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SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

ALASKA POWER AUTHORITY COMMENTS ON THE FEDERAL ENERGY REGULATORY COMMISSION DRAFT ENVIRONMENTAL IMPACT STATEMENT OF MAY 1984

VOLUME 4
APPENDIX II-
EVALUATION OF
NON-SUSITNA
HYDROELECTRIC
ALTERNATIVES

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Volume 4

Appendix II - Evaluation of Non-Susitna Hydroelectric Alternatives

August 1984

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Summary

As a part of the development of the Susitna Hydroelectric Project (Proposed Project), the Alaska Power Authority (Power Authority) examined numerous potential hydroelectric sites to determine which sites might best fulfill the energy needs of the Railbelt Region. Following a screening process based on environmental, economic, and engineering considerations, the Power Authority concluded that development of the Susitna project, including both the Watana and Devil Canyon sites, best served the energy needs of the state. This conclusion was reached by several Federal agencies in similar screening studies (Alaska Power Authority 1983a; Alaska Power Administration 1980). Therefore, the Power Authority proceeded with the requisite more detailed studies and submitted a License Application to the Federal Energy Regulatory Commission (FERC) in February 1983. A revised License Application was submitted in July 1983.

The FERC Staff concluded in its May 1984 Draft Environmental Impact Statement (DEIS) that "based on considerations of engineering feasibility, economic characteristics, and environmental impacts...a mixed thermal-based generation scenario, with selected non-Susitna hydropower projects added as needed, appears to be the most effective approach to meeting the projected generation requirements of the Railbelt area." The DEIS stated that a combination of five specific hydroelectric sites - Johnson site (210 MW) on the Tanana River, Browne site (100 MW) on the Nenana River, Keetna site (100 MW) on the Talkeetna River, Snow Site (100 MW) near Kenai Lake, and the Chakachamna site (300 MW) on Chakachamna Lake - should be used to partially fulfill the energy needs of the Railbelt (FERC 1984).

The Power Authority strongly disagrees that the combined non-Susitna hydro and thermal generation scenario is the most effective approach from an engineering, economic, or environmental perspective by which to meet the energy needs of the state.

This report specifically addresses and re-evaluates the FERC recommended non-Susitna hydro alternatives from engineering, economic and environmental perspectives. A separate report that specifically addresses the thermal alternatives is presented as Appendix III of this document. To fully consider the total impacts from the FERC combined hydro-thermal scenario, the total impacts from the thermal projects must be added to the sum total of hydro impacts.

This report illustrates that when comparisons are made between the non-Susitna hydro alternatives and the Proposed Project, certain key engineering and environmental aspects of the alternatives make them much less favorable than the Proposed Project. The key problems associated with the alternatives are discussed below.

Johnson Site

Engineering:

1. Extensive relocations of existing communities, the Alaska Highway, and a currently inactive petroleum pipeline would be required. This could require from 24 to 36 months.

2. This site would be susceptible to sedimentation and the development of extensive mud flats that would result in lost storage capacity and therefore winter energy generation.

3. This site is remotely located with respect to the Anchorage-Fairbanks Transmission Intertie. To connect the site with Fairbanks would require approximately 135 miles of transmission line at a cost of approximately $4,650,000. Approximately 1640 acres of land would be affected by the installation of the transmission line.

4. There would be difficulties in obtaining sufficient impervious borrow materials, and extensive foundation excavations might be required.

5. The site would probably require incorporation of fish passage facilities which are not always effective (Bell 1980). These facilities would materially add to the cost of site development.

Environmental:

1. Two communities, Dot Lake and The Living Word, with populations of approximately 70 and 200 persons respectively, would need to be relocated because they are within the impoundment zone. Construction and operation would affect the infrastructure of Delta Junction and Tok.

2. Approximately 23 miles of the Alaska Highway, the major overland route between Alaska and the lower 48, would need to be relocated. The relocated section would be considerably longer (approximately 33 miles).

3. An above-ground petroleum pipeline would have to be relocated. This would entail moving the pipeline from a fairly direct route and level gradient to one that traverses steep terrain and would be less direct.

4. The surface area of this impoundment alone (94,500 acres) would be far larger than that for the Proposed Project (45,800 acres) and thus would inundate greater existing habitat.

5. The project would inundate hunting and fishing sites in an extensive wilderness area.

6. Four peregrine falcon nest locations occur along the shoreline of the proposed impoundment zone. Three of these were active in 1983. This would make licensing of the project very difficult, if not impossible, because this species is classified by the Department of Interior, U.S. Fish and Wildlife Service as "endangered".

7. The floodplain in this area is an important wintering and calving area for moose and contains important black bear and furbearer habitat. Loss of this habitat would significantly decrease the carrying capacity of the area for moose and other wildlife and result in lower populations.

8. Anadromous salmon are known to exist upstream of the site. These fish are predominantly chum salmon, a species that would not successfully utilize passage facilities and therefore would probably be eliminated from upstream areas.

9. Changes in flow regimes downstream of the project would also impact salmon spawning and habitat.

10. Flow reductions in the summer could severely disrupt commercial navigation on the river, particularly in the lower Tanana. If both the Browne and Johnson site were developed, the cumulative impact of both projects on navigation downstream from Nenana could be significant.

11. Approximately 30,000 acres of palustrine wetlands would be inundated.

Browne Site

Engineering:

1. Extensive relocations of the existing major highway route between Fairbanks and Anchorage, the Alaska Railroad, a Golden Valley Electric Association (GVEA) transmission line, and several homes would be required. This could require up to 48 months.

2. The site could require substantial foundation excavations in excess of 100 feet in depth.

3. The site would probably require incorporation of fish passage facilities, which are costly and oftentimes not effective.

Environmental:

1. Impacts associated with development of this site would include relocating 8.5 miles of the George Parks Highway, 16 miles of the Alaska Railroad, and 16 miles of existing Golden Valley Electric Association transmission line.

2. Communities that would be significantly impacted by construction include Healy and Nenana.

3. Anadromous salmon are known to exist upstream of this site. As with the Johnson site, one of the species is chum salmon which would be expected to be eliminated from upstream areas. Fish passage facilities for other species would be needed for this site.

4. Changes in flow regimes downstream of the project would also impact salmon spawning and rearing habitat.

5. The Nenana River is used for recreational rafting. This would be eliminated from this reach of river. Downstream navigation, particularly in the lower Tanana, could be significantly disrupted by flow regulation from this site (and the Johnson site).

6. Approximately 50 cultural resources sites are known to exist at this site.

7. The river floodplain in the impoundment zone is an important overwintering area for moose. Loss of this habitat would significantly decrease the carrying capacity of the area for moose and result in lower moose populations.

Keetna Site

Engineering:

1. There may be difficulty in obtaining sufficient impervious borrow materials, which would require development of additional on-site roads along steep slopes to gain access to higher elevations where materials may be available. Inherent stability problems are associated with excavations on steep slopes.

2. The only suitable location of the construction camp site may be subject to flooding.

3. The site would require incorporation of fish passage facilities which lack proven effectiveness.

Environmental:

1. Highly significant runs of anadromous salmon exist upstream of the project. Salmon are known to spawn in areas within and upstream of the impoundment zone. Important impoundment zone spawning areas would be eliminated. In addition, there is a high risk that the chum salmon runs would be eliminated as well.

2. The high concentrations of salmon (particularly chinook salmon) in Prairie Creek (upstream of the site), attract large numbers (up to 100) of brown bears that feed on the salmon. This resource is considered a seasonally important critical habitat and may be important for maintaining the current levels of brown bear numbers in the area.

3. Changes in flow regimes downstream of the project would also impact salmon spawning and rearing habitat.

4. This section of the Talkeetna River (including Disappointment Creek) has been recommended by the Alaska Department of Natural Resources as a state recreation river. White-water kayaking in the impoundment reach and upstream passage of river boats from Talkeetna (which currently access upstream areas as far as approximately 2 miles above Iron Creek) would be eliminated.

5. Moose utilize the proposed impoundment zone year-round and concentrate in the floodplain during the fall and winter. Loss of this habitat would decrease the carrying capacity of the area for moose and result in lower moose populations.

6. The project could significantly impact bald eagles and other nesting raptors either through loss of nesting sites or a reduction in prey base.

Snow Site

Engineering:

1. This site would require upgrading approximately 83 miles of existing transmission line between the project area and Anchorage at a cost of approximately $1,400,000. A 4-mile long transmission line stub would be required from the powerhouse substation to this existing transmission facility.

2. The site is subjected to glacial outburst flooding every two to three years. This would entail very high costs for special design treatment in the way of increased project freeboard, increased spillway capacity or emergency spillways, or a reduced operating pool level.

Environmental:

1. The project would inundate hunting and fishing areas in a wilderness valley; an existing recreational fishery in Lower Paradise Lake would be eliminated.

2. Changes in flow regimes downstream of the project could impact salmon spawning and rearing habitat in the Kenai River.

3. Riparian areas within the impoundment zone would be eliminated. This is important habitat to moose and other wildlife. Loss of this habitat would decrease the carrying capacity of the area for moose and result in lower moose populations.

4. Views of the dam, transmission lines and other facilities would be highly visible to recreationists in the South Fork valley and to sightseers on the highway and railroad.

Chakachamna Site

Engineering:

1. The power tunnel, which is approximately 10 miles long, will require very detailed geologic investigation and study because of its greater susceptibility to problems created by changes in geology along its length.

2. High in-situ rock stresses may occur near the underground powerhouse due to the nearby presence of the Lake Clark-Castle Mountain fault. These stresses will cause significant design and construction problems which will be costly and time consuming.

3. The nearby presence of Barrier, Blockade, and McArthur Glaciers could make lake level prediction, and the resulting regulation of storage for power regulation, uncertain; could cause outburst flooding which affects the design and cost of project features; and could endanger the tailrace channel and portals of the tailrace tunnel and access tunnel to the underground powerhouse.

4. A large eruption of Mt. Spurr Volcano located about 7 miles from the outlet of Chakachamna Lake could inundate the proposed power intake site with volcanic ash, or trigger a large landslide or mudflow which would bury both the upstream and downstream ends of the fish passage facilities, dam, spillway, and power intake structure.

5. The site lies within a zone of high seismic risk.

6. This site is remotely located with respect to the Anchorage-Fairbanks Intertie and would require an extensive transmission line (approximately 130 miles in length and 1200 acres of corridor.

7. In addition to new access requirements, extensive improvement to existing roads and transportation facilities (e.g., Tyonek dock facilities) would be necessary.

8. Improvements to existing access facilities could take up to 48 months.

9. The site would require incorporation of potentially ineffective fish passage facilities for both upstream and downstream migrating fish involving a 930 foot long approach channel, and a 300 foot long tunnel connecting the downstream discharge facilities.

Environmental:

1. There is a potential loss of a significant sockeye salmon run (up to 40,000 fish) upstream of the site, and impacts to approximately 64,000 additional adults either downstream of the dam site on the Chakachatna River or in the McArthur River. In total, the number of adult salmon that could be significantly affected is over 100,000. These impacts may be due to either fish passage difficulties or diversion of flow from the Chakachatna River to the McArthur River which could result in miscueing for migration, changes in spawning habitat resulting from flow change, or delays in migration.

2. Changes in flow by diversion could also significnntly affect fish rearing habitat, particularly in areas, such as Noaukta Slough on the Chakachatna River, that are known rearing areas.

3. The project would adversely affect brown bear use of salmon spawning areas on the Chilligan and Chakachatna rivers. Stabilization of river and slough banks due to reduced flow of water down the Chakachatna River would have eventual, long-term impacts on moose and furbearers.

The decrease in river flow would also result in dewatering of areas used as nesting habitat by waterfowl.

Non-Susitna Hydroelectric Alternatives vs. Proposed Project

Compared to the Proposed Project, the non-Susitna hydroelectric alternatives would:

1. impact many more communities during construction and operation;

2. require more relocation of existing communities, highways, railroads, and transmission lines (virtually none would be required for the Proposed Project);

3. result in inundation and/or disturbance of far more acreage resulting in more extensive wildlife impacts;

4. place a significant number of anadromous salmon runs at high risk and result in possible elimination of many fish permanently;

5. eliminate existing free-flowing rivers that are now extensively used, some of which are recommended as state recreation rivers;

6. Disrupt important navigation, particularly on the lower Tanana River and perhaps on the Yukon River; and

7. directly impact four nesting locations of an endangered species, the peregrine falcon, at the Johnson site (the Proposed Project will not impact any endangered species).

Information in this Appendix shows that each site would have potential environmental impacts, engineering problems, or unfavorable project costs that often exceed those of the Proposed Project.

When the sum total of impacts is considered, it is clear that the combined non-Susitna hydro alternatives scenario is not a viable option, particularly when it is noted that the power produced will only partially fulfill the the Railbelt's total energy needs. Adding thermal units to meet those needs would only compound the environmental impacts. The feasibility of this combined hydro-thermal scenario becomes even more tenuous with the difficulties, both technical and sociopolitical, of siting coal-fired thermal units near the visually sensitive, Class I air quality area of Denali National Park and Preserve. The Proposed Project would meet more of the energy needs of the Railbelt with far fewer adverse impacts. The information and conclusions reached in this report should be useful to the FERC Staff in reconsidering its recommendation concerning the combined non-Susitna hydro-thermal generation scenario.

In addition to engineering and environmental considerations, this Appendix discusses cost comparisons (Section 8.0), primarily because it is necessary to clarify the useage of cost estimates in previous studies and by the FERC in the DEIS. When costs are based on a consistent analysis, the Proposed Project's cost per unit of installed capacity is significantly lower than for the hydro alternatives.

Power and energy comparisons of the alternatives, as described by FERC Staff in the DEIS, have been reexamined by the Power Authority (Section 9.0). This reexamination shows that, under the flow regimes presented in the DEIS, the seasonal regulation of flows by the alternative reservoirs would be very limited by the high minimum flow requirements in the summer. A large amount of energy would be spilled in the initial years of the alternative projects' operations because of low energy demand and high flow requirements in the summer. It is only when Railbelt energy requirements increase with time that more summer energy can be used.

1.0 Introduction

The Alaska Power Authority (Power Authority) concluded in its FERC License Application that the Susitna Hydroelectric Project (Proposed Project), including both the Watana and Devil Canyon dams was the best alternative capable of meeting the energy demands of the Railbelt region. This conclusion was reached based on studies of upper Susitna Basin potential hydroelectric alternative sites, non-Susitna hydroelectric alternatives, and other non-hydro developments. This Appendix addresses conclusions presented in the FERC's Draft Environmental Impact Statement (DEIS) which stated a preference for alternative power generation scenarios (FERC 1984). The preferred alternative identified in the DEIS consists of combined hydro-thermal facilities including hydropower facilities at sites outside the Sustina Basin plus various coal and gas-fired thermal units. The hydroelectric sites recommended were Johnson, Browne, Keetna, Snow and Chakachamna.

2.0 Purpose and Scope

The purpose of this Appendix is to evaluate the engineering and environmental feasibility of the alternative hydroelectric damsites identified by the FERC Staff in its DEIS. This Appendix describes and evaluates the general arrangement developed for each of the potential alternative sites. These studies have essentially followed the plan formulation and methodology outlined in the FERC License Application, Exhibit B (Alaska Power Authority 1983a, 1983b, 1983c). Information for the Johnson, Browne, Keetna, and Snow sites was mainly derived from site reconnaissance (aircraft overflights), review of existing information, and personal communications with individuals familiar with the sites. In addition to the above sources, the information for the Chakachamna site was supplemented by information contained in feasibility studies of the site that were funded by the Power Authority (Bechtel 1983). Therefore, the information base is much more extensive for this site than the other alternative hydro sites. Information on the Proposed Project was derived from the License Application submission to the FERC and the associated extensive studies.

3.0 Previous Studies

Numerous studies of hydroelectric potential in Alaska have previously been undertaken (Alaska Power Authority 1983a; Alaska Power Administration 1980). These date as far back as 1947, and were performed by various agencies including the Federal Power Commission (1976), the U.S. Army Corps of Engineers (COE), the United States Bureau of Reclamation (USBR), the United States Geological Survey (USGS 1961), and the State of Alaska.

To meet the energy needs for the Railbelt Region, technical, economic and environmental aspects of hydroelectric potential in Alaska were included in the Power Authority's License Application for the Proposed Project. The screening of non-Susitna hydroelectric alternatives was presented in Exhibit E, Chapter 10 of the License Application.

The above studies and, in particular, the inventories of potential sites by the U.S. Army (1981) and the Alaska Power Administration (1980) have been utilized in preparing this Appendix.

4.0 Evaluation Methodology

The evaluation process for comparing the alternatives with the Susitna project involved the following six basic steps:

Step 1: -Site visit by fixed wing aircraft.
-Review of available data.
-Determination of key items for evaluation.

Step 2: -Development of preliminary layouts, based on the site visit, available data and design criteria for the alternative dam types considered, including all related facilities and structures.
-Development of plans for each layout.
-Planimetering of project features and the impoundment zones to obtain surface areas. (Values presented in the DEIS were not used).

Step 3: -Development of cost estimates for each layout based on the drawings prepared under Step 2.

