even more apparent that such wage payments would be fully deductible from costs of any and all projects constructed.

CONSTRUCTION SCHEDULE

OMB COMMENT

> The 11-year construction schedule for the Watana project, based on preliminary inspection of comparable projects, appears to be on the short side. A longer schedule of 14 years appears more reasonable because of (1) normal slippages and (2) a 3-year peak construction schedule that calls for more work to be put in place on a single site than the Corps has ever accomplished in similar time periods. This should be reexamined and its effects on the project B/C ratio calculated.

GENERAL

The construction schedule has been reanalyzed and lengthened from 10 to 14 years. The Watana dam and powerplant will take 10 years to construct, an increase of 4 years over the previous schedule. The Devil Canyon project construction will require 8 years rather than the previously estimated 5 years. There will be 4 years of concurrent construction to meet power-on-line dates.

DIVERSION PLANS

The time for Watana diversion works construction and stream diversion has been extended to 3 years from the previously estimated 2 years, because the construction access to the tunnel portals requires extensive rock cuts and added time. The start of construction of the diversion works for the Devil Canyon dam has been delayed from the 5th to the 7th year of Watana construction because it is dependent on stream regulation by the upstream Watana dam.

MAIN DAMS

Foundation preparation at Watana would be delayed to the 4th year as a result of the extended diversion requirements which would delay the start of cofferdam construction. Watana embankment construction, scheduled to begin in the 5th year and continue into the 10th, would require 6 years instead of the previously estimated 3 years, based on construction seasons of 5 months with average daily placement rates of 80,000 cubic yards. Water impoundment would start in the 8th year with power-on-line in October of the 10th year. The reservoir filling would continue beyond the power-on-line date and would depend on the rates of inflow and power generation.

Foundation preparation for Devil Canyon dam would start in the 9th year, a 2 year delay from the earlier estimate. Concrete placement and dam completion would begin in the 10th year and require 5 years, an increase of 2 years over the earlier schedule. Impoundment would commence in the 13th year and end with a full reservoir in October of the 14th year.

EFFECT OF DELAY

The presently scheduled power-on-line dates are 1994 for Watana and 1998 for Devil Canyon. These were previously scheduled for 1986 and 1990 respectively. These dates include the result of the changes in assumed congressional construction authorization from July 1980 to October 1984 and the revised construction schedule. Transmission line construction could be completed in 1991, permitting connection of the Anchorage and Fairbanks load centers in advance of Watana power-on-line. The economic evaluation is based on this longer 14-year construction schedule and the delayed power-on-line dates.

Even with the longer 14-year construction period, additional construction delays are possible. The impacts, however, would be minimized by the recommended two-stage construction sequence. If significant delays were experienced on Watana, the start and schedule of Devil Canyon construction could be adjusted with minimal cost impact. Delays in Devil Canyon construction would have no effect on Watana's schedule.

The project's economic justification has been analyzed to assess the impact of construction delays that would extend the power-on-line dates. As an example, a 2-year delay in Watana completion was evaluated. The primary effect on project cost would be the accumulation of additional interest during construction. The 2-year delay increases average annual costs by about $17 million.

The delay of Watana power-on-line would also affect project benefits, although the change would be small. The impact on benefits is due to the mix and schedule of thermal plants coming on line prior to Watana and to the rate of load growth during the years after power-on-line. For a 2-year delay, equivalent average annual power benefits would be reduced about $4 million.

The net change in project economics would be an increase in total annual costs to $245 million and a reduction in annual benefits to $320 million. This decreases the benefit-cost ratio from 1.42 to 1.31.

Analysis shows that the construction period would have to be prolonged at least an extra 9 years before the Susitna project would become uneconomic.

SUPPLY ESTIMATES

OMB COMMENT

The analysis of the without project condition needs to be expanded considerably to clearly analyze the following:

a. Why, with natural gas projected to be in such short supply, the Anchorage utilities have only contracted for 55 percent of proved reserves or 25 percent of estimated ultimate reserves.

b. The sensitivity of the analysis to the collapse of OPEC and the cost of shipping oil to the east coast.

c. The necessity for an Anchorage-Fairbanks intertie at a cost of $200-300 million.

d. Scheduling of powerplants and the reduced risk of building small increments.

INTRODUCTION

The first two items must be considered in terms of national energy policy. The United States needs to reduce dependency on oil imports on both a short-term and a long-term basis and to accomplish a major shift away from oil and natural gas to alternative energy sources. The reasons for this include national economic considerations, as well as very real limits on national and world supplies of oil and natural gas.

In terms of national energy policy, oil and natural gas are not available alternatives for long-term production of electric power. There are remaining questions as to how quickly existing uses will be phased out and on how complete the prohibitions will be on new oil and natural gas-fired powerplants.

There is general agreement that implementation of national policy must include strong efforts in conservation, substantial increase in use of coal, and major efforts to develop renewable energy sources. Each of these components is sensitive to energy price and supply variables. A reduction in world oil prices or a period of oversupply serves as a marketplace disincentive for conservation efforts and work on alternative energy sources.

The lowest cost alternatives and those with fully proven technology are the least sensitive; those that depend on further research and development are most easily sidetracked.

The Susitna project involves large blocks of power and new energy from a renewable source, fully proven technology, long revenue-producing period (in excess of 100 years), and essential freedom from long-term price increases. Its power costs appear attractive in comparison to coal-fired powerplants. It is a two-stage project with opportunity to defer the second stage if demands are lower than present estimates or if price relationships change.

The above factors suggest that the Susitna project is much less sensitive to short-term oil price and supply variations than most other U.S. energy options.

If it is assumed that Alaskan oil and natural gas will be isolated from U.S. and world demand and pricing, Alaska would probably continue to use its oil and gas for most of its power. This assumption did, in fact, prevail between the initial oil and gas discoveries in the

Cook Inlet area and the 1973 oil embargo. In 1960, the Anchorage-Cook Inlet power supplies came almost entirely from coal and hydro. The low cost, abundant gas brought a halt to hydro development and destroyed the area's coal industry. The one remaining Alaskan coal mine barely survived the 1960's because of competition from relatively cheap oil.

Cook Inlet gas has been subjected to increasing competition in the last few years, including proposals for LNG facilities, additional petrochemical plants, and consideration of pipeline alternatives to tie in with the Alcan pipeline project. The competition resulted in increasing prices and increasing difficulty in obtaining long-term commitments of gas for power. The competitions and the price increases are expected to continue.

The real question on gas availability as it pertains to the Susitna project is: what is the outlook for long-term gas supplies for power after 1990? The answer is that the outlook is not good in terms of competing uses and national policy.

NATURAL GAS AVAILABILITY

The primary reason for not considering natural gas-fired generation as the alternative to Susitna hydropower development is not gas availability, but national energy policy. The Powerplant and Industrial Fuel Use Bill of the National Energy Act of 1978 clearly indicates that the intent of the Administration and Congress is to strongly discourage the use of natural gas for electrical generation. The law contains a prohibition against the use of natural gas as a primary fuel in any newly constructed utility generation facility. Permanent exemptions from this prohibition for a new base load powerplant may be obtained under certain circumstances. The Department of Energy's draft implementing regulations permit exemptions if utilities can prove it would be overly costly, environmentally unsound, or impossible because of insufficient or unavailable supplies of coal or other fuels at the plant's location. None of these exemptions appear applicable to Alaska. The Federal Energy Regulatory Commission, in not providing gas-fired generation costs, agrees with that assessment.

While national energy policy is reason enough to discount natural gas-fired generation as a long-term alternative to a major hydropower project, data on the local supplies of natural gas was presented in the 1976 report as additional evidence. That data has been updated using 1978 information.

There are an estimated 4,428 billion cubic feet (BCF) of recoverable gas reserves in Cook Inlet, with an additional speculative potential of from 6 to 29 trillion cubic feet. Approximately 3,698 BCF, or 84 percent of the estimated recoverable reserves are presently committed to Alaskan and export uses. The proportion of committments would even be higher but for an unwillingness on the part of natural gas owners to enter into contracts for the provision of gas during a period of rapidly escalating gas prices and great uncertainty regarding gas price deregulation. Additional committments are anticipated as the pricing structure stabilizes.

In 1976, 34 percent of Alaska's total energy consumption was provided by Cook Inlet natural gas. Several forecasts of gas demand have been completed, and estimated proven Cook Inlet gas reserves are inadequate to meet the requirements in all forecasted cases. The deficit through the year 2000 varies from a low of 783 BCF to a high of 3,804 BCF, depending on the forecasted use. The use of Cook Inlet gas for new gas-fired electrical generation after 1985 would increase the year 2000 deficit by about 532 BCF.

OIL PRICE CHANGE IMPACTS

The economic justification for the Susitna hydropower project is sensitive to changes in the price of oil only if oil-fired generation is considered a realistic long-term alternative for electrical generation in the railbelt area. However, the use of oil in benefit determination for 100 years of power for a major new hydro project does not seem appropriate in light of national energy policy in general and the National Energy Act of 1978 in particular. As in the case of natural gas, the use of oil in newly constructed generation facilities is prohibited with limited exception. The exemptions contained in the legislation do not appear pertinent in the face of the large supplies of coal and hydropower potential available to the railbelt area.

Despite the strong arguments against new oil-fired generation in the mid-1990's and beyond, project justification was examined using an oil-fired powerplant as the basis of benefit calculation. Oil-fired costs provided by FERC were used in the analysis, and the midrange load forecast was assumed. With stable prices, the project's annual power benefits fall $78 million from the $289 million calculated on the basis of the coal-fired alternative. Net benefits become $18 million, giving a benefit-cost ratio of 1.08.

To calculate the impact of relative changes in the price of oil on project feasibility, three sample cases were analyzed. First, there is an assumption that fuel costs esclate at 2 percent per year between 1978 and the 30th year beyond power-on-line, after which there is no additional escalation. The 30-year period corresponds to the service life of the initial thermal plant. The 2 percent rate is selected as representative of long-term real price increases arising from depleting more distant sources, increasing environmental safeguards in extraction, processing and handling, and anticipated producing nation pricing policy. Two percent annual escalation in the price of oil results in a 57 percent increase in annual power benefits over that with stable prices; the benefit-cost ratio becomes 1.60.

The second case looks at the possibility of no price escalation prior to power-on-line followed by a 30-year period of 2 percent annual escalation. This case is designed to reflect the possibility of a near-term softening of the market for oil due to slackening demand or increased supply in the short-term. With stable prices in the near term followed by a 30-year period of escalation, annual power benefits increase 22 percent over the stable price case, giving a benefit-cost ratio of 1.29.

The final case explores the impact of real oil price declines prior to power-on-line. An immediate sharp drop in price is assumed, with no change in price thereafter. This scenario is included to show the possible effect on project justification of a breakup of the OPEC cartel. The immediate decline in oil prices followed by stable prices results in costs exceeding benefits and a benefit-cost ratio of 0.85.