Step 4: -Review of all layouts on the basis of technical feasibility, cost, construction methods and materials, uncertainty of basic data and assumptions, safety, and environmental impacts.

Step 5: -Evaluation of each alternative project.

Step 6: -Comparison of the alternatives with the Proposed Project.

The key criteria used for evaluation of the alternative damsites were as follows:

(a) Economic/Engineering

- o Construction cost estimate (based on License Application)
- o Availability of construction materials;
- o Technical adequacy
- o Operation and safety.

(b) Environmental

To the degree possible, environmental categories considered in comparisons of hydroelectric alternatives were based on the FERC requirements for the preparation of the Exhibit E "Environmental Report" submitted as part of the License Application for the Proposed Project. These categories include project impacts on the following:

- o Human Resources:
  - Socioeconomics
  - Cultural Resources
  - Land Use
  - Aesthetics
  - Recreation
  - Visual Resources
- o Terrestrial Resources
- o Aquatic Resources

In addition to the above criteria used for comparing alternatives, the costs of the following items were considered, where applicable:

- o Measures to minimize or preclude the possibility of undesirable and irreversible changes to the natural environment (e.g. fish passage facilities).

- Measures which enhance the quality aspects of water and land. Care was taken when incorporating these aspects to ensure consistency between alternatives, i.e. that all alternatives incorporated the same degree of mitigation. For example, these measures included reservoir operation constraints to minimize environmental impacts and adoption of access road and transmission line design standards and construction techniques which minimize impact on terrestrial and aquatic habitat.

5.0 Description of Projects

5.1 General

The following sections (5.2 through 5.6) outline alternative hydroelectric projects considered for comparison with the Devil Canyon and Watana sites. The extremely preliminary level of study was sufficient to identify the major design features of each alternative, commensurate with the available data. The dam layouts are conceptual rather than definitive, and are intended only to give a representative design for each alternative that provides an adequate basis for comparison. Major factors considered include the associated diversion works, spillways, and power facilities; construction methods and materials; capital cost estimates; safety of operation; and impact on the environment. Sensitivity to changes in the available data regarding geology, topography, construction materials, and the level of seismic activity have also been considered.

For comparison purposes, project descriptions are also included for Devil Canyon (Section 5.7) and Watana (Section 5.8). It should be noted that project feasibility has been established for the Proposed Project dams through preliminary underground explorations, investigations, and design studies.

5.2 Johnson Dam and Reservoir

Location. The Johnson site is located on the Tanana River, 120 miles southeast of Fairbanks. The damsite is just downstream from the confluence of the Johnson and Tanana rivers at latitude 63°45'N, longitude 144°38'W (Exhibits 1 and 3).

Climate. The climate of the project area is described as continental. Mean annual air temperature is 23°F. Temperatures range from a mean minimum of -12°F in January to a mean maximum of 68°F in July. Precipitation averages

20 inches annually. Permafrost conditions exist at the damsite and in the drainage basin.

Seismic Potential. The project is located in Probability Zone 2, according to seismic risk maps of the Uniform Building Code (ICBO 1980). This is noted as moderate damage category (corresponds to intensity VII on the Modified Mercalli Intensity Scale).

Drainage Area. The drainage area above the damsite is 10,500 square miles.

Streamflow. The Tanana River streamflow has been recorded near Tanacross (USGS Gage No. 15476000) and at Big Delta. Big Delta records are available from 1948 to 1952 and from 1953 to 1957 and have since been discontinued. Tanacross records are continuous from 1953 to the present. Since the record at Tanacross is longer and continuous, the flows at the damsite were estimated from Tanacross flows by linear proportion to the catchment area. The average annual streamflow at the damsite is estimated at 9,800 cubic feet per second (cfs) or about 7,100,000 acre-feet per year.

Sediment. Based on sediment samples taken in the Tanana River basin, Johnson Reservoir has an estimated 50-year sediment deposition of 400,000 acre-feet in the active storage portion of the reservoir (U.S. Bureau of Reclamation 1965).

Project Description. The Johnson Reservoir would be formed by the construction of an earth dam across the Tanana River. The dam would have a maximum height of 210 feet from the base at elevation 1,280 to the crest at elevation 1,490. The crest length would be about 6,400 feet. A 2,000 foot long saddle dam of undetermined height would be required about 3.5 miles northeast of the main dam.

The Tanana River Valley is known to contain deep, permeable unconsolidated sediments, and such deposits would most likely be present at the site. The unconsolidated deposits could contain permafrost except for a shallow surface zone that thaws in summer. For seismic stability reasons, these materials would probably have to be excavated so the dam embankment could rest on bedrock. The powerplant would have an installed capacity of 210 megawatts (MW) with a 50 percent plant factor if the powerplant is not limited by system energy requirements. The generators would be driven by four Francis turbines.

Reservoir Characteristics. The normal maximum operating level of Johnson Reservoir would be at elevation 1,470 feet. The corresponding reservoir surface area and storage volume are 94,500 acres and 7,000,000 acre-feet respectively. Active storage would be 5,300,000 acre-feet after the 50-year sediment allocation is made. Estimated reservoir drawdown capability would be 80 feet. This drawdown could expose some 48,000 acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. The maximum depth of the reservoir would be 190 feet and retention time would be 11 months. Reservoir length would be 36 miles.

Project Operation. The drawdown of the reservoir would start with the recession of flow in the fall. The reservoir would be gradually drawn down through the winter, reaching the minimum reservoir level in May of each year. Annual filling would commence in May and continue for the remainder of the summer.

The minimum flows for the project are based on those presented in Table 2-7 of the DEIS (see Section 9.0 for a further discussion on the selection of these minimum flows). Minimum flows would be 24,000 cfs during the months of June, July and August and 3200 cfs during the other months. The June, July, August flow of 24,000 cfs represents the maximum of the historical Q_{90} value and is similar to the average flow occurring in the summer. Consequently, during dry hydrological years, it may not be possible to maintain this minimum flow. Maximum gross head would be 180 feet and average gross head would be approximately 149 feet. Tailwater elevation would be at approximately elevation 1,290 feet. Mean annual energy could reach approximately 950 Gigawatt hours (GWh) if energy production is not limited by the system requirement.

5.3 Browne Dam and Reservoir

Location. The Browne site is located on the Nenana River, approximately 65 air miles southwest of Fairbanks (Exhibits 1 and 4). See EBASCO 1982.

Climate. The climate of the project area is described as continental. Mean annual air temperature is 23°F. Temperatures range from a mean minimum of -12°F in January to a mean maximum of 69°F in July. Precipitation averages 20 inches annually.

Seismic Potential. The project is located in Probability Zone 3, per seismic risk maps of the Uniform Building Code (ICBO 1980). This is noted as major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

Drainage Area. The damsite has a tributary drainage area of 2,450 square miles. The basin drains the foothills on the north side of the Alaska Range. Terrain throughout much of the basin is relatively flat.

Streamflow. Nenana River streamflow records exist for three locations: Nenana River near Windy, Nenana River near Healy, and Nenana River near Rex. The Nenana River near Windy (USGS Gage No. 15516000) has a drainage area of 710 square miles and 22 years of record (1951-1973). The Nenana River near Healy (USGS Gage No. 15518000) has a drainage area of 1,910 square miles and 29 years of record. The Nenana River near Rex (USGS Gage No. 15518300) is near the Browne damsite. The gaging station has a drainage area of 2,450 square miles but only 4 years of flow data. Based on the Nenana River near Healy record, the average annual flow at the damsite is estimated to be 4,500 cfs (3,250,000 acre-feet). Mean monthly flows range from an average of about 500 cfs in late winter to 14,000 cfs in June.

Sediment. The Bureau of Reclamation (1965) estimated the sediment load at 1.2 acre-feet/square mile/year or 150,000 acre-feet in 50 years.

Project Description. The Nenana River flows in a gently sloping U-shaped valley. The steep abutments existing at the damsite indicate bedrock is nearly exposed on either side of the river. Foundation conditions are commensurate with construction of an earth and rockfill dam at this site.

The dam would be built with the crest at elevation 995± feet and the base at elevation 730± feet. The crest length would be about 6,300 feet. An ogee type gated spillway would be located on the right abutment. A power tunnel would be connected through the left abutment to a surface powerhouse. Four Francis turbines, each rated at 34,600 horsepower (hp) at a net design head of 170 feet, would be installed. The total capacity would be 100 MW at a plant factor of 50 percent.

Construction materials might be obtained from the adjacent rock outcrops along with alluvial deposits in the river valley.

Reservoir Characteristics. The Browne Reservoir would be operated at a normal maximum reservoir elevation of 975 feet. At this elevation, the reservoir would have a surface area of 12,500 acres and a total storage of 1,100,000 acre feet. Maximum drawdown capability of the reservoir is 85 feet, corresponding to a minimum reservoir elevation of 890 feet. This drawdown could expose 7000± acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. The active reservoir storage would be 760,000 acre-feet. Maximum depth of the reservoir would be about 205 feet. Retention time would be 4 months. The reservoir length would be 11 miles.

Project Operation. The reservoir would be gradually filled each year during the high flow summer period of May through September. During the winter low flow period, the reservoir would be gradually drawn down, reaching the minimum reservoir elevation about May. Minimum flow releases from the project would be 9,300 cfs during June, July and August and 1,400 cfs during the other months. These discharges are based on releases presented in Table 2-7 of the DEIS.

With the maximum reservoir elevation of 975 and a tailwater elevation of 780 feet, the resulting maximum head would be 195 feet. Average gross head would be approximately 180 feet. Mean annual energy is approximately 440 GWh if energy production is not limited by the system requirement.

5.4 Keetna Dam and Reservoir

Location. The Keetna site (Exhibits 1 and 5) is located on the Talkeetna River, approximately 85 miles north of Anchorage and 14 miles northeast of Talkeetna, approximately 1.5 miles downstream from Disappointment Creek.

Climate. The climate of the project area is described as continental. The mean annual air temperature is 30°F. Temperatures range from a mean minimum of -2°F in January to a mean maximum of 68°F in July. Precipitation averages 30 inches annually. Permafrost conditions exist at the site and in the drainage basin.

Seismic Potential. The project is located in Probability Zone 3, per seismic risk maps of the Uniform Building Code (ICBO 1980). This is noted as the major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

Drainage Area. The damsite has a tributary drainage area of 1,260 square miles. The basin lies east of the Susitna River and drains the western slopes of the Talkeetna Mountains. The lower elevations support growth of timber and other vegetation, while the upper elevations have little or no vegetal cover.

Streamflow. Streamflow records of the Talkeetna River are available from June 1964 to the present time for a gage 5-miles upstream from the river mouth (USGS Gage No. 15292700). For the energy simulation studies conducted for this Appendix, 14 years of streamflow data were used (1964-1978). Mean annual discharge at the Keetna damsite for this period was estimated to be 2,500 cfs (1,800,000 acre-feet) based on a proportioning of flow by drainage area.

Sediment. Approximately six percent of the drainage area is glaciated. USGS sediment discharge measurements from 1981 through 1983 at the Talkeetna River gaging station indicate that the sediment load is approximately half of the sediment load of the Susitna River above the Chulitna River. Based on a proportioning of the sediment load by drainage area and trap efficiences adapted from Brune (USBR 1977), it was determined that 65,000 acre-feet of sediment would accumulate in the reservoir in a 50 year period.

Project Description. At the project site, the Talkeetna River flows in a steep-walled, U-shaped valley. The near vertical abutments indicate bedrock is nearly exposed on either side of the river. Insofar as could be determined from the aerial reconnaissance, foundation conditions would allow construction of either an earth and rockfill dam or a concrete arch dam at this site.

The dam would be built with the crest at approximately elevation 965 and the base at elevation 550± feet. The crest length would be about 1,200 feet.

The diversion and power tunnels would be located on the left abutment along with an ogee type gated spillway.

The surface powerhouse would be connected to the reservoir by a 1,300± feet long tunnel. The powerplant would have an installed capacity of 100 MW and a plant factor of 49 percent.

Twenty-five miles of access road would be required from Talkeetna to the project. Construction of this access road would involve approximately 300 acres of right-of-way.

Construction materials might be obtained from the adjacent rock outcrops and the alluvial deposits in the river valley.

Reservoir Characteristics. The Keetna Reservoir would have a normal maximum water surface at elevation 945 feet. At this elevation, the reservoir area would be 5,500 acres. Total reservoir capacity would be 850,000 acre-feet, including 350,000 acre-feet of dead storage and 500,000 acre-feet of live storage. Drawdown capability would be 125 feet. This drawdown could expose about 2000± acres of unsightly mud flats and/or eroded slopes devoid of any vegetation. Maximum reservoir depth would be about 240 feet. Retention time would be 5.5 months. The reservoir length would be 10 miles.

Project Operation. The Keetna Reservoir would be drawn down to its minimum level in May of each year. During the high flow summer period (May through September) the reservoir would be gradually filled. During the fall and winter, the stored water would be gradually released until the minimum reservoir elevation is reached in May.

Minimum flow would be 5,000 cfs during the summer months of June, July and August and 720 cfs during the winter months. These flows are based on those presented in the DEIS (see Table 2-7). Maximum gross head would be 330 feet and the average net operating head about 286 feet. Tailwater elevation would be at approximately elevation 615 feet. Mean annual energy is approximately 430 GWh if energy production is not limited by the system requirement.

5.5 Snow Dam and Reservoir

Location. The damsite is on the Snow River in the Kenai Peninsula at river mile 8. (latitude 60° 18'N, longitude 149° 16'W)(Exhibits 1 and 6).

Climate. The climate of the project area is described as continental. The mean annual air temperature is about 36°F with temperatures ranging from a mean January minimum of 12°F to a mean July maximum of 63°F. Precipitation averages approximately 100 inches annually.

Seismic Potential. The project is located in Probability Zone 4, according to seismic risk maps of the Uniform Building Code (ICBO 1980). This is noted as the highest risk category.

Drainage Area. The damsite has a tributary drainage area of 105 square miles. The mountainous basin lies approximately 12 miles north of Seward in the Kenai Mountains. The lower elevations support the growth of timber and other vegetation while the upper elevations contain numerous glaciers with little or no vegetal cover.

Streamflow. Snow River streamflow has been measured at a point approxiately 1.5 miles upstream from the proposed damsite. The records from this gage ("Snow River near Divide") are available from December 1960 to July 1965. These records were extended by correlating with the records from the "Trail River" gage near Lawing which are available from May 1947. However, the floods caused by glacial outbursts, as they were considered in the flow data in the responses to Exhibits B and D of the License Application submitted to FERC on August 18, 1983, were not considered in this stream flow analysis or the power and energy study in Section 9. Based on this correlation, the average annual streamflow at the damsite is estimated at 660 cfs (478,000 acre-feet). Mean monthly flows vary from as little as 10 cfs in March to approximately 2,000 cfs in the July through September period.

Flood Potential From Glacier Dammed Lake. Release of water from an ice dammed lake high above the Snow River Valley has produced flood flows of about the same magnitude as storms (Post and Mayo 1971). The outburst flood of 1967 was estimated at 20,000 cfs. Historical records indicate that the glacial outburst floods in the Snow River Valley from the glacier-filled lake have occurred every 2 to 3 years. Should "outburst" flows occur simultaneously with a non-outburst flood, the combined flow could exceed 40,000 cfs.

Project Description. At the damsite (Exhibit 6), the Snow River flows in a deep, narrow gorge incised in bedrock on the floor of a steep-walled, U-shaped, glacial valley. Bedrock is well exposed in the near-vertical abutments although thin overburden mantles portions of the upper left abutment. The beds strike nearly due north, normal to the canyon, and dip steeply upstream. Insofar as could be determined from aerial reconnaissance, geologic conditions are favorable for construction of either a rockfill or a concrete arch dam at this site. A power tunnel along the right valley wall would penetrate rock similar to that exposed at the damsite.

Construction materials might be obtained from the adjacent rock outcrops along with alluvial and glacial deposits from the lower reaches of the river near its confluence with the South Fork Snow River, approximately 4 miles downstream from the site.

For estimating purposes, it is assumed that a dam would be built with the crest at approximately elevation 1,210 feet and the base at elevation 900 feet for a maximum structural height of 310± feet. The crest length would be about 820 feet.

The diversion and power tunnels would be located on the right abutment and a spillway would be constructed at the southern end of the reservoir, approximately 1 mile from the dam.

The powerplant would be connected to the reservoir by 10,000 feet of ± 11-foot-diameter tunnel and 2,000 feet of ± 8-foot-diameter surface penstock. The powerplant would have an installed capacity of 63 MW with a 50 percent plant factor.

Reservoir Characteristics. The Snow Reservoir would have a normal maximum operating level of 1,200 feet above sea level. At this elevation, the reservoir surface area would be 3,200 acres and the total storage would be 179,000 acre-feet. With a total drawdown capability of 150 feet, the active reservoir storage would be 173,000 acre-feet. This drawdown could expose 2200± acres of unsightly mud flats and/or eroded slopes devoid of vegetation. Maximum depth of the reservoir would be about 300 feet. Retention time would be 4 months. Reservoir length would be 7 miles. Lower Paradise Lake would be inundated at full pool elevation.

Project Operation. During the high runoff period of June, July, August and September the reservoir would be gradually filled from its minimum elevation of 1,050 feet. During the period October through May, the reservoir would be drawn down to its minimum level. Minimum flow for the project would be 740 cfs during June, July and August and 210 cfs at other times. These flows are based on those described in Table 2-7 of the DEIS.

Tailwater level would be 500 feet, resulting in a maximum gross head of 700 feet at full pool elevation. The average head would be 620 feet, allowing for 30 feet of head loss in the penstock. The energy output capabilities of the Snow Project were reevaluated using revised streamflow data. The 100 MW installed capacity, presented in both the License Application and the DEIS, was previously based on combined normal streamflow and flow resulting from glacial outburst flooding. This high flow gave the false impression that the Snow River could produce more continuous energy than it realistically could. Hence, a 100 MW powerplant is not appropriate for this project. Subsequent study considering only actual streamflow data (excluding flow from glacier outbursts) indicates that a 63 MW powerplant is more realistic, based on a plant factor of about 50 percent. This reduced capacity is used in this analysis as part of a more realistic preliminary design. Mean annual energy is approximately 270 GWh if the energy production is not limited by the system energy demand.

5.6 Chakachamna Dam and Reservoir

Location. The Chakachamna site would be located on the Chakachatna River, approximately 80 miles west of Anchorage (Exhibits 1 and 7).

Climate. The climate of the project area is described as transitional. Mean annual air temperature is 28°F. Temperatures range from a mean minimum of 8°F in January to a mean maximum of 69°F in July. Precipitation averages 80 inches per year.

Seismic Potential. The project would be located in Probability Zone 3, according to seismic risk maps of the Uniform Building Code (ICBO 1980). Proximity to a volcano plus the seismic potential put Chakachamna in the major damage category (corresponds to intensity VIII and higher on the Modified Mercalli Intensity Scale).

Drainage Area. The damsite has a tributary drainage area of 1,120 square miles.

Streamflow. Continuous streamflow records for the Chakachatna River near Tyonek (USGS Gage No. 15294500) are available for the period June 1959 to August 1971. This station is located at the outlet to Chakachamna Lake. Mean annual flow is 3,750 cfs (2.7 million acre-feet).

Project Description. The project (Exhibit 7) is the Bechtel recommended alternative (Alternative E, Bechtel 1983). It would consist of a rockfill dike constructed at the outlet of Lake Chakachamna. The dike would have a crest length of 600 feet and a crest elevation of 1,177 feet. Water would be diverted to a powerhouse located near the McArthur River via a tunnel 10 miles long. The diameter of this power tunnel would be 24 feet. Four vertical Francis turbines would be installed with a total installed capacity of 330 MW. The plant factor would be 45 percent. Fish passage facilities would be incorporated in the design.

Reservoir Characteristics. Chakachamna Lake would have a normal maximum water level of 1,155 feet. Reservoir area at this elevation would be 17,500 acres while the total volume would be 4,483,000 acre-feet. Active storage would be 1,105,000 acre-feet, corresponding to a drawdown capability of 72 feet. This drawdown could expose 2200± acres of unsightly mud flats and/or eroded slopes devoid of vegetation. Retention time would be 1.65 years.

Project Operation. The project would be operated to provide for fishery releases. From May through September the instream flow release would be 1,094 cfs. During the remainder of the year the instream flow release would be about 365 cfs. (These are the flows recommended in Alternative E, Bechtel 1983). The minimum flows recommended in Table 2-7 of the DEIS could not be satisfied for Chakachamna Alternative E. Since the requirements could be satisfied for Alternative D, this Alternative was used in the power and energy analysis presented in Section 9. Maximum gross head would be 945 feet and the average net operating head about 905 feet. Tailwater elevation would be at 210 feet. Mean annual energy production is estimated to be 1,301 GWh.

5.7 Watana Dam and Reservoir

Location. The potential damsite is located in the upper Susitna River Basin of Southcentral Alaska, at approximately River Mile 184. The Watana damsite is approximately 140 miles north-northeast of Anchorage.

Climate. The climate of the project area is described as continental. Mean annual air temperature is 28°F. The average temperature range is from -3°F to 64°F. Precipitation averages 24 inches per year. Average annual snowfall is approximately 100 inches.

Seismic Potential. There are no active faults crossing the site. The major source of earthquake shaking at the site may be attributed to the Benioff Zone (an interplate boundary) underlying the site at depth, the Denali fault (at a distance of approximately 43 miles), the Castle Mountain fault (at a distance of approximately 65 miles), and smaller local earthquakes occurring with no apparent surface expression in the crust of the Talkeetna terrain. The maximum local earthquake which needs to be considered would have a magnitude of 6 (Richter scale) and could possibly occur very close to the damsite (Woodward-Clyde 1983).

Drainage Area. The damsite has a tributary drainage area of 5,180 square miles. The drainage basin is bounded by the Alaska Range to the north and west, and the Chugach Mountains and the Gulf of Alaska to the south. Topography is varied and includes rugged, mountainous terrain, plateaus, and eroad river valleys.

Streamflow. Susitna River streamflow has been estimated using a linear drainage area-flow relationship between the Gold Creek and Cantwell (Vee Canyon) gage sites. The average streamflow at the Watana damsite is estimated to be in the range of 7,990 cfs (5,788,500 acre-ft/yr.).

Sediment. Reservoir sedimentation is estimated to be about 210,000 acre-feet in Watana reservoir over a 50 year period, based on a trap efficiency of 100 percent. This would result in a loss of dead storage of about 3.7 percent.

Project Description. The Susitna River flows in a U-shaped valley. The steep abutments existing at the damsite reflect the bedrock which is exposed on either side of the river. Based on feasibility level underground explorations, the Watana foundation conditions are commensurate with construction of a satisfactory earth and rockfill dam at this site.

The dam would be built with the crest at elevation 2,210 and the base at elevation 1,375. The crest length would be about 4,100 feet. An ogee type gated spillway would be located on the right abutment. A power tunnel would be connected through the right abutment to an underground powerhouse. Six generators would be installed for a total capacity of 1,020 MW. The turbines would be of the Francis type, and have a total rated output of 250,000 hp at a rated head of 680 feet.

Construction materials could be obtained from the adjacent rock outcrops along with alluvial deposits in the river valley.

Reservoir Characteristics. The Watana Reservoir will be operated at a normal maximum operating level of El 2185 ft above mean sea level. Average annual drawdown will be to El 2093 ft with Watana operating along. The maximum drawdown will be to El 2065 ft.

At El 2185 ft, the reservoir will have a surface area of 38,000 acres and a total volume of 9.47 million acre-feet. Live storage will be 3.74 million acre-feet. Maximum depth will be 735 feet and the mean depth will be 250 feet. The reservoir will have a retention time of 1.65 years.

Project Operation. As with many Alaskan hydro projects, Watana will be operated so that summer flows will be stored for release in winter. Generally, the Watana reservoir will be at or near its normal maximum operating level of 2185 feet each year at the end of September. Gradually, the reservoir will be drawn down to meet winter energy demand. The flow during this period will be governed by the winter energy demand, the water level in the reservoir, and the powerhouse characteristics.

In early May, the reservoir will reach its minimum annual level of approximately El 2093 ft and then begin to refill with the spring runoff. Flow in excess of both the downstream flow requirements and power needs will be stored during the summer until the reservoir reaches the normal maximum operating level of 2185 ft. The proposed minimum flows for the project are 5000 cfs from October through April, 6000 cfs in May, June and July, 12,000 cfs in August and the first half of September and 6000 cfs in the latter half of September. Tailwater level would be 1455 feet, resulting in a maximum gross head of 730. Mean annual energy generation is estimated to be 3500 GWh.

Further information on project operation can be found in Exhibit B Chapter 3 of the License Application.

5.8 Devil Canyon Dam and Reservoir

Location. The potential damsite (Exhibits 1 and 8) is located in the upper Susitna River Basin of Southcentral Alaska, approximately midway between Anchorage and Fairbanks.

Climate. The climate of the project area comprises cold, dry winters and warm, moderately moist summers. The average temperature range is from -3°F to 64°F. Precipitation averages 24 inches per year. Average annual snowfall is approximately 100 inches.

Seismic Potential. There are no active faults crossing the site. The major source of earthquake shaking at the site may be attributed to the Benioff zone (an interplate boundary) underlying the site at depth, the Denali fault (at a distance of approximately 40 miles), the Castle Mountain fault (at a distance of approximately 70 miles), and smaller local earthquakes occurring with no apparent surface expression in the crust of the Talkeetna terrain. The maximum local earthquake which needs to be considered would have a magnitude of 6 and could possibly occur close to the damsite (Woodward-Clyde 1983).

Drainage Area. The damsite has a tributary drainage area of 5,810 square miles. The drainage basin is bounded by the Alaska Range to the north and west and the Chugach Mountains and Gulf of Alaska to the south. Topography is varied and includes rugged, mountainous terrain; plateaus; and broad river valleys.

Streamflow. River flow has been estimated using linear drainage area-flow relationships between the USGS Gold Creek and Cantwell (Vee Canyon) gaging stations. The average annual streamflow at the damsite is estimated to be 9,080 cfs (6,578,000 acre-ft/yr.).

Sediment. With Watana in operation, about 16,100 acre-feet of sediment would accumulate in Devil Canyon reservoir in a 50 year period. This is 2.2 percent of the dead storage in the reservoir.

Project Description. The Susitna River flows in a U-shaped valley. The steep abutments existing at the damsite reflect the bedrock which is exposed on either side of the river. Based on feasibility level underground explorations, the Devil Canyon foundation conditions are commensurate with construction of a satisfactory concrete arch dam at this site.

The dam would be built with the crest at elevation 1,463 feet and the base at elevation 820±. The crest length, including thrust blocks, would be about 1,650 feet. An ogee type gated spillway would be located on the right abutment. A power tunnel would be connected through the right abutment to an underground powerhouse. Four generators would be installed for a total capacity of 600 MW. The turbines would be of the Francis type, operating at a rated full gate output of 205,000 hp at a rated head of 590 feet. Average tailwater would be at about elevation 850 feet.

Construction materials will be obtained from the adjacent high terraces along with alluvial deposits in the river valley.

Reservoir Characteristics. Devil Canyon reservoir will be operated at a normal maximum operating level of El 1455 ft above mean sea level. Average annual drawdown will be 28 feet with the maximum drawdown equalling 50 feet. At El 1455 ft the reservoir will have a surface area of 7800 acres (3120 ha) and a volume of 1.09 million acre-feet. Active storage will be 350,000 acre-feet. The maximum depth will be 565 feet and the mean depth will be 140 feet. The reservoir will have a retention time of 2 months.

Project Operation. After Devil Canyon comes on line, Watana will be operated as a peaking plant and Devil Canyon will be operated as a baseloaded plant.

Each September, the Watana reservoir will be filled up to its maximum water level. From October to May the reservoir will normally be drawn down to approximately El 2080 ft, although during dry years the reservoir will be drawn down to a minimum reservoir level of 2065 ft. In May, the spring runoff will begin to fill the reservoir. However, the reservoir will not be allowed to fill above El 2185 ft. From November through the end of July, Devil Canyon will be operated at the normal maximum headpond elevation of 1455 ft to optimize power production.

During August and early September, the Devil Canyon reservoir level will be drawn down to a minimum level of 1405 ft. When the downstream flow requirements decrease in mid-September, the Devil Canyon reservoir will be filled to El 1455 ft.

The proposed minimum flow requirements will be unchanged when Devil Canyon comes on line. At Devil Canyon, tailwater level would be 850 feet, resulting in a maximum gross head of 605 feet. Mean annual energy generation for both Watana and Devil Canyon combined will be 6900 GWh.

Further information on project operation can be found in Exhibit B Chapter 3 of the License Application (Alaska Power Authority 1983a).

6.0 Engineering Assessment of Alternative Projects

6.1 Site Assessment

6.1.1 Johnson Dam and Reservoir

6.1.1.1 General. The Johnson project location and layout are presented on Exhibits 1 and 3.

Access. No special or new access would be required. Access to the site would be provided by the existing Alaska Highway. Approximately 4,500 feet of abandoned Alaska Highway would provide on-site access to the damsite. It may be necessary to upgrade portions of the Alaska Highway and highway bridges to allow for the heavier construction traffic.

River Diversion. Based on the assumption that rock conditions are adequate for tunnelling, a diversion tunnel (± 2,500 feet long) would be provided through the right abutment. A nominal length of diversion tailrace channel (100 to 200 feet) would also be required. Upstream and downstream diversion cofferdams having a combined length of approximately 3,500 feet would be required.

Camp. The construction camp would be located in a flat area approximately 4.5 miles downstream of the immediate project work area. It would cover a total of about 100 acres of land.

Onsite Roads. Onsite roads would connect the construction areas, borrow areas and quarry, camp, etc. to the Alaska Highway as the main access. Minimal foundation excavation or stabilization may be required. The roads would have a minimum width of 20 to 30 feet.

Impervious Borrow. An impervious borrow of approximately 11.8 x 10^6 cubic yards may be provided from an area located in a low, flat floodplain between

Lake George and the Tanana River, and between the camp and dam axis. However, the floodplain along the river may prove to contain insufficient impervious borrow, in which case it may be necessary to obtain necessary borrow at higher elevations. This would involve the construction of on-site roads along steep slopes, with large excavations, creating possible stability problems.

Pervious Borrow. The entire pervious borrow capacity of 0.6×10^6 cubic yards may be obtained from existing upstream gravel pits, the river channel within the reservoir area, or both. The stretch of Alaska Highway passing through the reservoir area may be used for hauling pervious materials. A sufficient quantity of pervious material appears to be available on-site.

Rock Borrow. Approximately 45,000 cubic yards of quarry rock are needed to satisfy project needs, not considering concrete aggregate. A minimal quarry would provide for all rock needs.

Relocations. The Johnson project would require extensive and expensive relocations. About 23 miles of existing highway would have to be relocated to the south of the reservoir, requiring a 200-foot wide, cleared right-of-way (560± acres) at a cost in excess of 23 million dollars. The relocated road would be benched into steeper slopes and require larger excavations than at the present location, resulting in many high, exposed excavation slopes which do not presently exist.

As with the highway, approximately 23 miles of above-ground pipeline[1/] would have to be relocated. If the pipeline relocation does not coincide with the highway relocation, access for the pipeline construction would also have to be provided.

1/ The status of the pipeline is currently undetermined but, using a worst-case assumption, is treated herein as an active pipeline.

A new highway maintenance station would be provided adjacent to the relocated highway, complete with access from the highway. It would encompass an area of about 8 acres. Also, the community of Dot Lake and the Dot Lake landing strip would be relocated to the south rim of the reservoir. The community known as the Living Word would also need to be relocated to an area outside the project limits.

Existing gravel pits, which will be inundated upon reservoir filling, may have to be replaced with new sites outside the reservoir area.

Transmission. Transmission lines would extend from the Johnson powerhouse substation along the Alaska and Richardson highways to Fairbanks, where it may or may not be joined with the Anchorage-Fairbanks Intertie (Exhibit 2). The length of the line would be about 135 miles, and would require a 100-foot wide right-of-way (1640± acres).

6.1.1.2 Dam

Embankment. No special problems concerning dam design and construction are apparent at this time. The embankment would be a zoned section with finer grained, more impervious materials placed upstream of the dam axis, and the more pervious materials placed downstream of the axis. An inclined chimney drain, converted to a downstream blanket drain, would separate the two zones. The dam would have a 30-foot wide crest, a crest length of 6,400 feet, a maximum height of 210 feet, and a base width of about 1,200 feet at its maximum section. A 2,000-foot long saddle dam of undetermined height and zoning would be required approximately 3.5 miles northeast of the main dam.

Foundation

The Tanana River Valley contains deep, permeable, unconsolidated sediments, which are reported to be permanently frozen except for near surface deposits which are subject to summer thaw. It is most likely that these deposits (which could extend from 100 to 200 feet in depth) would have to be completely removed from beneath the dam, and the dam founded on the bedrock surface.

Disposal. Waste disposal would be upstream of the dam within the reservoir area and below the minimum normal reservoir level.

Powerhouse. The 210 MW surface powerhouse would be situated in or adjacent to the Tanana River channel. Minimal approach and tailrace channel excavation would be required.

Spillway. The spillway would be constructed in the Tanana River channel adjacent to the powerhouse. The embankment would flank the powerhouse and spillway structures. Minimal approach and tailrace channel excavation may be required.

Reservoir. The reservoir surface area would be 94,500 acres. Being so close to public transportation facilities, the reservoir would disrupt transportation facilities, and would displace communities. Based on sediment samples taken in the Tanana River basin, the active storage portion of the reservoir has a 50-year sediment deposition of 400,000 acre-feet, which would result in mud flat generation at the upstream end of the reservoir.

Existing and future transportation on the Tanana River would be disrupted by the project. If the river is to be kept navigable, locks would have to be included in the design and this would have a substantial impact on the cost of the project.