To summarize, oil-fired generation is not an appropraite long-term alternative to Susitna hydropower. If, nonetheless, oil-fired costs are used in benefit calculation, the project remains economically justified except in the extreme case of an immediate and precipitous drop in the price of oil.

OMB suggested that the issue of shipping costs be explored. The FERC fuel cost estimate that was used in the benefit calculation is net of transportation costs between Alaska and continental U.S. ports. The fuel costs used are the estimated cost of processed Alaskan oil at the power-plant. No additional consideration of shipping costs to the East Coast is deemed necessary.

ANCHORAGE-FAIRBANKS INTERTIE

The estimated construction cost (1978 dollars) for the transmission lines associated with the Susitna project is $338 million. The portion from the Susitna project to Fairbanks accounts for $152 million of the total.

There are several previous studies that demonstrate inherent feasibility of an Anchorage-Fairbanks intertie with or without construction of the Susitna project. The main reason that the intertie is not now in place is that short-term benefits to the Anchorage area are quite small; most of the short-term benefits for the intertie would occur through reduced energy and power costs in the Fairbanks area.

The Alaska Power Administration, in the 1976 Interim Feasibility Report, evaluated the provision of Susitna project power to Fairbanks on a cost-of-service basis (see Appendix I, p. 6-89 of the 1976 report). This was a specific demonstration of feasibility of including Fairbanks as part of the upper Susitna power market area.

Further verification of feasibility of the intertie is provided in the new load-resource analyses and system cost analyses prepared for the current studies. These general cases were analyzed:

Case 1. All future generating capacity assumed to be coal-fired steam turbines without intertie.

Case 2. All future generating capacity assumed to be coal-fired steam turbines with intertie.

Case 3. Future generating capacity to include the Susitna project plus coal-fired steam plants as needed. This includes the intertie.

The following table presents the costs of power in the year 2000 for each of the three cases. As shown, the costs of power are less with the intertie. The reduction in the cost of power is typically greater in the Fairbanks-Tanana Valley area than in the Anchorage-Cook Inlet area because the Anchorage-Cook Inlet area will have a higher percent of its generation supplied by steamplants which are more costly than Susitna.

COMPARISON OF POWER COSTS FOR YEAR 2000
(¢/kWh - 0% inflation)

	Anchorage			Fairbanks		
	High	Medium	Low	High	Medium	Low
Case 1	6.2	6.6	7.1	8.8	8.9	9.2
Case 2	6.1	6.2	6.2	8.0	8.4	8.8
Case 3	5.8	5.5	6.1	6.2	6.7	7.8

Following are the percent savings in total system costs between 1990 and 2011 for Cases 2 and 3 compared to Case 1, under the midrange load forecast.

	Anchorage	Fairbanks	Total
Case 2	-0.4	-7.9	-1.4
Case 3	-10.7	-28.1	-14.1

POWERPLANT SCHEDULING AND RISK REDUCTION

The risks associated with the overbuilding of powerplants is generally reduced by building small incremental additions to a system. In other words, as closely as possible, load growth should be matched as it occurs. The validity of this generalization increases as the degree of confidence or certainty in load growth forecasts decreases. This risk minimization is accompanied by an increase in economic costs, however, since economies of scale are a significant factor in powerplant costing.

The evaluation for the Susitna project recognized this risk factor in that a range of area load growth possibilities and assumptions required for their realization was developed. Those assumptions considered most likely were reviewed to form a most probable future condition. Therefore, the load forecast used represented a high degree of confidence by the cross section of disciplines and agencies who developed it. The evaluation further recognized the principle of load growth matching when determining the most likely alternative thermal plant in the absence of Susitna hydropower. Alternative thermal plants were phased in to match the portion of load demand provided from Susitna. For the initial years this means that only annual increases due to new load were evaluated.

As a further confirmation, an analysis of hydropower alternatives indicates that economical sites are not available in sufficient quantity to be comparable to Susitna. Small individual sites might be available, but they would satisfy only a small portion of the market area demand. Other sites with apparently acceptable power and economic capability have been or will be precluded by land status designation. This finding was supported by Alaska Power Administration's 1978 draft report on Analysis of Potential Alternative Hydroelectric Sites to Serve Railbelt Area and by the Corps of Engineers' Review of South-central Alaska Hydropower Potential completed in January 1979.

DEMAND ESTIMATES

OMB COMMENT

The analysis of load growth should be more specific with respect to:

a. Increasing use by consumers; and,

b. Increasing number of consumers.

c. Industrial growth, i.e., where does Alaska's comparative advantage lie outside the area of raw materials and government functions?

FORECAST METHODOLOGY

In order to explore the causative factors of load growth in greater detail, the method of forecasting has been changed in certain respects from that which was used in the 1976 Interim Feasibility Report. The Alaska Power Administration (APA) has used a simplified end-use model to forecast future power requirements, augmented by trend analysis and an econometric model. Total power demand has been categorized into three primary end uses: the residential/commercial/industrial loads supplied by electric utilities, the national defense installation sector, and the self-supplied industrial component.

Those factors in each category that best explain historical trends in energy use were identified. In the utility sector, those explanatory variables are population and per capita use. Population was forecasted with the help of a committee of experts using a regional econometric model, while per capita use estimates are an extrapolation of past trends adjusted to account for anticipated departures from those trends. National defense needs are assumed to depend on the level of military activity and the number of military personnel in the study area. Future self-supplied industrial power requirements are based on explicit assumptions regarding future economic development and the energy needs associated with such development.

POPULATION AND ECONOMIC ACTIVITY FORECAST

The most important sector in terms of magnitude of electrical energy use is the utility sector, and population is the key factor in this sector's future power requirements. Population forecasts in turn, are highly dependent upon assumptions of future economic activity. Economic activity assumptions are also important because they have a direct impact on energy requirements in the self-supplied industrial sector.

The population and economic activity assumptions used in this forecast are based on a draft report of the Economics Task Force, Southcentral Alaska Water Resources Study, dated September 18, 1978. The report is entitled, "Southcentral Alaska's Economy and Population, 1965-2025: A Base Study and Projection."

The report was a joint effort of economists, planners, and agency experts who were members of the Economics Task Force of the Southcentral Alaska Water Resources Study (Level B). It is being conducted by the Alaska Water Study Committee, a joint committee of Federal and State agencies, the Alaska Federation of Natives, the Alaska Municipal League, the Municipality of Anchorage, the Southcentral region borough governments, and regional Native corporations.

The projections reported relied on two long-run econometric models devised by economists from the University of Alaska Institute of Social and Economic Research (ISER) and from the MIT-Harvard Joint Center for Urban Studies with funding by the National Science Foundation's Man in the Arctic Program (MAP). The two specific models used here were modifications of the Alaska State and regional models developed under that program. The models produced estimates of gross output, employment, income, and population for the years 1975-2000. Population and employment were disaggregated and extrapolated to the year 2025 by ISER researchers under Economics Task Force direction, and using Task Force concensus methodology. The data required to run the model were provided by various members of the Economics Task Force. Assumptions were reviewed by the Task Force, and the model outputs and tentative projections were reviewed for internal consistency and plausibility by ISER researchers and by the Task Force.

The use of the econometric model requires a set of assumptions related to the level and timing of development. The assumptions primarily consist of time series on employment and output in certain of the export-base industries and in government.

FORECAST RESULTS

The Level B population forecast for the Anchorage-Cook Inlet subregion was adopted by APA for estimating power requirements without any modification. APA applied projected statewide growth rates to the Fairbanks-Tanana Valley area to develop population forecasts for that region. Actual population growth will likely fall within the limits established by the high and low forecasts.

UTILITY SECTOR

The midrange net generation forecast from 1977 to 1980 was based on the average annual growth rate between 1973 and 1977. This rate was adjusted upward and downward by 20 percent to establish the 1980 high and low forecasts respectively. Beyond 1980, the high and low case net generation is estimated by multiplying forecasted population by projected per capita use. Between 1973 and 1977, per capita use of electricity grew at an annual rate of 3.8 percent in Anchorage and 9.4 percent in Fairbanks. The lower Anchorage growth rate was adopted as the basis of the per capita use trend. Increasing electrification is assumed to be partly offset by increasing effectiveness of conservation programs, resulting in a gradually slower rate of growth in per capita use.

As a check on the validity of the per capita use projections, a comparison was made with two regions of the Pacific Northwest. The regions were selected for comparison on the basis of their similarity in population and commercial/industrial characteristics to the railbelt area. The Pacific Northwest regions' present per capita use rates of electrical power are significantly higher than those of the railbelt area. In fact, the current rates in the Pacific Northwest are comparable to those that are projected for the railbelt area in 1990. Without doubt, Alaska exhibits a considerable potential for increased electrification.

With the high and low population forecasts and with high, mid, and low per capita use assumptions, six different net generation forecasts were calculated. From these, the high population-high energy use and the low population-low energy use combinations were used for the high and low range net generation forecasts. The midrange utility sector forecast came from averaging the high population-low energy use and the low population-high energy use forecasts.

Peak load forecasts were calculated from projected net generation using a 50 percent load factor. For the low range forecast, utility sector peak load requirements are expected to increase from 667 megawatts (MW) in 1980 to 1,617 MW in the year 2000. Fifty-one percent of that increase is due simply to population growth, while the remainder of the increase is a result of increased per capita use. The comparable increase in forecasted peak load requirements between 1980 and 2000 for the high range forecast is 3,087 MW. In this case, population growth accounts for 43 percent of the increase, with the remainder accounted for by changes in per capita use.

NATIONAL DEFENSE SECTOR

The forecast for this relatively minor sector is based on historical data from Army and Air Force installations in the railbelt area. Zero growth is assumed for the midrange forecast. For the high range, growth at 1 percent per year is assumed, while the low range forecast is based on a decline of 1 percent annually.

SELF-SUPPLIED INDUSTRIES SECTOR

This category of load is comprised of those existing industries that generate their own power, along with all similar type facilities expected to be constructed in the future. It is likely that such industries would purchase power and energy if available at reasonable cost. The specific assumptions for this sector are based on Battelle's March 1978 report entitled Alaskan Electric Power, An Analysis of Future Requirements and Supply Alternatives for the Railbelt Region.

The high range development forecast includes enlargement of existing facilities as well as new industry. The new developments include an LNG plant, refinery, coal gasification plant, mining and mineral processing plants, timber industry, capital city, and some large energy intensive industry. This set of assumptions coincides with the Level B Study Task Force high case development assumptions with two exceptions. Coal gasification and an energy intensive industry were included by APA because informed judgement indicates their definite potential. Their impact on population and economic activity is relatively minor but their effect on peak load requirements could be substantial. Therefore, they have both been included in the development assumptions for the high range forecast.