6.1.2 Browne Dam and Reservoir

6.1.2.1 General. The location and layout of the Browne project are presented on Exhibits 1 and 4.

Access. No special or new access to the site would be required. Access would be provided by the George Parks Highway and access to a point 3 miles downstream of the damsite would be provided by the Alaska Railroad. It may be necessary to improve portions of the George Parks Highway and bridges, and the railbed to provide for the heavier construction traffic.

River Diversion. A conventional tunnel diversion would be utilized, if rock conditions allow. A diversion tunnel 2,000 feet long would be provided through the right abutment. A diversion tailrace channel (1,000 to 1,500 feet in length) would probably also be required. Upstream and downstream diversion cofferdams having a total length of approximately 3,500 feet would be required.

Camp. Camp(s) would be located in relatively flat areas outside of the immediate project work area and reservoir, covering a total of about 100 acres of land.

Onsite Roads. Onsite roads would connect the construction areas, borrow areas and quarry, camp, etc. with the main access. Foundation excavation or stabilization may be required. The roads would have a minimum width of 20 to 30 feet.

Impervious Borrow. All necessary impervious borrow may be obtainable from required excavation. A minimum borrow area would be provided.

Pervious Borrow. Approximately 22.3×10^6 cubic yards of pervious borrow material would be required. All pervious borrow would be taken from the river and river banks.

Rock Borrow. All rock needs could likely be satisfied through required excavations. However, a minimum quarry would be provided to satisfy filter and concrete aggregate needs.

Relocations. Browne requires extensive and expensive relocations. Approximately 16 miles of railroad would be routed around the reservoir to the east at a cost estimated to be in excess of 15 million dollars. Because of the more rugged terrain and steeper slopes that exist along the present alignment, large localized excavations would be required. A right-of-way 50 feet to each side of the alignment would be provided and cleared for construction.

Approximately 8.5 miles of highway would be relocated west of the reservoir, and a 200 foot wide, cleared right-of-way would be required (200± acres). The relocated road would be benched into steeper slopes than at its present location, resulting in higher exposed excavation slopes than presently exist.

Existing Golden Valley Electric Association transmission facilities would have to be relocated either along the relocated highway alignment, the relocated railroad alignment, or combined with the transmission connection to Fairbanks as presented in the License Application. The route of this transmission line connection to Fairbanks would have to be modified from the route shown in the Susitna Project License Application, to an alignment just east of the reservoir.

Transmission. Transmission lines would extend from the Browne powerhouse substation, across the Nenana River, and join the proposed Healy to Fairbanks transmission connection, which would be constructed as part of the project, at a point about 2 miles east of the dam right abutment. The line would be approximately 4.5 miles in length, and would require a 100-foot wide right-of-way (60± acres). Proposed transmission alignments are shown on Exhibit 2.

6.1.2.2 Dam

Embankment. The embankment would be a zoned rolled fill consisting of a central, impervious core, and pervious/rockfill shells. It would have a 30-

foot wide crest, a crest length of 6,300 feet, a maximum height of 265 feet, and a base width of about 1,500 feet at its maximum section.

Foundation. A moderately deep excavation would be required. Approximately 50 feet of material would have to be excavated throughout the valley flood plain (4,000 to 4,800 feet in length) beneath the core and shells of the dam. Near-surface rock exists at both abutments.

Disposal. Waste disposal would be upstream of the dam within the reservoir area. It would be to an elevation below the minimum normal reservoir level.

Powerhouse. Typical powerhouse design and construction would be applicable to the Browne powerhouse. Reservoir water would be transported to the 100 MW surface powerhouse by a power tunnel through the left abutment. A 1,500 foot long discharge channel would transport downstream discharges to the river.

Spillway. The spillway would be constructed in an excavation through the steep, right abutment rock. Nominal approach and tailrace channel excavation may be required.

Reservoir. The reservoir surface area would be 12,500 acres. Because of proximity to public transportation facilities, it could disrupt transportation, and displace communites.

Schedule. Relocations would have to be executed prior to project construction to minimize the impact of the Browne project construction on the environment.

6.1.3 Keetna Dam and Reservoir

6.1.3.1 General. The location and proposed layout of the Keetna project are presented in Exhibits 1 and 5.

Access. Approximately 25 miles of access road would be required from Talkeetna east along the south bank of the Talkeetna River at a cost in excess of one million dollars per mile. Just south of the project area the access road would turn north and cross the river approximately one mile southwest of the construction camp. The access road would be 20 to 30 feet wide and require a 100-foot wide strip of right-of-way. Some improvements to the Alaska Railroad railbed, and highways and bridges to Talkeetna may be necessary to provide for construction traffic.

River Diversion. A diversion tunnel 1,500 feet long would be provided through the right abutment. Upstream and downstream diversion cofferdams would be required, having a total length of approximately 1,500 feet.

Camp. The camp would be located in a relatively flat area about 4.5 miles downstream of the immediate project work area and reservoir, covering a total of about 100 acres of land. The camp would have to be either protected from flooding by dikes, or relocated, if future studies indicate frequent flooding at the confluence of the Talkeetna and Sheep rivers.

Onsite Roads. Onsite roads would connect the construction areas, borrow areas and quarry, camp, etc. with the main access. Minimal foundation excavation or stabilization may be required. The roads would have a minimum width of 20 to 30 feet.

Impervious Borrow. An impervious borrow capacity of approximately 2.4×10^6 cubic yards would be required, and may be obtainable from borrow excavations along the river. However, should the area prove unsatisfactory for use in impervious zones of the dam, borrow may be required from higher elevations above the floodplain. Exploitation of these areas would involve more difficult and costly onsite road construction, steeper cut slopes, and possible stability problems.

Pervious Borrow. Borrow capacity of approximately 16.9×10^6 cubic yards would be needed. All pervious borrow would be taken from the river and river banks within the reservoir area, and to 3± miles downstream of the dam alignment. Sufficient pervious borrow appears to be available.

Rock Quarry. All rock needs could possibly be satisfied through required excavations. However, a minimum quarry would be provided.

Relocations. No relocations would result because of the Keetna project.

Transmission. Transmission lines (Exhibit 2) would extend from the Keetna powerhouse substation, along the east and south side of the Talkeetna River to the Anchorage-Fairbanks Intertie east of the town of Talkeetna. The length of the line would be about 11 miles, and require a 100 foot wide right-of-way along its alignment.

6.1.3.2 Dam

Embankment. The assumed design would incorporate a zoned rolled fill consisting of a central, impervious core, and pervious/rockfill shells. It would have a 30-foot wide crest, a crest length of 1,200 feet, a maximum height of 415 feet, and a base width of about 2,300 feet at its maximum section.

Foundation. Deep excavations of approximately 70 to 100 feet would have to be made throughout the deepest part of the valley. The depth of excavation would be reduced to about 25 feet at the abutments. Excavation would be beneath both the core and the shells of the dam.

Disposal. Waste disposal would be upstream of the dam within the reservoir area, and to an elevation below the minimum anticipated reservoir level.

Powerhouse. Typical powerhouse design and construction procedures are anticipated. Reservoir water would be transported to the 100 MW surface powerhouse by a 1,300 foot long power tunnel through the left abutment. A nominal length of discharge channel may be required to transport downstream flow to the river.

Spillway. The spillway would be constructed in an excavation through the left abutment rock. Nominal approach and tailrace channel excavation may be required.

Reservoir. The reservoir surface area would be 5,500 acres. As much as 65,000 acre-feet of sediment could accumulate in the reservoir in a 50-year period, possibly resulting in the development of mud flats in the upstream reaches of the reservoir.

Schedule. No scheduling problems are foreseen at this time.

6.1.4 Snow Dam and Reservoir

6.1.4.1 General. The project location and layout are presented on Exhibits 1 and 6.

Access. Access to the site would be from the Seward Highway at a point approximately 4 miles north of the project area. The access road will be 20 to 30 feet wide, and require a 100 foot wide right-of-way. However, improvements to the Seward Highway and railbed may be necessary to provide for construction traffic.

River Diversion. A diversion tunnel (2,000 feet long) would be provided through the left abutment if rock conditions permit. A diversion tailrace channel (200 to 300 feet in length) and upstream and downstream diversion cofferdams having a total length of approximately 750 feet would be required.

Camp. The camp would be located in a relatively flat area about 1.5 miles west of the immediate project work area and reservoir, covering a total of about 100 acres of land.

Onsite Roads. Onsite roads would connect the construction areas, borrow areas and quarry, camp, etc. with the main access. Minimal foundation excavation or stabilization may be required. The roads would have a minimum width of 20 to 30 feet.

Impervious Borrow. Approximately 0.6 x 10^6 cubic yards would be required for construction.

Pervious Borrow. A borrow capacity of approximately 5.8 x 10^6 cubic yards would be needed. All pervious borrow would be taken from the river and river banks within the reservoir area and downstream to the confluence of the Snow and South Fork Snow Rivers.

Rock Borrow. All rock needs could possibly be satisfied through required excavations. However, a minimum quarry would be provided.

Relocations. No relocations are involved with the Snow project.

Transmission. Transmission (Exhibit 2) would be approximately 87 miles north from the Snow powerhouse substation, generally following the alignment of the Alaska Railroad, to Anchorage, where it may or may not be joined with the Anchorage-Fairbanks Intertie. The length of the new line (cost estimated to be $700,000), requiring a 100-foot-wide right-of-way, would be approximately 4 miles (50± acres), from the substation to the existing transmission facilities connecting Anchorage to Seward. The approximately 83 miles of existing lines would have to be upgraded to accommodate Snow energy generation.

6.1.4.2 Dam

Embankment. The embankment would be a zoned section consisting of a central, impervious core, and pervious/rockfill shells. It would have a 30 foot wide crest, a crest length of 820 feet, an estimated maximum height of 310 feet, and a base width of about 1,750 feet at its maximum section. Additional freeboard may be required to allow for reservoir storage of glacier outburst floods without overtopping the dam.

Foundation. Between 20 feet and 80 feet of material would have to be excavated throughout the foundation, with the deeper excavations occurring near and in the river channel. Foundation excavation would be beneath both the core and shells of the dam.

Disposal. Waste disposal would be upstream of the dam within the reservoir area, and to a level below the minimum normal reservoir level anticipated.

Powerhouse. Reservoir water would be transported to the 63 MW surface powerhouse by a 10,000 foot long power tunnel and 2,000 foot long penstock. The power tunnel would be located through the right abutment. A 2,000 foot long discharge channel would transport flow back to the Snow River. Penstock construction would require a 50 foot wide right-of-way. No problems would occur during design and construction of the tunnel provided the rock along the power tunnel alignment is of acceptable quality. This could be verified only by extensive and expensive exploration.

Spillway. The spillway would be constructed in a shallow valley at the southern end of the reservoir approximately 1 mile southeast of the dam. Nominal approach channel excavation may be required; 3,200 feet of tailrace channel excavation would be necessary. Unusual problems associated with the spillway would include the need to provide sufficient capacity to allow storage of glacier outburst floods without overtopping the dam, and dissipation of the surcharged reservoir without causing flooding downstream of the project. The increased spillway size would materially add to the project cost.

Reservoir. The reservoir surface area would be 3,200 acres. Portions of the Paradise Valley trail and Lower Paradise Lake would be inundated. The potential for glacial outburst floods on the Snow River would necessitate special operating procedures, a larger (or possibly emergency) spillway, additional project freeboard, and possibly other protective measures.

Schedule. There are no scheduling problems foreseen.

6.1.5 Chakachamna Dam and Reservoir

6.1.5.1 General. The project location and layout are shown on Exhibits 1 and 7.

Access. Access would be to within approximately 15 miles of the project site along existing roads from Tyonek. These roads would require improvement and possible widening prior to the start of construction. Access from Anchorage -- Tyonek would be either by water during the navigable months, by a road constructed between Tyonek and Anchorage, or both. Port improvements at Tyonek would be necessary. Access from the existing roads from Tyonek would be extended to both the dam area and to the powerhouse area by two 20 to 30 foot wide roads having a total length of approximately 24 miles. A 100 foot wide cleared right-of-way would be required along the entire length of new access road (290 acres).

River Diversion. No particular diversion problems are foreseen as the river would flow unimpeded during spillway construction; the spillway area would be cofferdammed to prevent flooding during construction. Following spillway construction, construction cofferdams would be removed from around the spillway, and the Chakachatna River diverted through the completed structure while the dam is constructed. The total length of cofferdam required from both stages of construction would be about 800 feet.

Camp. Camps would be located in relatively flat areas outside of the immediate project work areas, covering a combined total of about 100 acres of land.

Onsite Roads. Onsite roads would connect the construction areas, quarry, camp, etc. with the main access. Minimal foundation excavation or stabilization may be required. The roads would have a minimum width of 20 to 30 feet.

Impervious Borrow. Impervious borrow would probably be obtained from required excavations.

Pervious Borrow. Coarse grained materials would be obtained from the Chakachatna River channel, or processed from crushed quarry stone.

Rock Quarry. All rock would be obtained by developing onsite quarries in reasonable proximity to the dam.

Relocations. No relocations would be required.

Transmission. Transmission lines (Exhibit 2) would extend from the Chakachamna powerhouse substation, approximately due east and across the Knik Arm to Anchorage, where they may or may not join the Anchorage-Fairbanks Intertie. The length of the line would be about 130 miles, and require a 200-foot-wide right-of-way (3150 acres) at a cost estimated to be $60,000,000.

6.1.5.2 Dam

Embankment. The embankment would be a zoned section consisting of a central, impervious core, and pervious/rockfill shells. It would have a 20 foot wide crest, a crest length of 600 feet, a maximum height of about 30 feet, and a base width of about 200 feet at its maximum section.

Foundation. Some excavation of fine grained unconsolidated and/or frozen overburden deposits would be required beneath the core and shells of the dam.

Disposal. Waste disposal would be upstream of the dam along the north bank of the Chakachatna River and Lake Chakachamna. Waste would be graded to present a neat, well drained surface since it would be exposed most of the time.

Powerhouse. Chakachamna Lake water would be transported to the 330 MW underground powerhouse by a 10-mile long power tunnel which taps the southeast rim of the lake. A 100-foot long discharge tunnel would transport flow from the powerhouse to the McArthur River. Potential engineering problems could exist if the rock quality along the tunnel alignment is poor, or if high in-situ stresses exist in the rock at the underground powerhouse location due to the nearby presence of the Lake Clark-Castle Mountain fault. These potential problems would necessitate extensive and expensive subsurface exploration.

Spillway. The spillway would form the right abutment of the dam. A 210 foot approach channel would discharge directly into the Chakachatna River without need for tailrace channel excavation.

Fish Passage Facility. The fish passage inlet facility would be located approximately 350 feet southwest of the spillway. A 930-foot-long approach channel would direct lake water to the inlet facility, where it would be connected by a 3,000 foot tunnel to outlet facilities downstream on the south bank of the Chakachatna River. The engineering feasibility and cost of such a fish passage facility would depend upon the adequacy of the rock quality along the tunnel alignment.

Reservoir Characteristics. Chakachamna Lake would provide the necessary reservoir storage and would have a maximum operating level of elevation of 1,155 feet and a minimum operating level of elevation 1,083 feet.

Schedule. Roadway construction and improvements, and Tyonek dock facilities improvements would have to be completed prior to project construction. Winter boat transport restrictions would necessitate scheduling the majority of supply and equipment deliveries to the site during the months of the year that are navigable. Access to Tyonek by air would be available year-round.

6.1.5.3. Project Risk.

Project risk was discussed in detail by Bechtel (1983). It was found that the project would be attended by a number of risks associated with the physical layout of the project structures and natural phenomena occurring within and adjacent to the project area.

Lake Tapping. It has been presumed that a location can be defined by exploration where suitable rock conditions for lake tapping exist, based upon observed rock conditions above the lake water level. However, the exact physical location, design requirements and details would require a significant amount of design phase subsurface exploration.

Tunnel Alignment Rock Conditions. As mentioned previously, bedrock characteristics as they may affect tunnelling conditions have not been studied. High pressure ground water and adverse rock conditions are factors which could add to the cost of constructing the power tunnel. The great depth of rock cover prevents exploration at tunnel grade except near the two ends, and ice covering 25% of the alignment does not permit observation of the surface rock. In the absence of exploration over so much of the tunnel length, more water at high pressure, and more highly stressed rock than anticipated, might be encountered during construction of the tunnel. In that case, the constructed cost would be greater than current estimates indicate.

Underground Powerhouse Site. The location of the powerhouse should follow design level exploration, construction of an exploratory adit, and laboratory and in-situ measurement of the engineering properties of the rock. The possibility exists that high in-situ rock stresses may occur near the underground powerhouse excavation due to the nearby presence of the Lake Clark-Castle Mountain fault.

Barrier Glacier. Barrier Glacier contains Chakachamna Lake and controls its water level. No evidence of surging has been reported in Barrier Glacier. However, it has gone through various cycles of advance and retreat in recent time, and may reasonably be expected to continue to do so in the future. The extent to which such cycles might affect the lake level, and thus the amount of active storage, which would, in turn, affect power generation, cannot be predicted with certainty.

Blockade Glacier. Blockade Glacier is fed by large snow fields high on the southerly slopes of the Chigmit Mountains to the south of McArthur canyon. The glacier impounds Blockade Lake, which is the source of outburst floods that discharge into the McArthur River.

The present terminal moraine of the northeasterly flowing lobe of Blockade Glacier lies within about 1.5 miles of the mouth of the McArthur Canyon. If the Blockade Glacier were to advance during the life of the project, it is conceivable that the morainal material could also advance toward the McArthur River and cause the river bed to aggrade downstream of the mouth of the canyon. This could cause a rise in tailwater level to occur at the powerplant site with the extreme consequence being a flooding of the powerhouse.

The remote possiblity that climatological changes and consequent changes in mass ice balance may trigger surging of the Blockade Glacier during the life of the project cannot be forecasted or evaluated with any degree of certainty. Surging of the Blockade Glacier is considered to be the most likely mechanism that could be expected to produce an advance of the glacier that might impact on the proposed McArthur powerhouse site.

McArthur Glacier. The terminus of this glacier lies in the McArthur canyon about 5 miles upstream from the proposed powerhouse site. An advance of the glacier over that distance, although remotely possible, would endanger the tailrace channel and portals of the tailrace tunnel and access tunnel to the underground powerhouse.

Mt. Spurr Volcano. The summit of Mr. Spurr lies about 7 miles northeasterly from the outlet of Chakachamna Lake and 7.5 miles from the proposed power intake site. The intake could be located further to the west and away from the volcano, but this would increase the length and cost of the power tunnel, and also the difficulty and cost of access to the intake site along the precipitous mountain slopes on the south side of the lake.

Mt. Spurr is regarded by some volcanologists to be similar, in several respects, to Mt. St. Helens in the State of Washington whose May 18, 1980 eruption devastated a 200-square-mile area. Present technology for predicting volcanic activity is limited to the short term, and there is no way to forecast when Mt. Spurr will next erupt, or whether it might erupt during the life of the project. Mt. Spurr's last major eruption occurred on July 9, 1953. A catastrophic blast, such as occurred at Mt. St. Helens, is a rare event, but of course cannot be ruled out. The general direction of a future eruption is expected to be directly across and down the Chakachatna Valley. The proposed power intake site on Lake Chakachamna could be an area of ash deposition. It could also be affected by a large landslide or mudflow, or by hot blasts from pyroclastic flows, if such were to occur. The evidence is that these have occurred in the past, particularly in the Chakachatna Valley.

While future events similar to the 1953 eruption would probably have little effect on the ability of the power facilities to continue in operation, they could readily put the fish passage facilities out of service. Another mudflow could dam the river below Crater Peak thus causing it to back up and flood the proposed structure at the downstream end of the fish passage facilities. The reduced flow in the Chakachatna River would not have the same erosive power to cut its way down through the debris dam and it could well become necessary to mechanically excavate a channel through the debris to lower the water level and return the fish passage facilities into operation. A catastrophic event of the Mt. St. Helens type, if directed towards the lake outlet and intake structure, could have very serious consequences and possibly bury both the upstream and downstream ends of the fish passage facilities, and the power intake, beneath a massive mudflow. The tremendous amounts of heat released by pyroclastic ash flows could melt ice in the lower parts of the Barrier Glacier and interfere with the glacier's ability to continue to contain Lake Chakachamna.

The powerhouse and associated structures in its vicinity would probably not be significantly affected by volcanic activity at Mt. Spurr because they are shielded from the direct effects of a volcanic blast by the high mountains between the Chakachatna and McArthur valleys.

Seismic Risk. The site lies within a zone of high seismic risk. Potential seismic sources which may affect the project site are the subduction zone faults in the crustal seismic zone and severe volcanic activity. The Lake Clark-Castle Mountain fault (crustal source) and the megathrust segment of the subduction zone are considered the most critical with respect to peak ground acceleration and duration of strong shaking at the site.

The Lake Clark - Castle Mountain Fault is a major regional fault that has been traced for over 300 miles. At least one crossing of the fault by the power transmission line cannot be avoided; this will be in the vicinity of the mouth of the McArthur Canyon. The powerhouse switchyard also would be in this vicinity. Thus, some of the transmission towers and switchyard structures would be subjected to very strong shaking in the event of a major earthquake on the fault near the McArthur Canyon. Underground structures would probably be less vulnerable to damage than surface structures. The structures can be designed to withstand the strongest lateral forces expected to occur, but it is not possible to design against significant displacement in the foundation at any given structure site. Consequently structures should not be located in the fault zone.

The Bruin Bay Fault is one of the major regional faults in Southcentral Alaska. In the vicinity of the project site, it is inferred to occur more or less parallel to the Cook Inlet coastline about 20 miles southeast of the mouth of the McArthur Canyon.

Four features which may be significant to the project have been identified in the Chakachatna Valley. These features include faults which may offset Holocene deposits (less than about 2 million years old); also, one of the features trends toward the site of the proposed power intake structure. Further study of the project should include evaluation of the age and extent of faulting which is related to these features, in order to better assess the potential for fault displacement at or near project structures.

6.1.6 Watana Dam and Reservoir

6.1.6.1 General. The project location and layout are presented on Exhibits I and 8.

Access. Access to the Watana damsite will connect with the existing Alaska Railroad at Cantwell where a railhead and storage facility occupying 40 acres will be constructed. This facility will act as the transfer point from rail to road transport. From the railhead facility the road will follow an existing route to the junction of the George Parks and Denali Highways (a distance of two miles), then proceed in an easterly direction for a distance of 21.3 miles along the Denali Highway. A new road, 41.6

miles in length, will be constructed from this point due south to the Watana camp site. This road will require a 200 foot right-of-way.

River Diversion. Diversion does not present any foreseeable problems, based upon existing subsurface exploration information. Two diversion tunnels (4,050 and 4,140 feet in length) will be provided through the right abutment. A total combined discharge channel length of 500 feet will be involved. Upstream and downstream diversion cofferdams having a total length of approximately 1,200 feet will be required.

Camp. The construction camp will be located in relatively flat areas north and northeast of the immediate project work area and reservoir, covering a total of about 200 acres of land. No particular location problems are expected.

Onsite Roads. Onsite roads will connect the construction areas, borrow areas and quarry, camp, etc. with the main access. Minimal foundation excavation or stabilization may be required. The roads will have a minimum width of 20 to 30 feet.

Impervious Borrow. Impervious borrow will be obtained from required excavations and borrow. Borrow areas covering approximately 900 acres of land will be provided.

Pervious Borrow. Pervious borrow will be provided by borrow pits along the Devil Canyon-Watana access link, and from the river and river banks.

Rock Borrow. A left abutment quarry supplemented by the required excavations will provide for rock and aggregate needs.

Relocations. No relocations will be required because of the Watana project.

Transmission. Transmission lines (Exhibit 2) will extend from the Watana powerhouse substation to the Gold Creek switching station where it will join the Anchorage-Fairbanks Intertie. The length of the line will be about 45 miles, and require a 300 foot wide right-of-way. No special problems associated with the transmission line are foreseen.

6.1.6.2 Dam

Embankment. The embankment will be a zoned section consisting of a central, impervious core, and pervious/rockfill shells. It will have a 35 foot wide crest, a crest length of about 4,100 feet, a maximum height of 885 feet, and a base width of about 4,000 feet at its maximum section. No unusual problems associated with dam design or construction are anticipated.

Foundation. Approximately 110 feet of material will have to be excavated beneath the core and shells of the dam to allow it to be founded on bedrock.

Disposal. Waste disposal will be upstream of the dam within the reservoir area, and to a level below the minimum normal reservoir.

Powerhouse. Reservoir water will be transported to the 1,020 MW underground powerhouse by three 500-foot-long concrete and steel-lined tunnels through the right abutment. A 1,000-foot-long approach channel will direct water to the upstream end of the tunnel, and 1800-foot-long tailrace tunnels will direct flow from the surge chamber downsream of the powerhouse to the river. No unusual problems are foreseen based on existing subsurface exploration data.

Spillway. The service spillway and spillway excavation will be constructed in the steep, right abutment. Approach and tailrace channel excavation (4,000 lineal feet) will be required. No unusual problems are anticipated.

Reservoir. The reservoir surface area will be 38,000 acres.

Schedule. Construction access roads and railroad will have to be scheduled for completion prior to mobilization so as not to delay construction.

6.1.7 Devil Canyon Dam and Reservoir

6.1.7.1 General. The project location and layout are presented on Exhibits 1 and 8.

Access. Access to the Devil Canyon development will consist primarily of a railroad extension from the existing Alaska Railroad at Gold Creek to a railhead and storage facility adjacent to the Devil Canyon camp area.

To provide flexibility of access, the railroad extension will be augmented by a road between the Devil Canyon and Watana damsites. From the railhead facility at Devil Canyon a connecting road will be built to a high-level suspension bridge approximately one mile downstream of the damsite. The route then proceeds in a northeasterly direction. After crossing Tsusena Creek, the road continues south to the Watana damsite. The overall length of the road is 37.0 miles.

The road and railroad route mainly traverse terrain with gentle to moderate side slopes, where a right-of-way width of 200 feet will be sufficient. Only in areas of major sidehill cutting and deep excavation will it be necessary to go beyond 200 feet.

River Diversion. A diversion tunnel (1,500 feet long) will be provided through the left abutment. A diversion tailrace channel will be required. Upstream and downstream diversion cofferdams having a total crest length of approximately 500 feet will be required. Based upon existing subsurface exploration data no diversion problems are anticipated.

Camp. The camp will be located in a relatively flat area about 2-miles downstream of the immediate project work area on the left side of the river. A total of about 100 acres of land will be utilized.

Onsite Roads. Onsite roads will connect the construction areas, borrow areas and quarry, camp, etc. with the main access. Minimal foundation excavation or stabilization may be required. The roads will have a minimum width of 20 to 30 feet.

Pervious Borrow. All pervious borrow will be taken from the river and river banks, or from the borrow pits located along the main access between the damsite and Gold Creek.

Rock Borrow. All rock needs could possibly be satisfied through required excavations; a minimum quarry would be provided.

Relocations. No relocations will be required because of the Devil Canyon project.

Transmission. Transmission lines (Exhibit 2) will extend from the Devil Canyon powerhouse substation, paralleling the transmission lines from Watana, and join the Anchorage-Fairbanks Intertie at the Gold Creek switching station. The length of the line will be about 10.5 miles, and will not require a special right-of-way because of the Watana transmission which will then exist.

6.1.7.2 Dam

Structure. The Devil Canyon Dam will be a thin, double curvature concrete arch dam. No problems with dam design and construction are anticipated at this time.

Foundation. The dam will be founded on sound bedrock. An excavation depth of approximately 20 to 40 feet will be required to attain foundation level.

Disposal. Waste disposal will be upstream of the dam within the reservoir area. It will be placed below the minimum normal reservoir level.

Powerhouse. Reservoir water will be transported to the 600 MW underground powerhouse through the right abutment by a 250-foot-long approach channel and 900-foot-long concrete and steel lined power tunnels. A 6,800-foot-long tailrace tunnel will direct water from the surge chamber downstream of the powerhouse to the river. A 200-foot-long excavated channel will be at the downstream end of the tailrace tunnel. No particular problems with design or construction are foreseen at this time based on available subsurface information.

Spillway. The spillway will be incorporated into the dam.

Reservoir. The reservoir surface area will be 7,800 acres.

Schedule. No unusual scheduling problems are anticipated.

6.2 Comparison of Non-Susitna Alternative Projects with the Proposed Project

6.2.1 Summary and Conclusions. Development of the Watana and Devil Canyon sites would result in less potential engineering design and construction problems than the five alternatives - Browne, Johnson, Keetna, Snow, and Chakachamna. The major problems with the alternatives include the massive amounts of relocation involved, and the possible difficulty in finding impervious borrow material. Sedimentation and flooding are also potential problems with the alternatives. Table 1 summarizes the engineering assessments for each alternative and additional descriptions are provided below.

6.2.2 Comparisons

Access. There do not appear to be any unusual access difficulties for any of the hydro alternatives, except for Chakachamna and Watana. Watana access would be long and expensive, involving both rail and roadways, Chakachamna access would not only be long and expensive, but would also involve much improvement to existing facilities.

River Diversion. There are not any apparent diversion difficulties for any of the sites, provided that bedrock is of acceptable quality for tunnelling.

Camp. With the information available, all camp locations appear acceptable. The Keetna camp site may be subject to flooding, depending upon the hydraulic conditions at the confluence of the Talkeetna and Sheep rivers. Dike protection may be necessary.

On-Site Roads. No unusual difficulties at any of the project sites are evident.

Impervious Borrow. Obtaining sufficient quantitites of impervious materials could be a problem at the Johnson and Keetna sites. Additional on-site roads, involving construction on steep slopes to gain access to higher elevations where impervious material may be more readily available, is a possibility.

Pervious and Rock Borrow. Sufficient pervious and rock material should be available at all project sites.

Relocations. The Browne and Johnson sites would require a substantial amount of relocation of public transportation facilities, transmission lines, road maintenance facilities, towns and communities, and other miscellaneous features which will be inundated upon reservoir filling. None of the other sites evaluated require any relocations.

Transmission. Johnson, Snow, and Chakachamna sites are remotely located with respect to the Anchorage-Fairbanks Intertie, and would require long transmission trunk lines to connect to the Intertie.

Dam. On a preliminary basis, none of the dams, whether embankment or concrete, appear to present any unusual design or construction problems.

Foundation. All of the sites would require substantial foundation excavation to remove pervious, loose, and possibly frozen unconsolidated materials from the river channels and immediate floodplain on either side of the river. Chakachamna, being a low dam, may or may not require such extensive foundation preparation.

Disposal. Disposal can be handled acceptably at all sites.

Powerhouse. Those sites which will include either a power tunnel or an underground powerhouse may require special design and construction considerations depending upon the quality of the rock along the structure alignment. The Chakachamna power tunnel, which is approximately 10 miles long, would require very detailed geologic investigation and study because of its greater susceptibility to problems created by changes in geology along its length.

Spillway. No unusual design or construction problems are foreseen at any of the project sites.

Reservoir. Special engineering considerations would be required at the Browne, Johnson, Keetna, and Snow sites. Browne and Johnson reservoirs will necessitate extensive relocations. Johnson and Keetna reservoirs will be particularly susceptible to sedimentation and the development of mud flats, which will result in lost storage capacity and therefore winter energy generation. The Snow site is periodically subjected to glacial outburst flooding, which will require special design treatment involving increased project freeboard, increased spillway capacity or emergency spillways, or a reduced operating pool level.

Schedule. The Browne and Johnson projects would require proper scheduling to enable relocation of transportation facilities far enough in advance of project implementation so that no interruption in the transportation facilities occurs. Improvements to existing access facilities for Chakachamna (Tyonek dock facilities, existing roads, etc.) would have to take place sufficiently in advance of mobilization so as not to cause delays in the work.

6.3 Transmission Lines

Both the Susitna project and the non-Susitna alternatives would utilize the transmission intertie connecting Anchorage and Fairbanks. In addition, there would be the individual links between projects and the Intertie. The transmission facilities would include 370 miles of overhead transmission line, 4 miles of submarine transmission line, switchyards, and substations.

The right-of-way (ROW) acreage for the non-Susitna hydroelectric sites is approximately 3000 acres more than the Proposed Project (13,790 acres compared to 10,600 acres for Susitna). These total ROW acreage figures are based on approximate ROW widths for various line voltages and on line lengths, including the intertie upgrade between Fairbanks and Anchorage.

7.0 Environmental Evaluation of Alternative Sites

7.1 Background

In this section (7.0), the Power Authority supplements and evaluates the environmental information that FERC presented in the DEIS with information that has been obtained or became available since the initial screening study. This section is presented in the following manner to assist in the review of potential environmental impacts. In Section 7.2, a description of environmental components of each non-Susitna site (Johnson, Browne, Keetna Snow, and Cnakachamna) is presented. Included in this description is a discussion concerning potential impacts (primarily to human resources, terrestrial resources and aquatic resources) at each site. In Section 7.3, comparisons are made among the sites. Finally, in Section 7.4, a summary and conclusions are presented concerning the potential environmental consequences of the non-Susitna hydro generation scenario.

7.2 Site Analysis

7.2.1 Johnson Site

7.2.1.1 Social Sciences

Socioeconomics

The communities that would most likely experience socioeconomic impacts from development of the Johnson site include Tok, Delta Junction, Tanacross, Dot Lake, and The Living Word (a community located on Dry Creek) (see Exhibit 1). The most serious impact would be the inundation of Dot Lake and The Living Word, causing the displacement of all residents from their homes, social settings, and sources of livelihood. It is assumed that the costs of relocating both these communities to other suitable sites would be born by the Applicant.