The midrange forecast is the same as the high range except that the large energy intensive industry (aluminium smelter) is excluded. The low range further excludes the new capital city. There is also some reduction of peak load requirements of the mid and low range cases.

Alaska is not a heavily industrialized state nor is it expected to be. The oil and gas industry is presently the dominating sector of the State's GNP and will continue to be so for at least the balance of the 20th century. This is the principle source of revenues for the State and thus the driving force behind state programs for education, local government assistance, welfare, and so on. Other important industries are fisheries, forest products, and recreation-tourism.

The low and mid-range population estimates incorporate very modest assumptions of industrial expansion based on pioneering of Alaskan natural resources for the most part; the specific industrial assumptions reflect proven sources of natural resources and projects that are well along in the planning stages.

Extraction and processing of natural resources will undoubtedly continue to be major aspects of the Alaska economy. Other important aspects include business activities of Native Corporations and increasing amount of land made available to State and private ownership. Actions pending on the new National Parks, Refuges, and Wild and Scenic Rivers will encourage further development of the recreation and tourism industries.

As in most parts of the country, Alaska employment is not dominated by the industrial sectors. Most jobs are in service industries, commercial establishments, transportation, utilities, and government. The new population estimate by ISER indicates that the distribution of employment will not change appreciably. The anticipated growth in the economy, employment, and in power demands is primarily in the non-industrial sectors.

It should be noted that the railbelt area demands for electric energy in 1977 were 2.7 billion kilowatt-hours, which is approaching the firm energy capability of the Watana project. The load resource analyses demonstrate full utilization of Watana energy essentially as soon as it becomes available, even under the lower power demand case. This basically leads to a finding that the upper Susitna justification is not dependent on major industrial expansion in Alaska.

SENSITIVITY ANALYSIS

OMB COMMENT

> Power demand should be subjected to a sensitivity analysis to better assess the uncertainties in development of such a large block of power. The typical utility invests on the basis of an 8-10 year time horizon. The Susitna plan has an 11-16 year horizon in face of risks that loads may not develop and the option of wheeling power to other markets is not available. It should be noted that the power demand for Snettisham was unduly optimistic when it was built. This resulted in delays in installing generators. A similar error in a project the size of Susitna would be much more costly and would have a major adverse effect on the project's economics.

INTRODUCTION

The new power demand estimates and load/resource, economic, and financial analyses presented in this report all provide a better basis for examining these questions. In addition, there is need to review some of the Snettisham project history to bring out similarities and differences with the upper Susitna case.

SNETTISHAM REVIEW

The Snettisham Hydroelectric Project is located near Juneau, Alaska and is now the main source of power for the greater Juneau area. The project was authorized in 1962 on the basis of feasibility investigations by the Bureau of Reclamation, constructed by the Corps of Engineers, and operated by the Alaska Power Administration.

The project was conceived as a two-stage development and construction of the first, or Long Lake, stage was completed in late 1973 with first commercial power to Juneau in December 1973. The second, or Crater Lake, stage was to be added when power demands dictated.

Juneau remains an isolated power market area. Difficult terrain and long distance have thus far prevented electrical interconnection with other southeast Alaska communities and neighboring areas of Canada; however, such interconnections may prove feasible within the next 15 to 20 years. The project planning and justification was premised on service only to the greater Juneau area.

The Snettisham authorization was based on power demand estimates done in 1961 by the Alaska District, Bureau of Reclamation (now Alaska Power Administration). The estimates were based on actual power use through 1960 and projections to the year 1987. The outlook at that time was that the first stage construction would be completed in 1966 and that total project capability would not be needed until 1987. The actual 1977 energy load was 112,197 megawatt-hours or 81 percent of the 1977 estimate forecasted in 1961 on the basis of historical records through 1960.

The inherent flexibility of a staged project proved to be very beneficial in the case of Snettisham. APA made periodic updates of the power demand estimates during construction of the Long Lake stage. For several years, these forecasts indicated a need to proceed with the Crater Lake stage construction immediately on completion of the Long Lake stage. The Corps of Engineers construction schedules and budget requests, based on the APA power demand estimates, anticipated start of construction on Crater Lake in FY 77. Major factors in these forecasts were plans for a new pulp mill in the Juneau area and for an iron ore mining and reduction facility in the vicinity of Port Snettisham. Neither of these developments were anticipated at the time of authorization. Both of these resource developments failed to materialize, and this resulted in a substantial reduction in the APA power demand estimate and a decision in late 1975 to defer the Crater Lake construction start.

Many other factors influenced Juneau area power demands and utilization of project power. Of particular concern at the moment is impact of Alaska's capital move initiative. This would certainly change use of project power, with the most likely outcome that the community would move more quickly into an all-electric mode (space heating and electric vehicles appear particularly attractive in this area), and industrial use of power would increase through economic diversification.

The key points of the Snettisham review are:

1. The project was planned and authorized with intent to handle growth in area power requirements for a 20-year period.

2. The load forecasts used as a basis for authorization were reasonably accurate.

3. The actual use of project power may turn out to be substantially different than originally anticipated.

4. The flexibility of staged projects was used to great advantage.

5. The outlook for financial viability appears excellent at this time.

IMPLICATIONS FOR SUSITNA

First, the typical planning horizon for utility investments is in excess of 8 to 10 years. This is evidenced by experiences dating from about 1970 on the time required to plan, obtain necessary permits or authorizations, find financing, and then build new powerplants and major transmission facilities. The 8 to 10 years is specifically much too short for nuclear, coal, or hydro plants or for major transmission lines.

A 20-year planning horizon is more appropriate with careful checks at each step in the process and business-like decisions to shift construction schedules if conditions (demands) change. The Snettisham experience is very positive in this light.

The Susitna project is similar in that project investment is keyed to three major stages of development: transmission interconnection, Watana, and then Devil Canyon. The commitment of construction funds for Watana would be needed in 1984 to have power-on-line by 1994. If conditions in 1984 indicate the need to defer the project, it should be deferred. Similarly, start of actual construction on Devil Canyon can and should be based on conditions that actually prevail at the time the decision is made.

The degree of uncertainty for upper Susitna is greater in one respect than was the case for Snettisham because of higher interest costs and larger total investment. At the same time, sensitivity to change in demands is much less for Susitna because of its large and diversified power market area. There are many more ways that Susitna project power could be effectively utilized in the event that traditional utility power markets are smaller than anticipated at the present. The whole field of oil and gas fuel displacement could be explored with emphasis on electric heat for office buildings, electric vehicles, and electrification of oil and gas pipeline pump and compressor stations.

Further, the Susitna project does not have as many uncertainities in terms of environmental questions as would equivalent power supplies from coal or nuclear plants. Uncertainties regarding air quality are particularly relevant for any large Alaskan coal-fired powerplants.

CURRENT EVALUATION

Power demands were estimated for high, medium, and low cases to year 2025 assuming logical variations in population and energy use per capita. The projections reflect per capita energy use based on detailed studies of 1970-1977 data from both the Anchorage and Fairbanks areas. The projections considered variations in per capita use ranging from increased use of electricity in the home to anticipated effects of conservation.

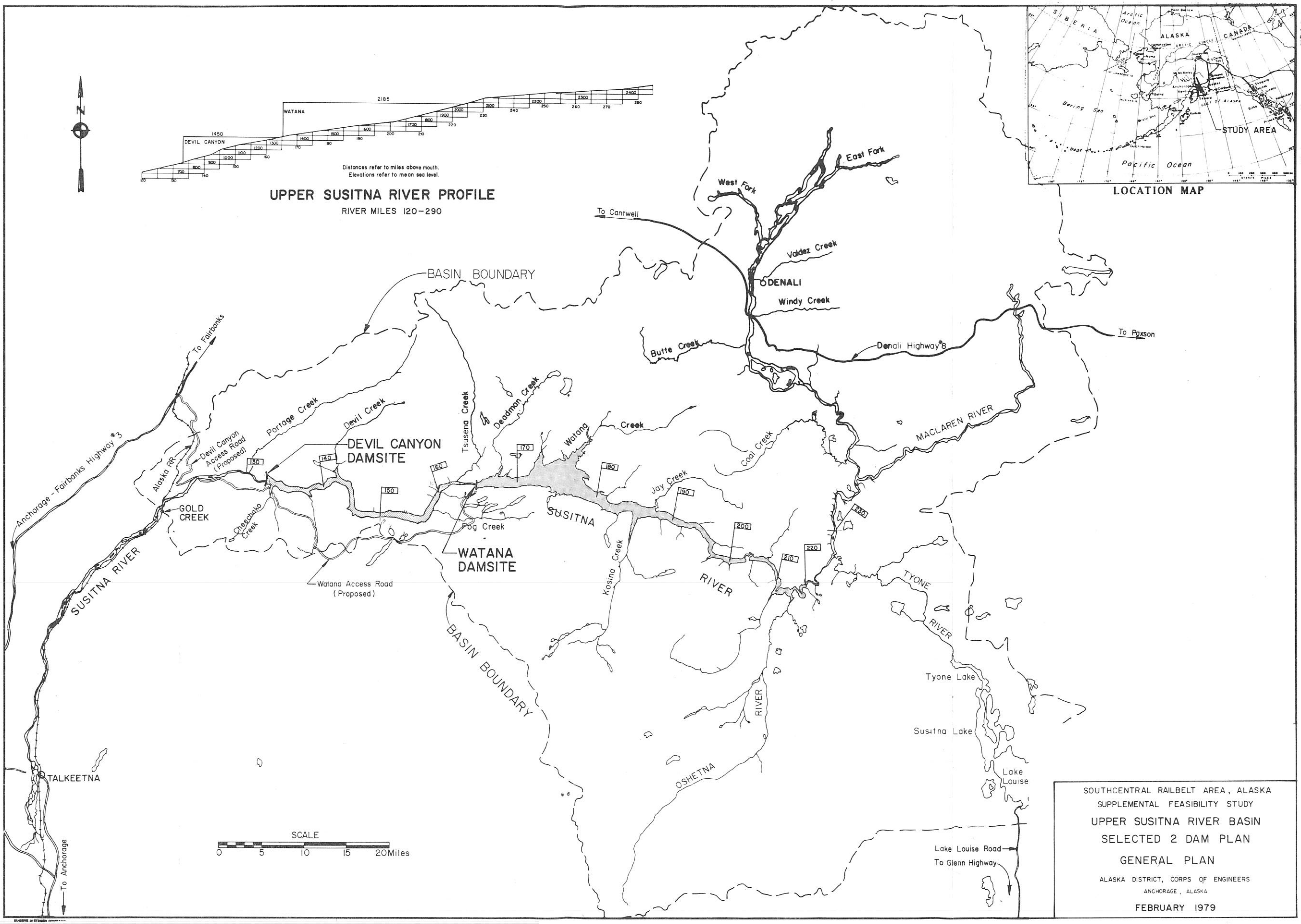
The project's economic justification was tested to determine, among other things, its degree of sensitivity to variations in load growth. The circumstance potentially most damaging to the economic viability of the project entails a sudden decrease in the rate of load growth immediately after the project is completed. The analysis indicated that the annual rate of load growth would have to fall to 0.8 percent before project costs exceed benefits. This rate should be compared to the annual growth rates of 12.7 percent in Anchorage and 10.5 percent in Fairbanks between 1973 and 1977 and to the low range forecast for the post-1994 period of 4.2 percent.