Dot Lake with a population of approximately 50 people, is a Native community settled in the late 1940's whose residents are primarily Athabaskans (Martin 1983). Some non-Athabaskans have moved into the community in the last ten years. Hunting, trapping, fishing, and plant gathering are very important to residents, primarily due to the limited, unreliable, and temporary nature of wage employment (Martin 1983). The seriousness of Dot Lake's possible relocation is unknown since information regarding the relocation and adjustment of Alaskan Native communities to new places due to dam construction is nonexistant. What is available, however, is extensive research on the effects of displacement due to hydro projects in Africa (Scudder 1971 and 1977), related Alaskan studies which focus on relocation of Native communities to internment camps during World War II, and studies on the relocation or consolidation of a number of communities around regional schools or other services. Even though these studies do not address the situation which could arise at Dot Lake, many effects for those places studied have been negative.

The Living Word is a small non-Native religious community of approximately 200 people located on Dry Creek which was founded in the early 1970's. This community is an incorporated, non-profit corporation dependent on farming, timber sales, and services provided to nearby towns. Its inundation would create serious consequences for residents (Guinn 1984) since the community would no longer exist and residents would 'ave to relocate and reestablish their sources of livelihood, their homes and overall patterns of interaction with each other and the surrounding environment.

Tok, an unincorporated town providing services for tourists and other traffic along the Alaska Highway, had a population of 750 residents in 1980 (FERC 1984). Delta Junction, a larger, incorporated community with a 1982 population of 1,044 (FERC 1984), provides full community services that include a fire station and health center and is also tourist-oriented.

A projected population influx of 1,300 persons during the peak construction period would nearly double the population of the Tok-Delta Junction area causing both communities to experience severe socioeconomic impacts. This number reflects only the construction work force for the dam and not the construction or relocation of roads, railroads, and transmission lines. Therefore, the influx would probably be greater than 1,300.

Since the majority of immigrants would reside in Tok and Delta Junction, about 400 new houses would be required. In addition, community services would have to be expanded considerably. Commercial operations would also require expansion and new ones would probably be opened. The benefits of these expansions might be tempered by a decrease in the rural, undeveloped nature of the area and a change in the quality of the setting for current residents.

Tanacross (1982 population of 117) is a Native community located between Tok and the Johnson site (FERC 1984). The community was incorporated in May 1980 and the land is in the process of being conveyed from the regional corporation to the village corporation and then to individuals. Project development could result in serious impacts to this community due to cultural conflicts and interference with subsistence activities.

The Johnson project would also inundate a lodge, three gravel pits, a highway maintenance station, a telephone line, two stream-gaging stations, portions of the Alaska Highway and a pipeline, and airstrips at Dot Lake and The Living Word. Again, it is assumed that the costs of relocation would be born by the Applicant.

Land Use

The area in and around the Johnson site is primarily forest, wildlife habitat, and recreation land with isolated settlements, mineral and gravel extraction areas, and transportation and utility corridors. Seasonal uses of the area include sport hunting and fishing and subsistence activities.

These uses would be greatly impacted by the 94,500 acre reservoir created by the dam and by access to new areas opened up by roads, transmission corridors and the re-routing of portions of the existing highway and pipeline. That is, much land would be lost to hunting while at the same time, some areas would experience new hunting pressure. Additionally, the inundation of portions of the existing highway and pipeline, a highway maintenance station, three gravel pits, two gaging stations, a telephone line, and the communities of Dot Lake and The Living Word, would also result in severe land use changes and impacts resulting from the required relocation of these routes and facilities. Moreover, since land ownership within the project area is complex and includes State forest lands, Native lands, and private tracts acquired through the State of Alaska's land disposal program, the acquisition of access and inundation rights through purchases or easements could pose problems.

Cultural Resources

No historic or archeological sites are currently known at the Johnson damsite or within the resulting impoundment area. However, this reflects the lack of surveys conducted in the area rather than a lack of cultural resources. The general geographic similarities between the Johnson and Proposed Project areas suggests that the Johnson site, if subject to the same level of survey as the Proposed Project area, would be found to contain a large number of cultural resources sites. Construction and operational impacts can be expected to be of the same type as those associated with the Susitna development. Mitigation measures would also be qualitatively similar, with an anticipated emphasis on data recovery (salvage excavation) from significant sites within direct impact areas.

Recreation

The Tanana River is proposed by the State as a multiple-use river. This proposal recommends that approximately 300 feet beyond each river bank be retained in public ownership (Alaska Department of Natural Resources (ADNR)

1983). Guidelines under this classification allow for limited development sucn as cabins, agriculture, and timber harvest, right-of-way and utility corridors. The Tanana River is heavily used for private and commercial river boating, primarily in the lower river. A charter boat service is located at Dot Lake.

The Tanana River also supports a moderate level of sport fishing with intensive fishing occurring in a number of small lakes in the area (Martin 1983). Lake George, located northeast of the damsite (Exhibit 3), is used for recreational boating and fishing. Lowlands along the river corridor support intensive small game hunting while intensive 1/ big game hunting occurs throughout the general project area (ADNR 1984a). There are many multiple-use trails throughout the area. The trails to Knob Hill and Robertson River are recommended by the ADNR for protection from incompatible uses and visual impacts (ADNR 1983).

Developed recreation is focused primarily on public campgrounds, waysides, lodges, and service facilities oriented towards recreationists and sight-seers traveling down the Tanana Valley on the Alaska Highway. Sightseeing in the project area is oriented across the project site towards views of the Wrangell Mountains and wildlife viewing in the valley.

1/ Designations of intensive and moderate are defined by ADNR (1982) as follows:

Intensive - areas identified by both the Alaska Department of Fish and Game (ADF&G) and personal interviews.

Moderate - areas identified only through personal interviews or by ADF&G.

Recreation impacts resulting from the Johnson project would include: loss of 94,500 acres used for hunting and fishing; loss of recreational boating and river transportation; and inundation of at least 23 miles of the Alaska Highway with associated wildlife viewing areas, viewpoints, as well as loss of recreation support facilities at Dot Lake. Relocation of the highway and introduction of 135 miles of new transmission line, a 210 foot high and 6,400 foot long dam and existence of other facilities would reduce the attractiveness of the area for recreation and sightseeing, especially from trails recommended by the State for protection mentioned previuosly.

The new reservoir would have only very limited recreation value as a result of extensive mud flats and shore erosion during drawdown. Sightseeing and perceptual impacts to recreationists could occur in the vicinity of Lake George due to the presence of a saddle dam less than a mile from its shores. Competition for resources and facilities through increased use of the area resulting from new access and more people may also occur. Recreation demand would likely increase substantially due to the predicted doubling of the resident population.

This, in turn, would result in increased use of existing regional and community recreation facilities.

<u>Aesthetics</u>

The dominant landform in the Johnson project area is the Alaska Mountain Range. The Johnson River is located in a glaciated U-shaped valley. It is a braided river that flows toward the broad valley of the Tanana River, which is bordered by the Alaska Range to the south and rounded, gentle ridges and slopes of the Yukon-Tanana upland area to the north. The vegetation near the damsite is predominantly bottomland spruce-poplar forest. Vegetation at higher elevations is mostly upland spruce-hardwood forest.

This section of the valley is considered by ADNR to have moderate scenic value and the highway has been recommended for scenic protection by ADNR

(1983) in the Tanana Basin Plan. Guidelines for this classification allow limited development as long as it does not degrade or detract from the scenic quality and views of the area. Major views to the north are oriented to the Wrangell Mountains and the Knob Ridge area to the south. Foreground views concentrate on the river lowlands and associated wildlife. Notable natural features are the Tower Bluff Rapids and the bluffs themselves at the southeast end of the inundation zone. Extended views of various tributary valleys such as the Robertson, Johnson, Billy, and Sand valleys are also possible.

Impacts will primarily result from the flooding of 94,500 acres of valley land and wildlife habitat. Further impacts will result from the relocation of a section of the Alaska Highway and an existing above grade pipeline onto steeper land due to the significant amount of construction activity and cuts into the mountainous terrain. Since the Alaska Highway is a major travel route in Alaska, the visual impacts of the reservoir and other project facilities would be visible to a large number of people and therefore are quite significant. Foreground views will be dominated by the reservoir with its associated mud flats, which will be extensive. Valley vistas will be flooded, as will Tower Bluff Rapids. Views up and down the valley will be further degraded by the introduction of 135 miles of new, project-related transmission lines. New right-of-way will be required for 45 of the 135 miles of transmission line. Views of the 210 foot high by 6,400 foot long dam and associated facilities would be possible for some distance down the valley.

7.2.1.2 Terrestrial Resources

The Johnson project would create a reservoir inundating approximately 94,500 acres of wildlife habitat. In addition, vegetation and animals would be disturbed due to the construction of the transmission lines and relocation of the existing highway. The impacted area is mainly bottomland spruce-poplar forest with the Tanana River floodplain supporting riparian vegetation. The broad floodplain is dissected by side channels and sloughs, creating a mosaic of embankments and islands vegetated with shrubs and poplar. In the foothills to the north and south of the Tanana River, and along the Johnson River, the vegetation is mostly spruce-hardwood forest. In the Sand Creek and Billy Creek drainages and in portions of the Tanana bottomlands, the mainstem channel and side sloughs have created wide areas of wetlands (wet meadows, bogs, and ponds) and lowlands covered with sedge-grass and low shrub communities. Based on estimates made from U.S. Geological Survey topographic maps, approximately 30,000 acres of lowland wetlands are present in the area. At higher elevations, the spruce-covered mountain slopes give way to low shrub and alpine tundra communities.

The impoundment zone from Johnson Slough to Billy Creek, and the Billy Creek drainage are important moose winter range because it is a low elevation area and contains early successional vegetation important as moose forage, within active flood plains. The Billy Creek drainage is an important calving area and summer range. In the fall, moose move into the nearby subalpine draws to mate. Subalpine willow stands provide food until heavy snows force the animals down to critical windblown areas along the Tanana River floodplain (ADNR 1984b; Martin 1983). The Tanana River lowlands and the Sand and Billy Creek drainages probably represent critical winter range for local moose populations during severe winters. Average year-round moose densities in the area have been estimated to be 1 moose/mi^2 (Johnson 1984).

The Macomb caribou herd frequents the Macomb Plateau, two to three miles south of the proposed impoundment in the vicinity of Dry Creek. The animals generally do not occur in the impoundment zone. However, during severe winters of deep snow, some animals will utilize the Tanana River drainage, especially the Johnson Slougn-Sand Creek flats area (Martin 1983; ADNR 1984b; Johnson 1984). Dall sheep do not frequent the impoundment zone, but are found in the mountainous areas at the head of the Johnson River, Dry Creek, Sheep Creek, and Cathedral Creek drainages (Martin 1983).

Brown bears occasionally visit the Billy Creek drainage during moose calving periods, but mainly frequent alpine ridges and areas above the impoundment zone. Black bears frequent the entire impoundment zone. Special-use areas include lowlands and valley bottoms along the south bank of the Tanana River, Billy Creek, and smaller drainages, in addition to subalpine and alpine berry stands (ADNR 1984b; Johnson 1984).

Lowlands associated with the Tanana River, Johnson Slough, and Billy Creek, are special-use areas for mink, muskrat, otter, and beaver. Red fox utilize the riparian vegetation and sedge hummock areas. Riparian areas along George, Sand, and Billy creeks are important hunting and travelling corridors for many furbearers including lynx, coyote, wolf, and wolverine (ADNR 1984b).

The Dot Lake, Sam Creek, and Billy Creek wetlands comprise important waterfowl habitat. Based on estimates made from U.S. Geological Survey topographic maps, approximately 30,000 acres of lowland wetlands are present in the area. These regions provide nesting and molting habitat, and stopover areas during migration for high concentrations of several species of waterfowl and sandhill cranes. Golden eagles, bald eagles, and red-tailed hawks nest in the impoundment zone (ADNR 1984b, Robus 1984).
In addition, four peregrine falcon nest locations (three of which were active in 1983) occur along the shoreline of the impoundment zone (Robus 1984; Money 1984). This species is classified as "endangered" by the U.S. Dept. of Interior, Fish and Wildlife Service. Spruce grouse, ruffed grouse, and willow ptarmigan are present and hunted in the impoundment area (Martin 1983).

The amount of habitat lost or disturbed due to the Johnson project would be approximately 98,160 acres (Table 2). The project would eliminate year-round habitat important to local moose populations especially as wintering and calving areas. Because much of this area probably represents critical winter range during severe winters, loss of this winter range is likely to result in a significant reduction in area moose populations. The loss of lowlands, and the riparian vegetation associated with those areas, would eliminate important special use areas and year-round habitat for black bears and remove valuable habitat for most furbearers. The impoundment would eliminate prime waterfowl nesting, molting, and stopover habitat, and would inundate many raptor nesting locations. Four peregrine falcon nest locations would be significantly impacted resulting in the probable abandonment of one or more of these locations.

7.2.1.3 Aquatic Resources

The Alaska Department of Fish and Game (ADF&G 1983) has documented that chum, coho, and chinook salmon migrate upstream of the Johnson damsite. Chum salmon have been recorded as far up river as the middle Chisana River, or approximately 1,297 river miles from the mouth of the Yukon River. Chum salmon spawning has been recorded within the proposed impoundment zone, primarily in slough areas of the Tanana River near its confluence with Billy Creek (Exhibit 3). Major chum spawning areas have been designated downstream, particularly near the confluence with the Delta River which is approximately 55 to 65 miles downstream of the dam site (Buklis 1981).

Although quantitative estimates of escapement to areas upstream of the damsite are not available, it is expected that these fish contribute to the extensive commercial and subsistence fisheries that occur in the lower Tanana River and in the lower Yukon River. For example, from information developed by ADF&G (1983), approximately 144,000 chinook, 13,000 coho, and over 1,000,000 chum salmon were caught in the commercial fisheries downstream of the project in the lower Tanana and Yukon rivers (includes Districts 1, 2, 3, 4a-c, and 6; portions of District 5 are above the confluence and therefore the entire District was excluded from this estimate). Alaska Department of Fish and Game figures on 1984 subsistence fishing show that during 1983, 475 chinook, 2,276 summer chums and 3,830 fall chum and coho (combined) were taken in the Tanana River upstream of Wood River (Exhibit 1). (These subsistence numbers were derived from 147 permitees reporting catches, out of a total of 259 permits issued).

In order to maintain those fish which spawn upstream of the proposed Johnson damsite, it would be necessary to incorporate structures that facilitate both upstream and downstream passage of anadromous fish. With the large size of the reservoir, it is uncertain if such passage facilities would be of value because the fish may not be capable of passing through the reservoir due to its large size and its change from a flowing water system to a lake-like reservoir.

It is also uncertain whether or not the passage facilities would be successful in moving fish upstream and downstream of the dam. Chum salmon resources upstream of the site would be particularly sensitive and probably would be eliminated (Bell 1984). Similarly, success with adapting coho and chinook salmon that are normally accustomed to riverine habitat to newly created large impoundments has not been demonstrated. Therefore, on a worst case basis, these species might also be eliminated. Mitigation might be required for spawning areas lost within the impoundment zone and for areas potentially impacted downstream of the project. Such measures could include flow regulation, habitat modification, or artificial propagation. Additional impacts downstream that would potentially require mitigation are changes in turbidity, temperture, fish spawning and rearing habitat, fish growth, and water quality.

Resident fish within the proposed impoundment zone include Dolly Varden, burbot, grayling, whitefish, sheefish and northern pike. No estimates are available on the numbers of fish present. However, according to ADF&G (1983), "fish are reported to be second to moose in comprising a large amount of wild food in Dot Lake residents' diets." Many of these fish are caught from areas within the proposed impoundment zone, primarily by set gill net. The main types of fish of interest are four separate species of whitefish. Additional fish are taken from small lakes and streams in the impoundment zone by rod and reel (Martin 1983). Extensive studies would be required to quantify potential impacts and formulate detailed mitigation plans.

7.2.2 Browne Site

7.2.2.1 Social Sciences

Socioeconomics

The places that would likely experience socioeconomic impacts from development of the Browne site and associated facilities are Healy and Nenana. Healy and Nenana currently have populations of about 350 and 475 persons, respectively (U.S. Bureau of Census 1980).

Population influxes to Nenana (which is approximately one-half Native Alaskan) during the peak construction phase of the Browne project could create the most severe impacts. Cultural differences between Native residents and non-Native immigrants, interference with subsistance activities, and dramatic changes in lifestyles (such as, not knowing one's neighbors, more formal personal and business relationships and shifts in local power structure) for current residents accustomed to a small-town setting would occur. Economic opportunities might expand, but these would be of more benefit to developers and in-migrating support workers and their households than to current residents who would be less likely to have the experience necessary to adequately provide needed services and skills. In Nenana as well as Healy, shortfalls in housing and community and commercial services would likely occur, and the planning and financing problems for rapid growth would develop. Fairbanks would not be expected to experience such great difficulties.

From aerial reconnaisance, it appears that 5 to 15 houses may be inundated by the Browne impoundment in an area just west of the river near the upper river limits of the impoundment zone. In addition, one recently built house, barn, and garage near June Creek would be inundated. People in all of these houses may have to be relocated. Even if they are above the inundation zone, the project would still extensively change these residents surroundings by reducing the land and terrestrial wildlife resourse base;

creating lakeshore property; and presenting new potential for commercial, residential, recreational, and natural resource development.