The load/resource and cost analysis provided system costs for comparison of cases both with and without the Susitna project. The analysis also compared the power demands to the resources required to determine sizes and timing of new plants. Even under the most conservative load growth condition, 1,500 MW is needed to meet the continued Anchorage-Fairbanks demands during the 1990's; this is roughly the capability of the Susitna project.

Cost of system power estimates indicate that, in the medium case for the year 2000, Anchorage costs are 5.5¢/kWh or 17 percent less than without Susitna. For Fairbanks the difference is much larger, 6.7¢/kWh or 25 percent less than without Susitna.

Examination of the system cost on an annual basis reveals the case "with" Susitna is cheaper than the "without" Susitna case for each year except the first few years after Watana comes on line.

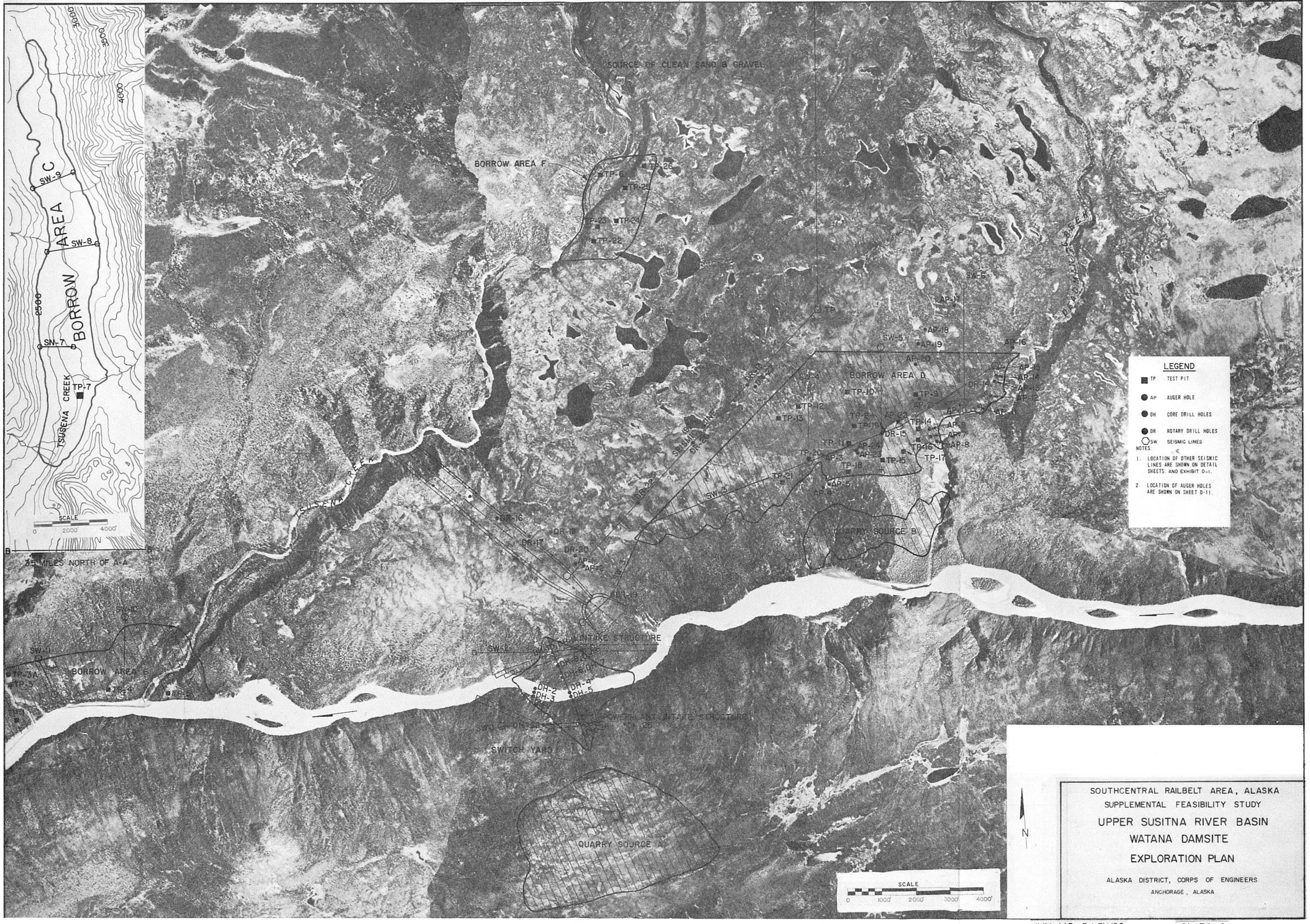
It should be noted that in the low energy use case the total system cost for the railbelt area during the period from 1990 to 2011 amounts to $1.1 million less with Susitna than without the project. The difference is even larger in the medium and high cases. The combined Anchorage-Fairbanks cash savings for the same period based on the medium power use estimate is over $2 billion.



SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
SELECTED 2 DAM PLAN
GENERAL PLAN
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

PLATE 1

1032-79



SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

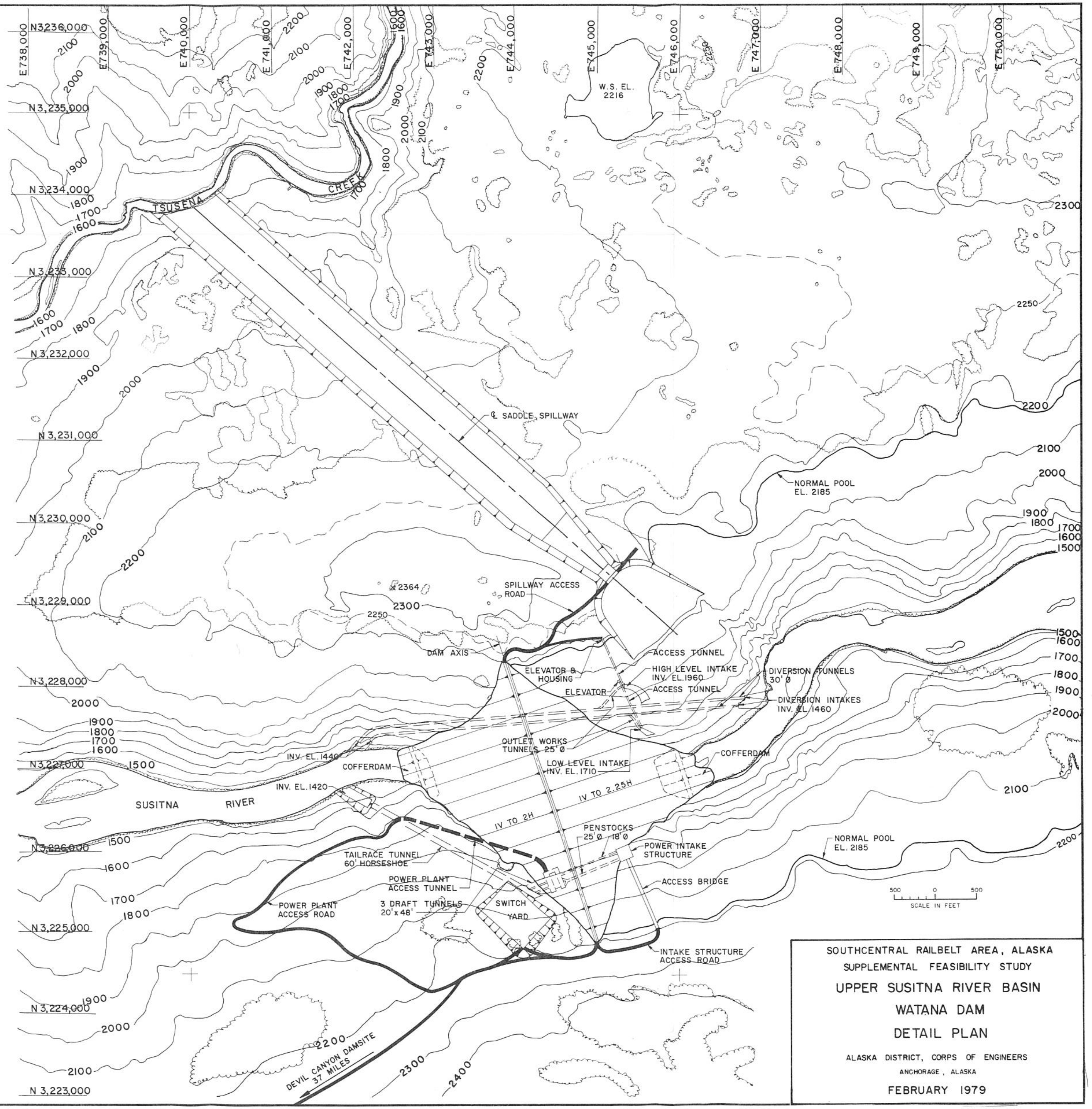
UPPER SUSITNA RIVER BASIN
WATANA DAMSITE
EXPLORATION PLAN

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

INV. NO. DACW85- PLATE 2

NOTES:

1. TOPOGRAPHIC CONTOURS ARE BASED ON AERIAL PHOTOGRAPHY DATED 10 JUNE 1978. VERTICAL DATUM IS MEAN SEA LEVEL (MSL)



SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

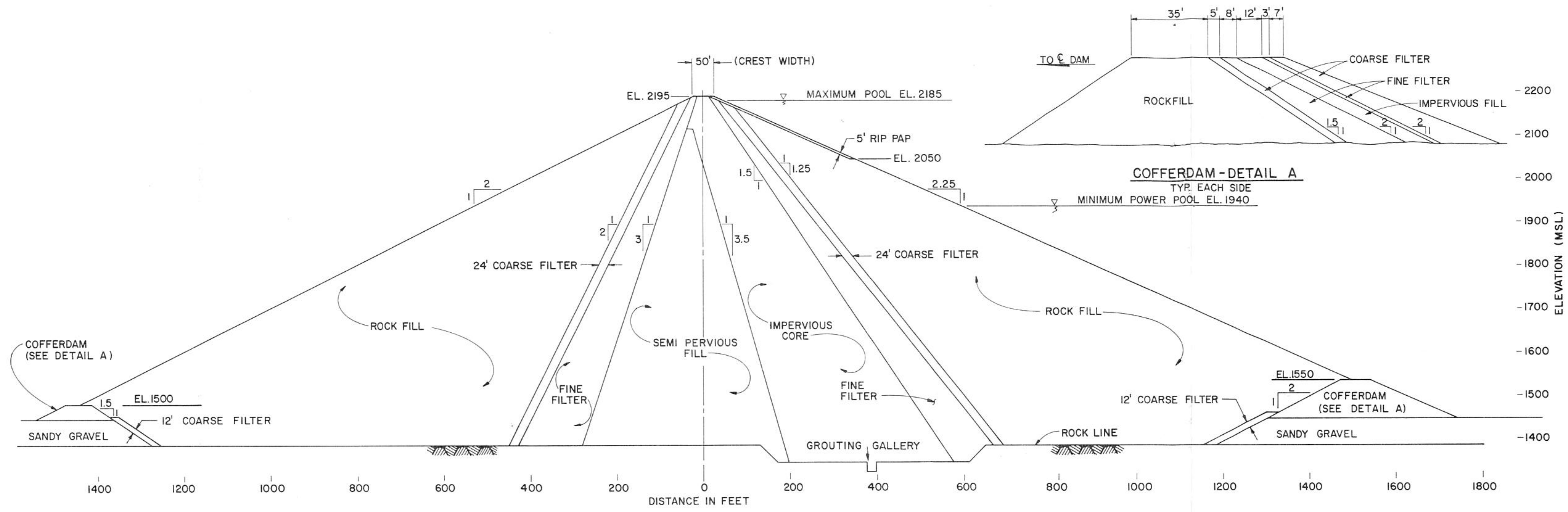
UPPER SUSITNA RIVER BASIN
WATANA DAM
DETAIL PLAN

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

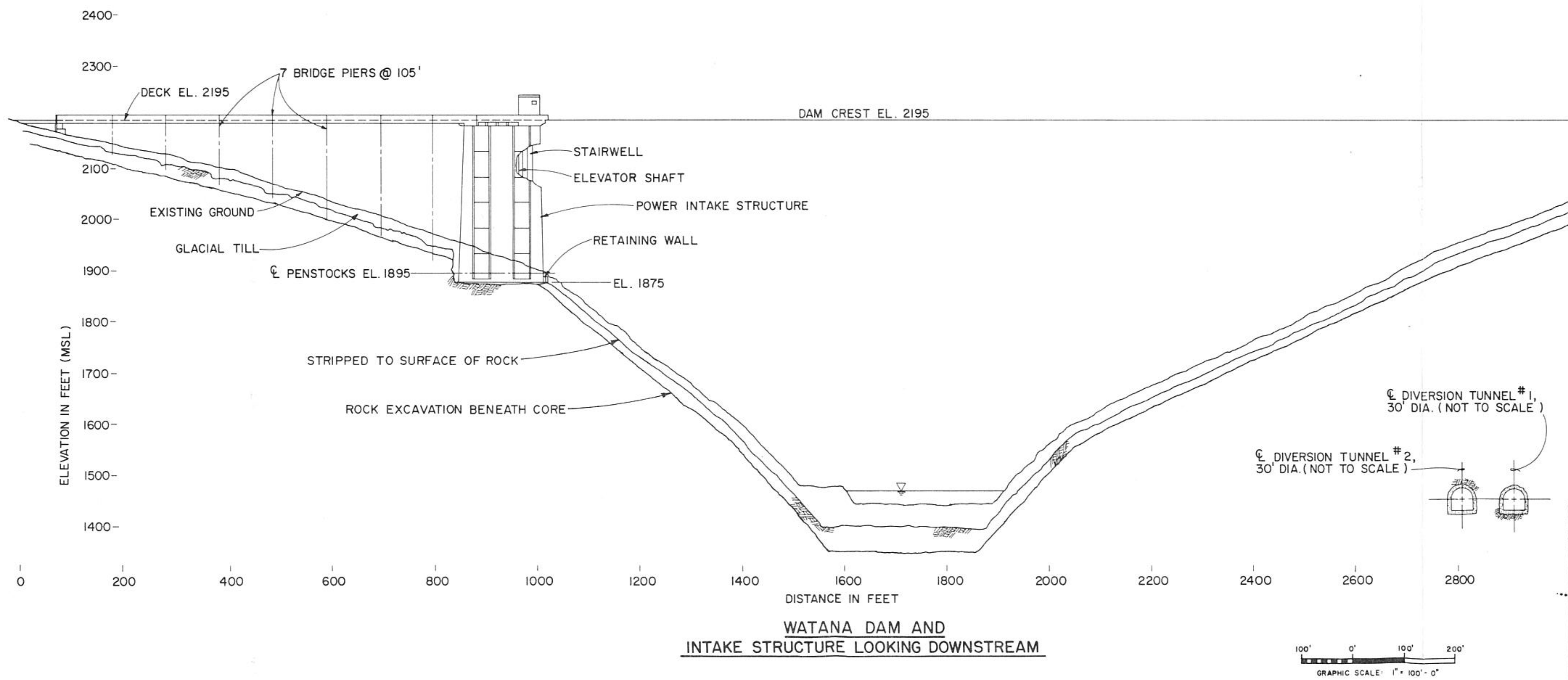
FEBRUARY 1979

EUGENE DIETZGEN COMPANY

PLATE 3



TYPICAL SECTION



WATANA DAM AND
INTAKE STRUCTURE LOOKING DOWNSTREAM

SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

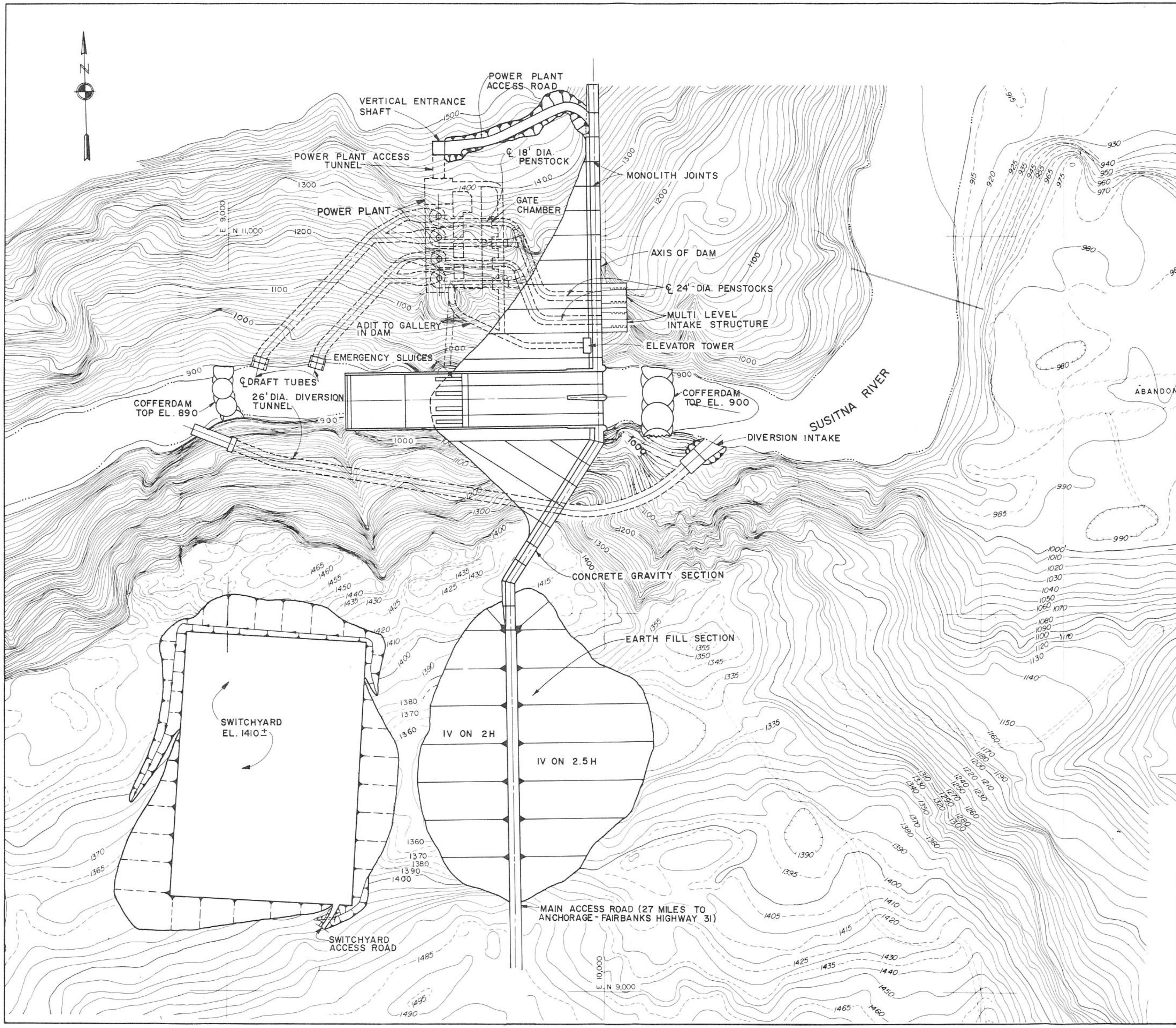
UPPER SUSITNA RIVER BASIN

WATANA DAM
SECTIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

FEBRUARY 1979

EUGENE DIETZGEN COMPANY



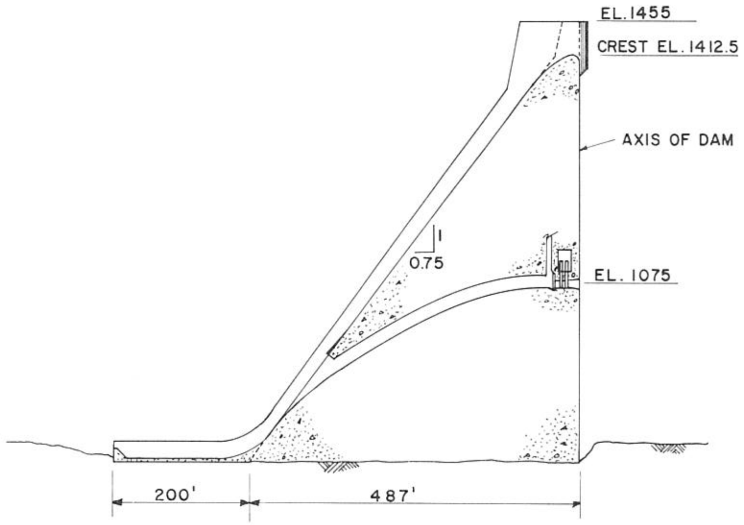
SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