Land Use

The predominant existing land uses at the Browne project site are recreation, settlement and agricultures which is limited by poor to moderate soil conditions. These uses are of low intensity. The majority of these lands have been, or are being disposed to private individuals by the State as remote parcels or subdivision lands. Consequently, ownership is for the most part private or State, with the closest Native parcels located to the southwest approximately one mile from the inundation area.

Project-related impacts would be severe as the reservoir would inundate 12,500 acres of agricultural subdivision and remote parcel lands designated for disposal to private individuals by the State. At least one mining claim and portions of the George Parks Highway and the Alaska Railroad would be inundated. The subdivision, known as the Healy Agricultural Subdivision, has mixed areas of permafrost and agricultural soils. Additional lands required for access and transmission routes would cross approximately 20 to 30 miles of private disposed or State lands, thereby potentially increasing development pressure, increasing competition for recreation opportunities and disruption of the natural, remote setting. Since the inundation area is intended for private ownership, project uses could conflict with those of a variety of private landowners.

Cultural Resources

The Browne site is presently known to contain more than 50 archeological and historic sites, many of which are believed to be significant (FERC 1984; Appx. O). At least two sites are located at the damsite and would be directly impacted. The exact nature and extent of cultural resource surveys in the area is unknown, and an additional survey would be required to fully identify unrecorded sites. Impacts and necessary mitigative measures may be qualitatively similar to those required for the Susitna project.

Recreation

The Browne site is located north of Healy on the middle section of the Nenana River (Exhibit 2). The proposed damsite is approximately 12 miles from the Denali National Park and Preserve. The reservoir would be approximately two miles from the Park Boundary. The George Parks Highway and the Alaska Railroad parallel the river. Both transportation corridors are heavily used for sightseeing. In addition the Nenana river is used intensively by local residents for river travel and moderately for recreational boating and fishing. Other area activities include a moderate level of hunting, fisning, and hiking (ADNR 1982). Guidelines for this classification allow only limited development compatible with recreation opportunities. Developed recreation facilities in the area include the Denali National Park and Preserve, private lodges, highway rest areas, and scenic overlooks.

Within the project area, there are a number of small areas which the ADNR considers to have high recreation potential and which they have recommended for state protection (ADNR 1983). These include June and Bear creeks and Kobe Hill areas.

Potential recreation impacts of the Browne project include: severe impacts to a sightseeing corridor of high scenic value (by introducing project facilities including a reservoir with drawdown and snore erosion); impacts to recreationists in Denali National Park who will view the development; and loss of river boating, hunting, fishing, and hiking opportunities. Impacts will also result from the relocation of the highway, railroad, and existing Golden Valley Electric Association (GVEA) transmission line. In addition, the ADNR recreation sites at June and Bear creeks as well as the June Creek rest area will be inundated. Moreover, Kobe Hill will be severely degraded by construction of the left dam abutment and other project facilities on its flanks.

The reservoir itself would have limited value as a recreation resource as a result of drawdowns and associated mud flats in the summer. Windy conditions on the reservoir, lack of current, and turbid waters will also detract from the value of the reservoir as a recreational attraction. Ice slumping in the winter may create hazardous situations to potential users accessing areas via the reservoir.

Aesthetics

This site is highly visible due to its location within view of Denali National Park, the George Parks Highway, and Alaska Railroad, which are all heavily used for sightseeing. The Parks Highway has been recommended for scenic highway designation (ADNR 1981). Furthermore, this segment is considered to have very high scenic value as there are good opportunities for views to the Alaska Mountain Range. In particular, Kobe Hill offers vistas up and down the valley and into Denali National Park and Preserve.

Aesthetic impacts of the Browne alternative would be quite significant. Impacts to the area would include elimination of long valley views due to construction of the 265 foot high dam, construction of 25 miles of new transmission lines and other project facilities into the highly scenic and visible Nenana River Valley which has little capability to absorb visual impacts. Views from Kobe Hill will be severely degraded by the construction of the dam and powerhouse on its side slopes. The major impact, however, will result from the inundation of the valley floor, which will necessitate relocating the highway, railroad, and an existing powerline. Locating new alignments will be difficult as all flat land will be flooded and construction will cause extensive scarring. In addition, views into the mountains may be lost and foreground views will be degraded by construction scarring, beach erosion, muddy reservoir waters, and extensive mud flats. These impacts would be visible to many viewers since the George Parks Highway and the Alaska Railroad are major travel and tourist routes. Views of project facilities from the northern borders of Denali National Park would also be possible.

7.2.2.2 Terrestrial Resources

Vegetation along the Nenana River within the Browne impoundment area is varied. The river islands and stream banks support a shrub-poplar plant community with occasional aspen stands on the slough banks. The broad floodplain area extending from the river channel to the base of surrounding foothills is covered with riparian communities, occasionally intermingled with low spruce and poplar. Noticeable in this region are open areas of wet meadows and thinly timbered black spruce woodlands. At higher elevation the vegetation grades into low shrub and alpine tundra communities. Approximately 12,500 acres of habitat would be inundated by this project, and an additional 4.5 miles of disturbance due to transmission line construction would occur. Rebuilding and rerouting about 8.5miles of highway and 16 miles of railroad track inundated by this project would cause additional long and short-term impacts on vegetation and wildlife both inside and outside the impoundment zone.

The moose population in the vicinity of the Browne project area has been described as good and expanding (Jennings 1984). Average year-round moose densities in the area have been estimated to be 1-1.5 moose/mi^2 (Jennings 1984). Many animals utilize the willow and dwarf birch subalpine and alpine communities east of the Nenana River after the mating period. Where these shrub communities are windblown and free of deep snow, high densities of moose will remain throughout the winter. When snow becomes too deep, moose will move into the lowland valleys and river floodplains to utilize the riparian communities that occur in these areas. In the impoundment zone, the broad river floodplains between Browne and Ferry function mainly as winter range in addition to providing cover during the calving period (ADNR 1984b).

Caribou in the region belong to the Delta herd and mainly occur in the foothills east of the Nenana River. Mating generally takes place between the Nenana and Wood rivers in the mountains and tundra covered or brushy plateaus. The early part of the winter is usually spent in the same area, but some caribou cross the Nenana River and winter in the Otto Lake-Healy region approximately 25 miles south of the proposed damsite. Small numbers of this wintering group of caribou occasionally wander north and use the impoundment area as a winter range (ADNR 1984b).

Both black bear and brown bear occur in the area but brown bear tend to be more numerous (Jennings 1984). Brown bear forage throughout the Browne impoundment area, concentrating in the valley bottoms in early spring where green shoots first appear. The rest of the year is spent in the subalpine and lower alpine shrub communities east and west of the proposed dam site. Compared to other areas in the Tanana Basin, present black bear populations in the impoundment area are low (populations are considered to be moderate north of Clear). The black bears that do occur in the impoundment area mainly utilize the lowland and floodplain riparian areas. Both bear species have been postulated to move out of the impoundment zone in spring in order to travel to salmon spawning streams in the tributaries of the Nenana River, traveling as much as 50 miles to reach them (ADNR 1984b).

The Browne impoundment area provides habitat for the full range of Interior Alaska furbearers. Resident in the floodplain and less timbered shorelines are coyote, red fox, weasels, muskrat, wolves, and beaver. In the forested areas, marten, wolverine, and lynx occur. Because of easy access via the highway, railroad, and trails, this portion of the Nenana River drainage is intensively used by local fur trappers (Robus 1984).

The Nenana River is a migratory corridor for waterfowl nesting in northern Alaska (AEIDC 1974). The paucity of lakes capable of producing waterfowl food in the impoundment area results in little waterfowl nesting.

The main use of the sloughs and ponds in the area appears to be as resting habitat for migrating ducks and cranes. Raptor use of the impoundment area is unknown, but in similar habitat further south (near Healy) nest sites for red-tailed hawks, sharp-shinned hawks, kestrels, and goshawks have been found (Elliott 1984). Bald eagle nesting along the river may also occur.

The amount of habitat lost or disturbed due to the proposed Browne hydro project, including the inundation zone and major project facilities, would be approximately 13,090 acres (Table 2). The project would remove year-round habitat for moose especially important during winter and calving seasons, in an area where moose numbers are increasing. Inundation of the area would eliminate early spring green-up vegetation used by local brown bears, year-round black bear habitat, furbearer habitat, and raptor nesting locations.

7.2.2.3 Aquatic Resources

The ADF&G (1983) has documented the occurence of chinook, chum and coho salmon upstream of the Browne site as far as the town of Lignite (approximately 18 miles upstream of the damsite). Although no quantitative estimates are available, these fish contribute to important down river subsistence and commercial fisheries in the lower Tanana and the lower Yukon, much the same as those fish potentially impacted by the Johnson site (see Section 7.2.1.3).

It is anticipated that, due to the existence of anadromous runs upstream of the dam, fish passage facilities would be needed for the Browne site to facilitate both upstream and downstream passage. The success of such facilities is uncertain except that chum salmon passage probably would not be successful (Bell 1984). On a worst-case basis, all other runs of anadromous species would also be eliminated from upstream areas.
Downstream of the site, spawning areas occur over a wide area, particularly in the complex of sloughs, rivers and creeks in the lower 10 miles of the

Nenana River (ADF&G 1983). Impacts could include effects of changes in temperatures, turbidity, fish spawning and rearing habitat, fish growth, and water quality. Mitigation for these impacts could include instream flow regulation, habitat modification or artificial propagation. Development of such plans would require extensive consultation with resource agencies to determine which mitigation measures would be needed.

Resident species such as grayling, burbot, sheefish and whitefish, that are common to the Tanana River drainage would most likely be found at this site. Creeks and lakes in the vicinity of the proposed project are known to support sport fisheries, particularly for grayling. However, no information is available on the level of harvest (ADF&G 1983).

7.2.3 Keetna Site

7.2.3.1 Social Sciences

Socioeconomics

The communities which would experience the most significant socioeconomic impacts from development of the Keetna site include Talkeetna, and Trapper Creek (Exhibit 4). The 1981 population of Talkeetna was estimated at 640; Trapper Creek was estimated at 225 (FERC 1984).

The impacts in Talkeetna and Trapper Creek would be of a type similar to, but of lesser magnitude and for a shorter period, than those projected for the Susitna project. Projections of peak construction period populations show that, for the Keetna project, Talkeetna would experience about a 45 percent increase in population and Trapper Creek about a 20 percent increase. If the access road and transmission line construction work force are also considered, these percentages would be greater. Rapid growth would occur and the small-town rural lifestyles of residents (in these and other Railbelt communities) would be affected. Additionally, both Talkeetna and Trapper Creek would be likely to experience substantial increases in housing needs. These communities would also be expected to install centralized water and sewer and expand schools, police and fire, and health facilities.

Land Use

Current land uses at the Keetna dam and inundation sites are characterized by dispersed low-intensity recreation, hunting and fishing activities on State land. Immediately to the west are settlement lands disposed of by the State to private individuals as homesteads, subdivisions and remote parcels. Thus, the State and private individuals own the land in and around the project area.

Few immediate or localized effects would result from the creation of a dam and 5,500-acre impoundment in this area since the land is State-owned and use is limited. However, the development of access and transportation routes could pose considerable problems since they would cross the private lands to the west. The negotiation of purchases or easements would be necessary and possibly difficult to obtain. Resultant impacts to the area, which might create conflicts with private uses of the land, would include increased traffic, increased recreation pressures on State lands around the site, and effects on remote and natural settings.

Cultural Resources

No cultural resource sites are presently known to exist within the Keetna project area (FERC 1984; Appx. O) because no systematic surveys have been conducted. Archeological surveys are necessary to insure the full identification of each site present in the area. The relatively small size of the Keetna impoundment suggests that fewer sites might be affected by inundation than may be affected by the larger Susitna, Browne, and Johnson alternatives.

Recreation

The project will flood 12 miles of the middle section of the Talkeetna River. The upper white-water portions of the river are considered some of the finest rafting and white water areas in Alaska. Access from Talkeetna via power boats is possible as far upstream as approximately two miles above the confluence with Iron Creek (Exhibit 5). The lower portion of the river is very popular for canoeing, sport fishing, and other water-related activities. Disappointment Creek, which is located just upstream of the damsite and would also be inundated, is a popular fishing creek. Land areas adjacent to the river corridor are considered to be exceptionally valuable for wildlife, and many types of wilderness recreation.

The Talkeetna River has been recommended as a State recreation river. The Susitna Area Plan (ADNR 1984c) calls for a 0.5 mile wide corridor on the Talkeetna River and 1,000 foot wide corridor on Disappointment Creek. These corridors are recommended for protecting fish, riparian, and wildlife habitats and providing a visual buffer for recreation. Only limited development that is compatible with the recreational character of the area would be allowed.

The Keetna project would have significant impacts to boating, fishing, and hunting activities. The Talkeetna River is presently before the Alaska State Legislature for approval as a State recreation river. Access and construction-related activities would have a significant effect on the community of Talkeetna which would most likely necessitate the need for additional recreational facilities for that community. Access to the dam site would also significantly increase use of the surrounding area for hunting, fishing, and other dispersed activites.

Recreation impacts resulting from damming the Talkeetna River would include the loss of one of Alaska's most important white-water kayaking and boating resources, blockage of upstream passage for river boats, inundation of 12 miles of the river, and potential elimination of popular fishing resources and sites upstream of the dam.

Land related impacts would include inundations of 5,500 acres of riparian and other wild habitats which support intensive hunting, hiking, and other activities. The area lost would include some of the most popular moose hunting areas in the Susitna Basin (ADNR 1984c).

Aesthetics

The Keetna site is located in the lower half of the Talkeetna River Basin. The major landform is the Talkeetna Mountains, located to the northeast. The vegetation above the river at higher elevations is a mixture of low shrub communities, sedge-grass tundra, and mat and cushion tundra. Two scenic areas located in the vicinity include Sentinel Rock and Granite Gorge (Exhibit E, Vol. 9, Chap. 10, p. E-10-13 of the License Application).

Aesthetic impacts resulting from the project include loss of about 16 miles of scenic corridor which is recommended for protection on the Talkeetna River and Disappointment Creek, and inundation of 5,500 acres of riparian and other wild habitats within a river corridor presently viewed by boaters and recreationists. Mud flats, while not as extensive as some of the other alternative sites, will still be visible to people in the area. Impacts also arise due to the introduction of a 415 foot high dam and associated roads and transmission lines into the scenic Talkeetna corridor.

7.2.3.2 Terrestrial Resources

The Keetna impoundment would permanently inundate about 5,500 acres of habitat. Additional habitat would be disturbed in the construction of 26 miles of transmission line and about 25 miles of project access roads. Spruce-birch forest types predominate within the impoundment zone. A low shrub-poplar community extends along the river channel and as a narrow band up the Disappointment Creek drainage. The broad floodplain within the

Iron Creek drainage supports a riparian community intermixed with poplar stands. The steeply sloping hillsides extending up from the Talkeetna River are covered with spruce-bircn forest. At higher elevations, the spruce grades into low shrub communities and mesic sedge-grass and mat and cushion tundra.

Moose utilize the impoundment area year-round. Fall and winter concentrations occur on the floodplain and partially forested islands that occur up river from the Keetna damsite, especially in the region between Disappointment Creek and Iron Creek (Steen 1984). The impoundment area probably represents critical winter range to local moose populations during severe winters.

Caribou occupy the region on a year-round basis. Small resident herds are scattered over the area. A major grouping (150 to 200 animals) occurs near Wells Mountain one mile east of the impoundment. Near (3-5 miles) the impoundment zone a small herd utilizes the Disappointment Creek drainage, concentrating their activities in the upper reacnes of the stream (Pitcher 1984). Dall sneep and mountain goats are present in the vicinity of the Keetna impoundment, but generally above 2500 feet (AEIDC 1977).

Brown bears are not very common in the impoundment area, being found instead in the less timbered highlands to the north and south of the Talkeetna River. However, when salmon come up the river to spawn, brown bears frequent the spawning areas in the impoundment zone especially the Disappointment Creek drainage. Black bear populations in the area have been described by ADF&G biologists as "good", occupying the riparian covered floodplains and islands east of Disappointment Creek, and the less densely timbered stream drainages and foothills (Steen 1984).

Because the Keetna dam would have an impact on anadromous fisn runs upstream of the reservoir (see Section 7.2.3.3.), it would also impact brown bears that frequent the Prairie Creek drainage, located northeast of the impoundment, because the bears concentrate in this area to feed on salmon. ADF&G biologists regard this area as seasonally important critical habitat for brown bear because it attracts bears from a 2,800 square mile area (Miller 1983). This food resource may be important for maintaining the current levels of brown bear numbers in the area. Miller and McAllister (1982) estimated that 30-40 brown bears fished in the Prairie Creek area in the summer of 1980, and 50-100 utilized the resource in summer of 1984 (Schneider 1984). High bear use of Prairie Creek during the king salmon spawning season has continued to occur (Miller 1983).

The river drainage within the impoundment zone is used heavily by furbearers. The shrub dominated floodplain provides habitat and travel corridors for mink, weasels, and red fox. The tree covered foothills and wooded river islands are used by lynx, wolf, and wolverine (Steen 1984).