UPPER SUSITNA RIVER BASIN
DEVIL CANYON DAM
CONCRETE GRAVITY DAM
DETAIL PLAN

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

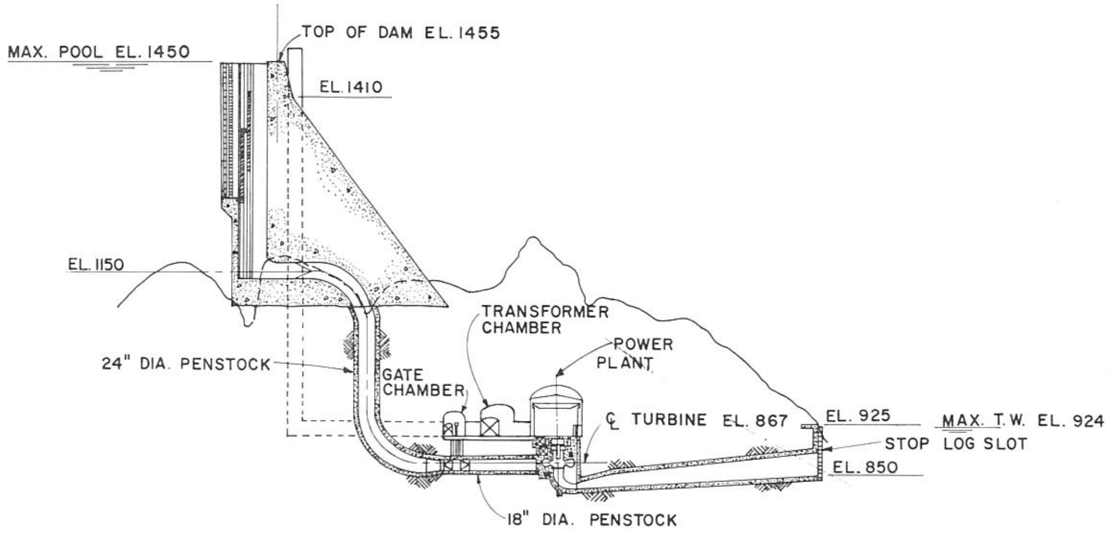
FEBRUARY 1979

PLATE 5

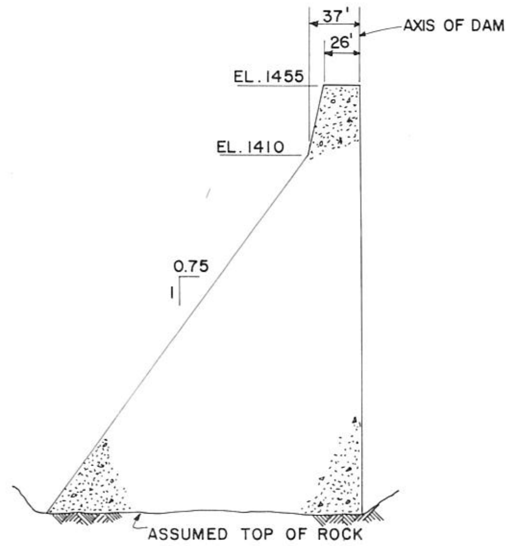


SPILLWAY SECTION

100' 0' 100' 200'
GRAPHIC SCALE: 1" = 100'-0"

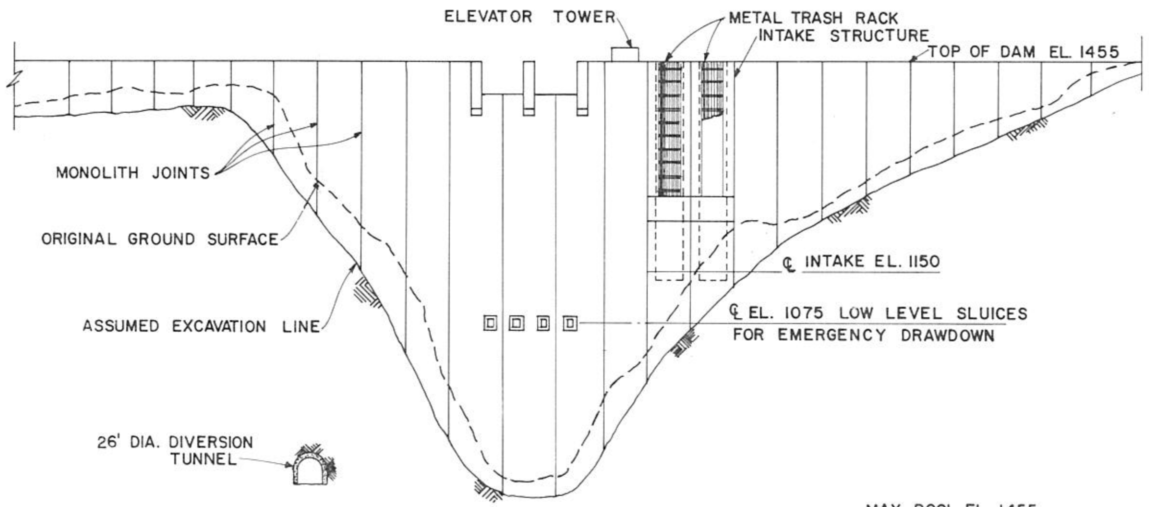


SECTION THRU PENSTOCK AND POWER PLANT
SCALE: 1" = 100'

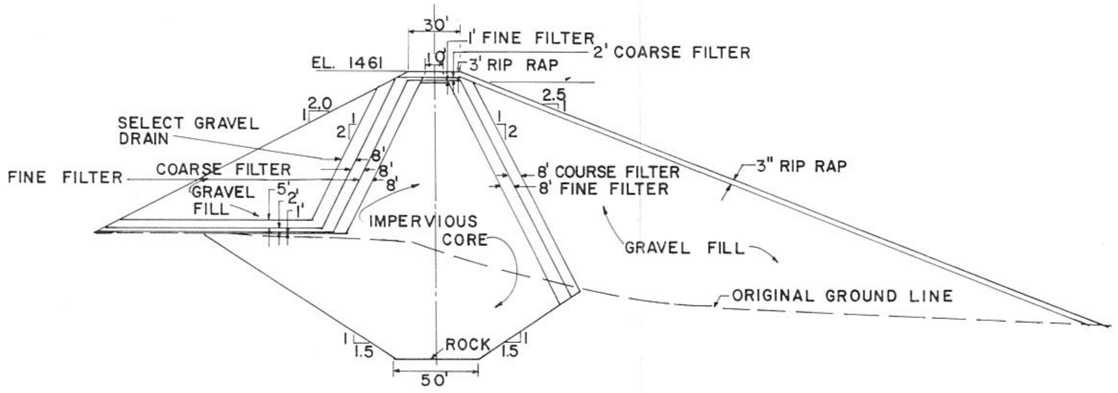


TYPICAL NON-OVERFLOW SECTION

50' 0' 50' 100'
GRAPHIC SCALE: 1" = 50'-0"

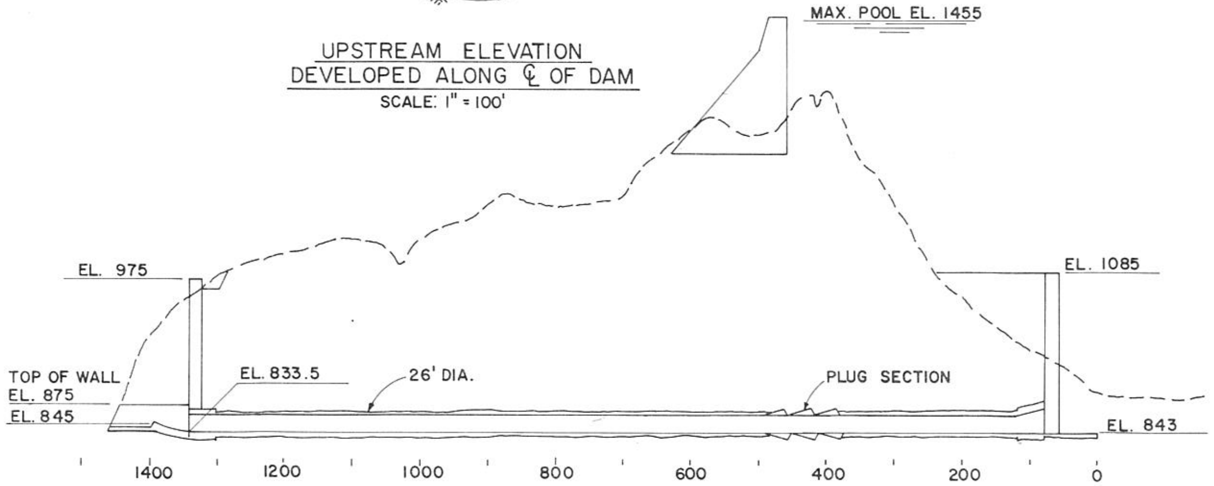


UPSTREAM ELEVATION
DEVELOPED ALONG ℄ OF DAM
SCALE: 1" = 100'



DEVIL CANYON AUXILIARY EARTH FILL DAM

40' 0' 40' 80'
GRAPHIC SCALE: 1" = 40'-0"



DIVERSON TUNNEL PROFILE
SCALE: 1" = 100'

SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY
UPPER SUSITNA RIVER BASIN
DEVIL CANYON DAM
CONCRETE GRAVITY DAM
ELEVATION AND SECTIONS
ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
FEBRUARY 1979

EUGENE DIETZGEN COMPANY

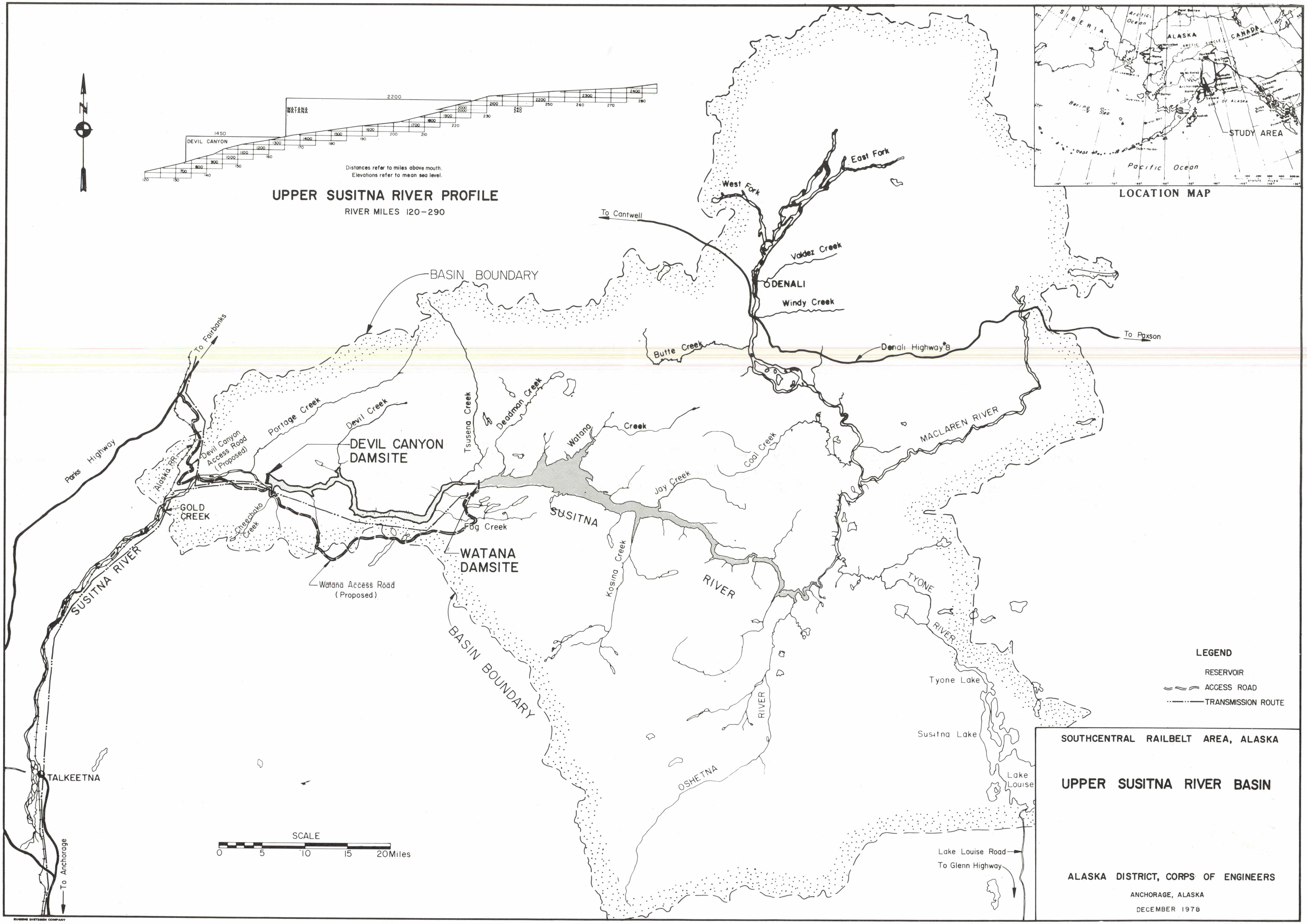
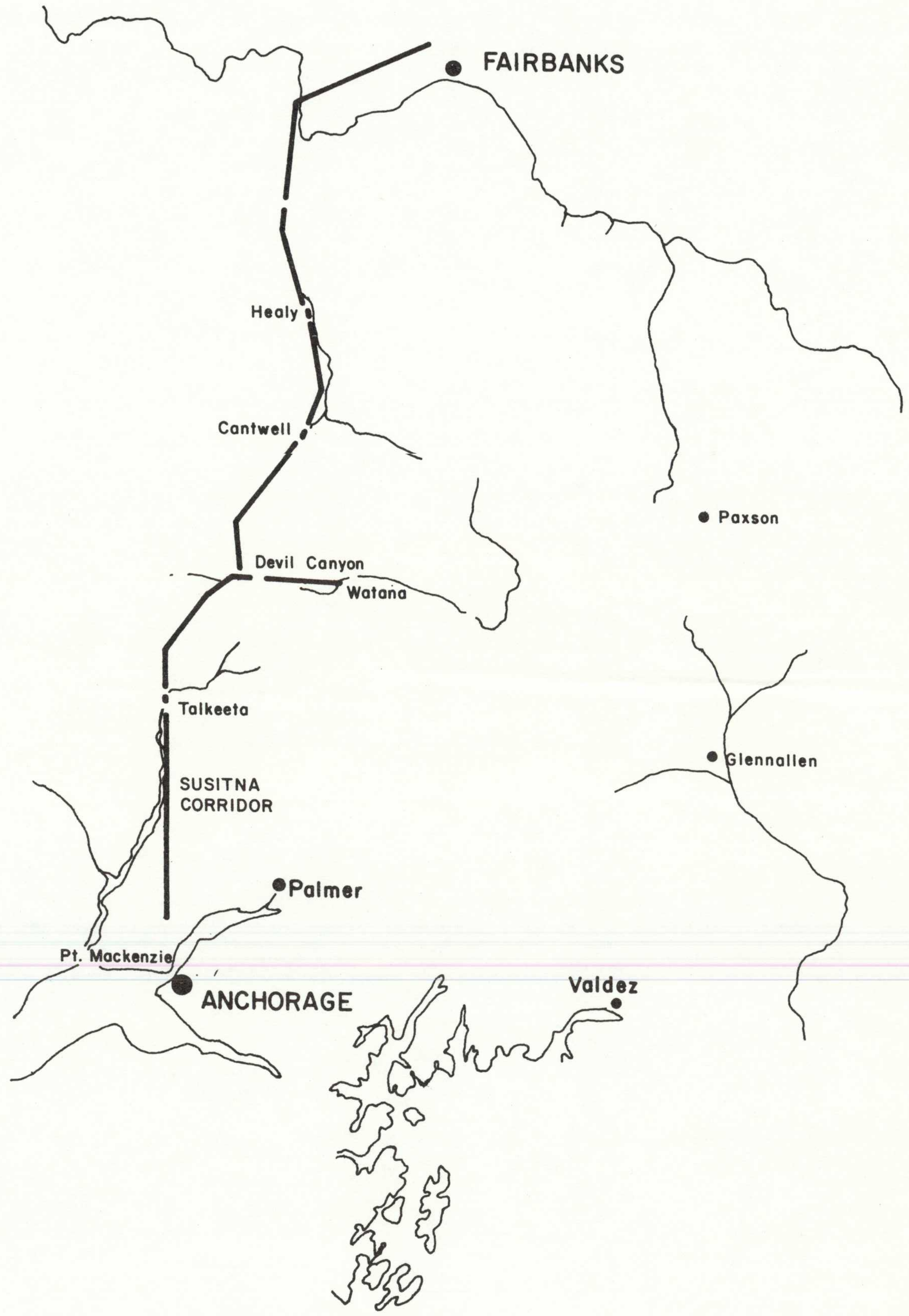


FIGURE I

791-79



SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN

PROPOSED TRANSMISSION CORRIDOR

ALASKA DISTRICT, CORPS OF ENGINEERS

ANCHORAGE, ALASKA

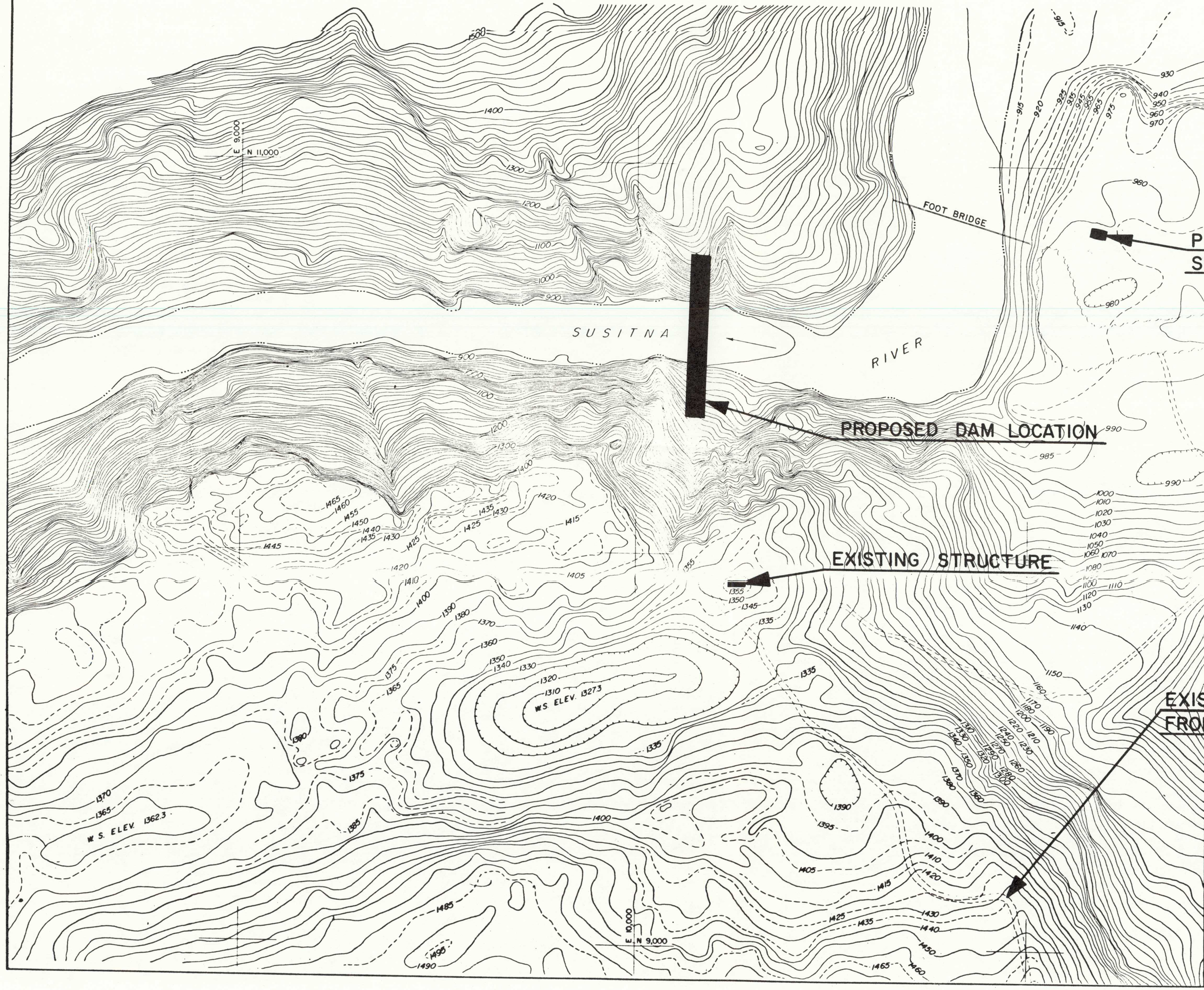
DECEMBER 1978

SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN
WATANA DAMSITE
FIELD CAMP FACILITIES

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
DECEMBER 1978

FIGURE 3



SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN
DEVIL CANYON -
FIELD CAMP FACILITIES

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
DECEMBER 1978

FIGURE 4

SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN

PROPOSED ACCESS CORRIDOR - DENALI HIGHWAY TO WATANA DAMSITE

ALASKA DISTRICT, CORPS OF ENGINEERS

ANCHORAGE, ALASKA

DECEMBER 1978

LEGEND

PROPOSED CLIMATOLOGICAL STATION
EXISTING CLIMATOLOGICAL STATION
STREAM GAGING STATION

CLIMATOLOGIAL STATIONS

C-1 EAST FORK OF SUSITNA
C-2 MONAHAN FLAT
C-3 MACLAREN GLACIER
C-4 CLEARWATER LAKE
C-5 LAKE LOUISE
C-6 LITTLE NELCHINA
C-7 SQUARE LAKE
C-8 DEADMAN LAKE
C-9 FOG LAKE
C-10 DEVIL CANYON

STREAM GAGING STATIONS

G-1 SUSITNA LODGE
G-2 MACLAREN RIVER
G-3 SUSITNA RIVER NEAR TYONE
G-4 TYONE RIVER

G-5 OSHETANA RIVER
G-6 SUSITNA RIVER NEAR WATANA

G-7 SUSITNA RIVER AT DEVIL CANYON
G-8 SUSITNA RIVER AT GOLD CREEK
G-9 SUSITNA RIVER NEAR SUNSHINE

G-10 SUSITNA RIVER NEAR CANTWELL

ELEVATIONS IN FEET

MILES
10 0 10 20 30

SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

UPPER SUSITNA RIVER BASIN CLIMATOLOGICAL AND STREAMGAGING STATIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

ANENOMOMETERS

A-1 MCKINLEY PARK
A-2 WINDY
A-3 SUMMIT
A-4 HURRICANE
A-5 CHULITNA
A-6 GOLD CREEK
A-7 CHULITNA RIVER
A-8 MOODY PASS
A-9 WOOD RIVER
A-10 WELLS CREEK
A-11 DENALI HIGHWAY
A-12 DEADMAN MOUNTAIN
A-13 WATANA / DEVIL CANYON
A-14 UPPER CHULITNA CREEK
A-15 TALKEETNA RIVER
A-16 SUSITNA FLATS

ELEVATIONS IN FEET

10 0 10 20 30

STATUTE MILES

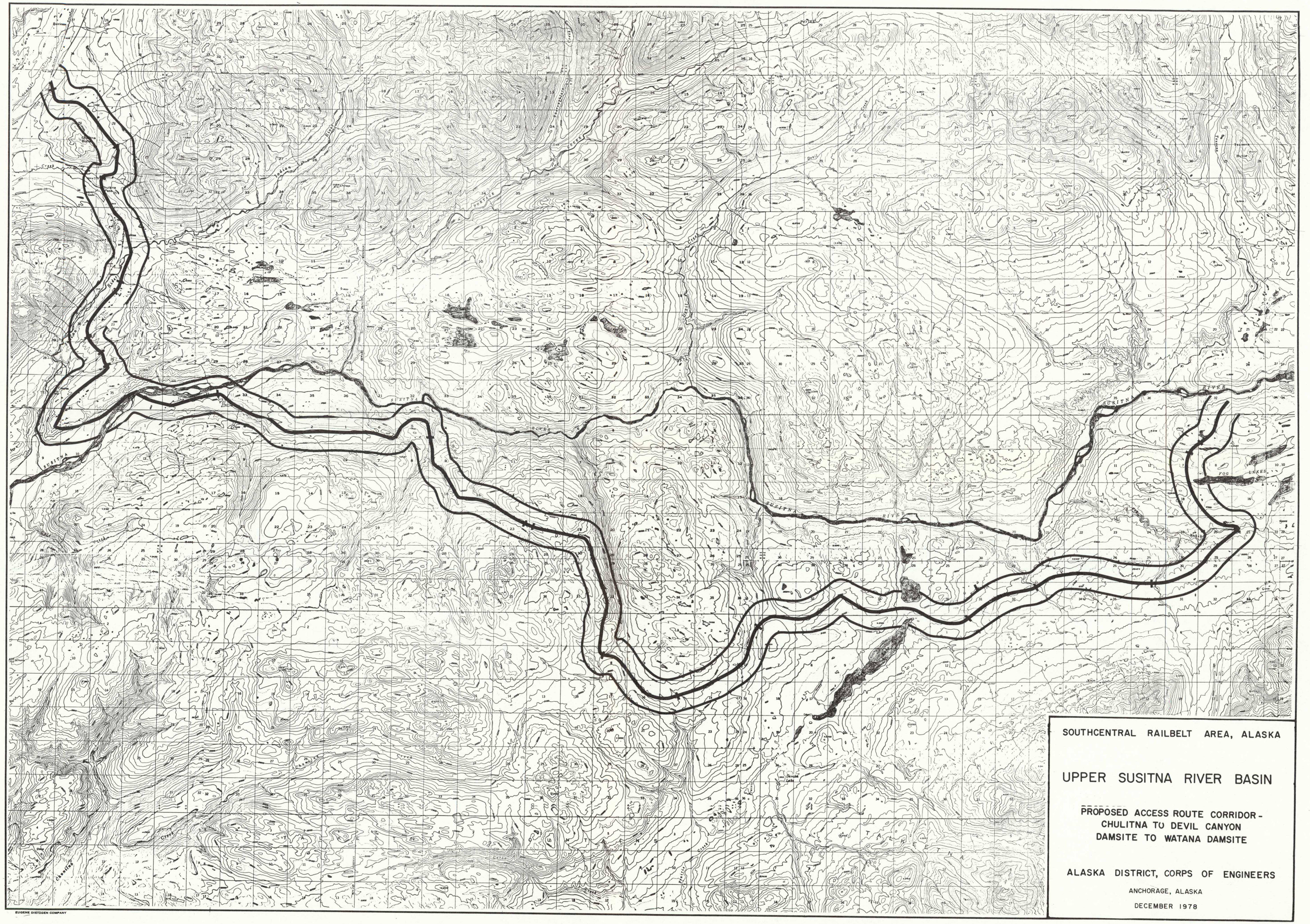
SOUTHCENTRAL RAILBELT AREA, ALASKA
SUPPLEMENTAL FEASIBILITY STUDY

UPPER SUSITNA RIVER BASIN

ANEMOMETER STATIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA

FIGURE 7



SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN

PROPOSED ACCESS ROUTE CORRIDOR -
CHULITNA TO DEVIL CANYON
DAMSITE TO WATANA DAMSITE

ALASKA DISTRICT, CORPS OF ENGINEERS

ANCHORAGE, ALASKA

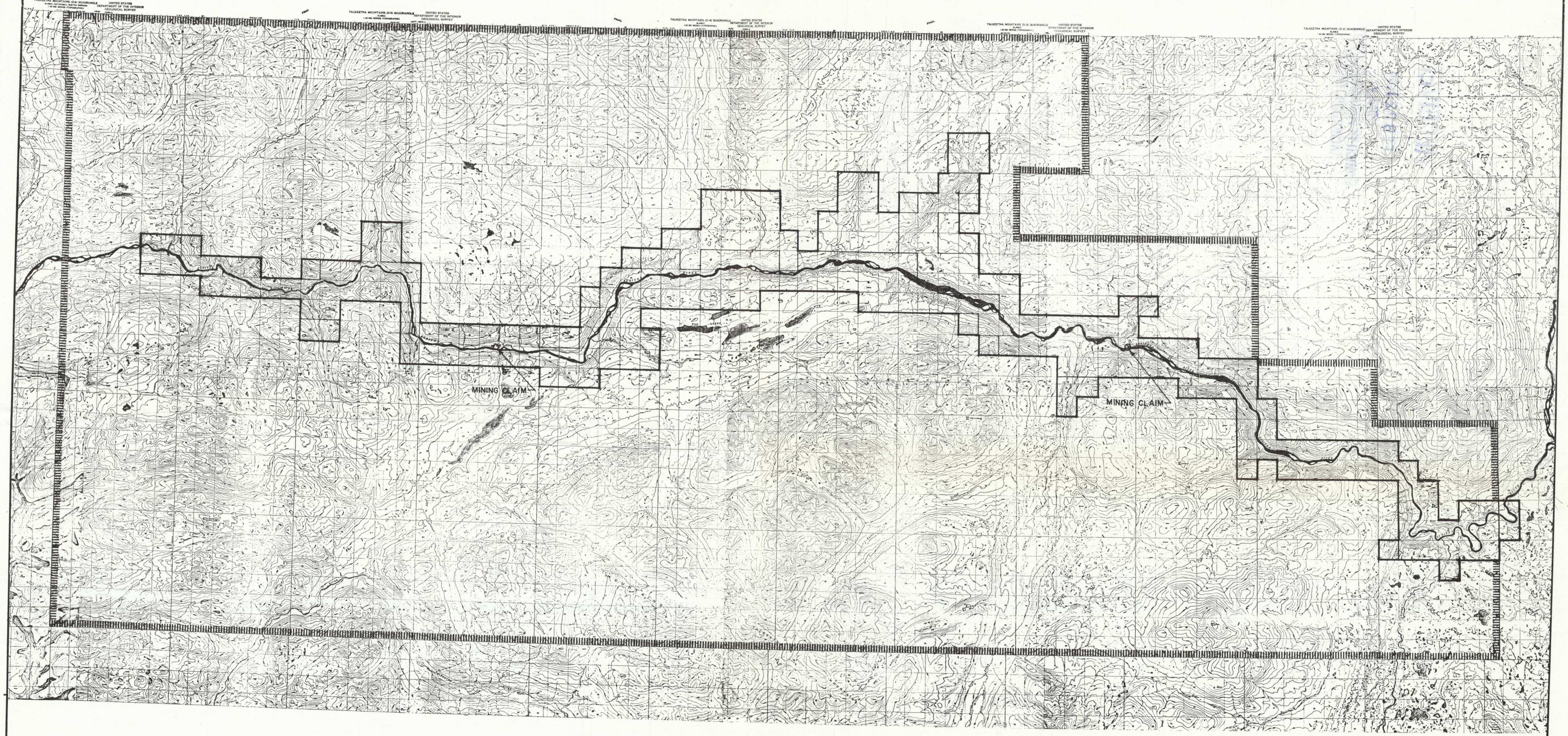
DECEMBER 1978

FIGURE 8

SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN
WATANA DAMSITE
BORROW SITE EXPLORATION AND
TESTING LOCATIONS

ALASKA DISTRICT, CORPS OF ENGINEERS
ANCHORAGE, ALASKA
DECEMBER, 1978



LEGEND

- FEE AREA BOUNDARY
- STATE LAND SALE AS OF NOV. 14, 1978
- LANDS TO BE CONVEYED TO CIRI PER P.L. 94-456
- DEFICIENCY AREAS FOR CONVEYANCE TO CIRI PER P.L. 94-456
- LANDS CONTROLLED BY BLM (WITHDRAWN FOR CIRI REGIONAL DEFICIENCY AREA)
- LANDS CONTROLLED BY BLM (WITHDRAWN FOR CLASSIFICATION-D-1)

SOUTHCENTRAL RAILBELT AREA, ALASKA

UPPER SUSITNA RIVER BASIN

LAND STATUS

ALASKA DISTRICT, CORPS OF ENGINEERS

ANCHORAGE, ALASKA

DECEMBER 1978

EUGENE DIETZGEN COMPANY

FIGURE 10