Little is known of the avian community in the area, but bald eagles have been observed nesting in the impoundment area, particularly at the mouth of Disappointment Creek (Arneson 1984). Because of the availability of potential nest sites along the river and the food resources available in the area, it is possible that several bald eagle nests occur in the impoundment zone.

The total amount of habitat lost or disturbed due to the proposed Keetna hydro project would be approximately 5,970 acres (Table 2). The project would eliminate year-round habitat for moose and caribou, especially fall and winter concentration areas for local moose. The impoundment would inundate seasonally important salmon streams used by brown and black bears, and affect the seasonally important critical brown bear fishery at Prairie Creek. Loss of floodplain vegetation would eliminate riparian areas and hardwoods important to furbearers and raptors, especially bald eagles. Increased access and the probable increase in hunting, trapping, and other human activities, in a previously unroaded area, will impact local wildlife, particularly big game and furbearers.

7.2.3.3 Aquatic Resources

Extremely important runs of anadromous fish are found both upstream and downstream of the Keetna site (ADF&G 1983). Chinook, coho, chum and sockeye spawn in upstream areas, particularly in the Prairie Creek drainage (see Exhibits 1 and 5). For chinook salmon, Prairie Creek has consistently had the highest spawning ground counts (dating back to 1972) for the species of any eastside Susitna River tributary (Bentz 1983). For example, the 1982 escapement count for chinook salmon in Prairie Creek was 3,844 fish whereas Portage Creek, the stream with the next highest count had 1,111. Not only do these fish contribute to downstream commercial, sport and subsistence fisheries, they also annually attract large numbers of brown bears that prey on the salmon (Miller 1983). Even with fish passage facilities, the dam and reservoir as proposed would have major impacts on anadromous salmon utilizing these upriver areas. On a worst case basis, all of these fish would be eliminated.

Within the impoundment zone, spawning areas for chum and chinook salmon occur in Disappointment Creek and potentially in the mainstem Talkeetna (ADF&G 1983). Site development would eliminate these areas from production. Downstream of the dam are spawning areas within the mainstem and tributaries for all five salmon species.

Due to the significant anadromous runs that exist at this site, facilities for upstream (potentially fish ladders or trucking of adults) and downstream (screening or bypassing of intakes) passage of anadromous fish would be required. However, due to the height of the dam and the length of the impoundment, the success of these facilities is not certain. As with other sites previously discussed, passage for chum salmon would be expected to be unsuccessful (Bell 1984). Mitigation would potentially be required to replace the spawning habitat lost within the impoundment zone.

Impacts that could occur downstream include effects of changes in temperature, turbidity, fisn spawning and rearing habitat, fish growth, and water quality changes. Mitigation for these impacts could be made through the use of flow regulation, habitat modification, or artificial propagation. Extensive studies would be required to quantify the level of potential impacts and formulate a detailed mitigation plan.

Little or no quantitative information is available on resident fish that might be impacted. It is known, however, that rainbow trout, grayling and Dolly Varden are present (Watsjold 1984). A sport fishery for resident species exists at the mouth of Disappointment Creek. Increased access to the area could result in some negative impacts on the resident sport fisheries if proper harvest regulations were not implemented.

Mitigation may also be required for these fish. Access to these fishing areas is primarily made via boat from the town of Talkeetna. The access road for this project would follow the river and thus would allow additional opportunities for access to the area.

7.2.4 Snow River

7.2.4.1 Social Sciences

Socioeconomics

The areas most likely to be affected by the Snow River hydro alternative are the eastern peninsula of the Kenai Peninsula Borough and the City of Seward. Together, these areas form the Seward Census Division, which had a 1982 population of 3,500 persons, a 31% increase over the number in 1970 (FERC 1984). Peak construction in-migration for the Snow project would add about 900 persons (excluding workers needed for construction of ancillary facilities) to the area creating adverse effects on housing, commercial operations, community services and transportation. Although housing vacancy rates for the City of Seward are unavailable, the fact that up to 300 new housing units would be required indicates that housing would have to be expanded.

Sewer, water, and other community services as well as school staff would require additional expansion.

Land Use

The Snow site is located on Federal land within the Chugach National Forest, which is managed for multiple use (Exhibit 6). Consequently, the dam and 3,200 acres of inundated land would not be expected to conflict with general management policies although site-specific management plans may not favor such a use. Impacts due to project-related access and the reservoir would increase backcountry use, increase impacts on vegetation and wildlife resources, and affect the natural setting of the forest lands, particularly in areas near to the highway. Recent proposed developments (e.g., access roads to mining claims on the Russian River and placer mine development on Quartz Creek) in this general area have generated considerable controversy and strong opposition from public and environmental groups. Similar controversy would probably also be generated for the Snow project.

Cultural Resources

The general area of the Snow River project possesses several known historic sites (FERC 1984). However, no detailed surveys have been undertaken of the project area. Extensive surveys are necessary to identify and evaluate cultural resources in the Snow project area. The relatively small size of the project's impoundment area suggests that fewer sites may be impacted than may be affected by the Proposed Project area, but in the absence of data on regional site densities and the relative significance of those sites, no realistic estimate of the nature and extent of adverse impacts can be made.

Recreation

Recreation within the North Fork valley includes moose hunting, other big game hunting, fishing, camping and hiking. While trail access is limited, two Forest Service cabins are located on the Paradise Lakes for fly-in recreationists. Recreation demand in the area is increasing and the Forest Service may open a trail into tne valley in the future (Wilson 1984).

Several sizable Forest Service campgrounds located along Kenai Lake are within 5 miles of the site. The Seward Highway and Alaska Railroad, both of which are heavily used sightseeing routes, pass by the valley. A scenic viewpoint is located opposite the valley opening for views into the site from the highway.

Recreation impacts resulting from the project would include inundation of hunting and fishing areas in a wilderness valley and inundation of the Lower Paradise Lake, and Snow River gorge. Project roads would provide increased access to the remaining wilderness areas with resulting increases in recreation demand for area resources. Aesthetically unpleasant views of the 310 foot high dam, powerhouse roads, transmission lines, and other project facilities as well as 8 miles of riverbed with regulated flows (lower than existing flows in summer and higher in winter) would be highly visible to recreationists utilizing areas downstream of the dam and to sightseers on the highway and railroad. Construction activities and noise will impact recreationists enjoying the wilderness character of the area, and construction-related traffic on the Seward Highway will conflict with recreation travel on the road which is particularly heavy during the summer months.

Recreation opportunities may be possible on the new reservoir as it will be more protected from wind than Kenai Lake. However, drawdowns and associated mud flats in the flatter areas would detract from its value. The water is expected to be turbid in the summer, thus decreasing the impoundment's potential for use as a fishing area.

Aesthetics

The Snow River is part of the Kenai Peninsula's major river drainage system. The region is characterized by glacially carved valleys, rugged, snow-capped mountain ridges, and a variety of vegetation types. The visual setting of the region is dominated by the steep, snow-capped peaks of the Kenai Mountain Range, with sharply defined ridges, steep-sided crests, and boulder outcrops. Three prominent peaks over 4,000 feet in elevation surround the site location. Large glacial icefields are located in the Kenai Mountains northeast of the site. Mixed conifer and deciduous species constitute most of the densely forested valley areas. Alpine vegetation and subalpine herbaceous meadows dominate the slopes above the tree line. Slopes higher than 4,000 feet in elevation are typically barren rock and talus surfaces.

The North and South forks of the Snow River meet just below the proposed powerhouse site and flow north into Kenai Lake (Exhibit 6). The Seward Highway and Alaska Railroad run along the narrow Kenai Lake and continue past the mouth of the project valley (North Fork) and on south through the South Fork Valley.

Notable natural features in the project area include the gorge at the damsite, Paradise Peak to the south, and Paradise Lakes in the North Fork Valley. Views are possible along the South Fork Valley (both north and south) as are views up the North Fork Valley from the Grayling Lake pullout and trailhead located opposite the damsite.

Aesthetic impacts in the North Fork Valley would include the inundation of much of the lower portion of the valley, Lower Paradise Lake, and the Snow River Gorge. Impacts in the South Fork Valley would include views of eight miles of riverbed that would have regulated flows; intensive land disruption from facility construction; and views of the dam, powerhouse, transmission lines, and associated project facilities. This valley, which is of very high scenic value, has moderate ability to absorb these impacts. Further

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7.2.4.2 Terrestrial Resources

The Snow hydroelectric project would inundate about 3,200 acres of habitat. Additional clearing or loss of vegetation would occur due to the construction of 87 miles of transmission line and approximately 4 miles of access road. Alpine tundra types cover the areas above tree-line while forested areas along the mountain slopes and uplands are mainly coastal western hemlock-Sitka spruce. Upriver from the damsite, the spruce dominated foothills are intermixed with wetland areas. These broad wetlands consist of small lakes, ponds, meandering stream channels, and bogs and wet meadows edged with willows and cottonwood. These shrub communities often extend between water bodies and cover wide areas.

The fauna of the Kenai Peninsula is relatively simple compared to that of the mainland because physiography poses a formidable barrier to animal migration. The peninsula is connected to the mainland only by a mountainous isthmus about 12 miles across. Many species which are widely distributed and locally abundant in Interior Alaska, e.g. arctic ground squirrels, pikas, caribou, are either absent or have severely restricted range on the Peninsula.

An estimated 90-130 moose inhabit the Snow River Valley and would be impacted by the project (Spraker 1984). The floodplain area one mile east of the proposed damsite and the Paradise Valley region support extensive riparian communities especially important to moose in the spring and winter. The tendency for the region to receive large amounts of snow makes the riparian vegetation especially important as a food source for wintering moose. The dense coniferous forest in the region functions as valuable thermal cover and provides more snow free, less energy-demanding, travel corridors for overwintering moose.

Dall sheep and mountain goats do not frequent the Snow impoundment zone, but occupy the higher elevation sites, especially Sheep Mountain, Andy Simons Mountain, and Paradise Peak (AEIDC 1974). These sites are generally a mile or more from the impoundment zone.

Black and brown bears live in the area, with black bears being very abundant and brown bears at a much lower density (Spraker 1984). In the early spring, brown bears frequent the lowland areas adjacent to the present river corridor, and south-facing slopes and meadows. For the remainder of the year they occupy the high elevation meadows and alpine zones found in the surrounding mountains. Black bear use is heaviest along the river shoreline and floodplain riparian zones, especially in the Paradise Lakes area (AEIDC 1974).

There is a large wolfpack (8 to 10 members) in the area (Spraker 1984). The forested areas adjacent to the impoundment zone provide marten habitat. The floodplain and shoreline associated with the main channel of the Snow River, and the streams and lakes prevalent in the upper Paradise Valley, all support muskrat and beaver (Nichols 1984). The riparian vegetation in the valley and high elevation meadows in the adjacent mountains provide denning and hunting habitat and travel corridors for lynx, coyote, weasels, and wolverine.

Bald eagles nest in the shoreline and floodplain cottonwoods while sharp-shinned hawks utilize the small pockets of hardwoods that occur throughout the spruce forest. Waterfowl use the scattered ponds and lakes (especially in the Paradise Lakes region) as nesting and molting habitat.

The amount of habitat lost or disturbed due to the Snow hydro project would be approximately 4,110 acres (Table 2). The project will remove year-round moose habitat, especially riparian areas important to moose in spring and winter. Loss of the shrub areas along the river and floodplain will remove areas valuable to black bears and furbearers. The loss of floodplain cottonwoods in clearing the impoundment zone will remove raptor nest sites. Increased access and the probable increase in hunting, trapping, and other human activities in a previously unroaded area, will impact the wildlife populations, especially moose, Dall sheep, mountain goats and furbearers.

7.2.4.3 Aquatic Resources

Both anadromous and resident species exist within the Snow River drainage. Grayling are found in Upper Paradise Lake. Both grayling and rainbow trout occur in Lower Paradise Lake and probably occur in the Snow River both above and below the damsite (McHenry 1984). These fish contribute to an existing recreational fishery primarily in Lower Paradise Lake. This lake would be inundated by the proposed project (see Exhibit 6). The new impoundment would probably be highly turbid due to the runoff from glaciers within the basin and therefore, this recreational fishery would probably be lost.

Although both Nichols (1984) and McHenry (1984) believe that a velocity barrier exists near the damsite which prevents upstream passage, ADF&G documents that sockeye salmon do migrate upstream of the potential damsite (ADF&G 1983). Therefore, the information presented by ADF&G in 1983 needs to be verified. A worst-case assumption that the sockeye do migrate past the site must be used for planning and comparison purposes. Therefore, either passage facilities for upstream and downstream migration would have to be considered in the design of the project or other forms of mitigation may be required. If no fish pass upstream, mitigative measures for passage would not be needed.

Both coho and sockeye salmon spawning has been documented in the Snow River downstream of its confluence with the South Fork (ADF&G 1983). An estimate of total escapement for these fish has not been made.

These fish would contribute to the highly important sport and commercial fisheries in areas downstream (primarily below the outlet of Kenai Lake) that are supported by the Kenai River system (Mills 1983). Mitigation for any potential impacts downstream of the project (primarily in lower Snow River) would require extensive coordination with resource agencies to determine the most appropriate form of mitigation. These impacts could include effects of changes in temperature, turbidity, fish spawning and rearing habitat, fish growth, and water quality. These types of mitigation could include maintenance of instream flow, habitat modification, or artificial propagation.

7.2.5 Chakachamna Site

7.2.5.1 Social Sciences

Socioeconomics

The socioeconomic environment of the Chakachamna hydro site would include the Native village of Tyonek (approximately 30 miles east of the powerhouse site) and the surrounding sparsely populated area. Tyonek had a population of 239 people in 1980, only seven persons more than in 1970 (FERC 1984).

Most of the employment in this area is seasonal with opportunities in fishing, timber, and petroleum exploration as well as a few service-related jobs in the village (FERC 1984). Average household income in 1981 was $13, 441. This figure, which is considered low income, was approximately 30% below the State's average in that year (Darbyshire & Assoc., 1981). In addition, households rely on Native/public health benefits and other sources of aid and there is heavy reliance on subsistence activities.

Dam construction could result in the projected inmigration of as many as 2,000 people to this area, and substantial impacts would occur to the Native culture, lifestyle, and subsistence activities. This estimate of in-migrants may be considered low because it does not include the additional increases due to construction of ancillary facilities such as transmission lines or access roads. Also, since the village has no vacant housing (with the exception of 24 rooms at the Shirleyville Lodge), housing would have to be significantly expanded even assuming that a construction camp would be provided.

The projected influx of in-migrants for the Chakacnamna project would strain community services beyond their capacities. Sewer and water systems, fire and police protection personnel, and local medical facilities and personnel would have to be added. Commercial operations would also be required to expand and diversify.

Tyonek and the surrounding area are now accessible by unpaved roads; but no road to Ancnorage is open year-round except wnen the frozen Susitna River allows for winter crossings. One main airport in Tyonek and several private airstrips provide for air transportation and a barge serves the coastline. Permits to construct new access roads to the damsite may be difficult to obtain due to the Tyonek Native Corporation's policy of refusing easements and rights-of-way on their land (FERC 1984).

Land Use

The Lake Chakachamna area is remote and rugged, and current land use is diverse and of low intensity. Of the current use, recreational uses (including hunting, fishing, and backcountry travel) are most prevalent and increasing. Project-related access roads and a transmission line corridor into this area would further increase recreational utilization. However, since project-related access roads and utility lines would pass through lands owned by the State, the borough, and Native entities, significant conflicts with the various landowners could likely occur.

Overall, the Chakachamna project would require limited conversion of lands from one use to another, the major changes occurring with the construction of the access roads and transmission line. Therefore, effects at the lake tap site would be minimal. In the future, increased accessibility would accelerate probable resource extraction, processing and transportation of oil, gas, coal, and timber, and affect the quality of the recreation setting. In addition, increased access would likely produce increased recreation demand.

Cultural Resources

No historic or archeological sites are currently known to exist within the Chakachamna project area and field reconnaissance indicates that the proposed sites for the power intake and powerhouses have a low potential for cultural sites (Bechtel 1983). A cultural resources survey is necessary to identify and evaluate cultural resources. The relatively small size of the direct impact area (due to the absence of an impoundment) suggests that fewer archeological sites may be impacted than at any of the other alternative hydro sites, but this tentative evaluation may likely be subject to revision once field survey data becomes available. No estimate can be made at this time as to the significance of sites which might be impacted by development of the Chakachamna project.

Recreation

Lake Chakachamna is in a remote wilderness setting located in Merrill Pass. The pass is a major air corridor for fly-in recreationists going to Lake Clark National Park located west of Lake Chakachamna (Exhibit 7). Recreationists land on Lake Chakachamna with float planes and on the lake's gravel bars and river deltas with wheeled planes and use the lake as a staging area for hunting, fishing, kayaking, and hiking. National park rangers estimate that as many as 75 planes may fly through the area each day and as many as 10 to 20 people might use the project area in a day (Hartell 1984). Some hikers use the lake to access Lake Clark National Park via Lake Kenibuna to the west. This area of the Park is classified wilderness and has no ground access.

Recreation on the McArthur and Chakachatna rivers include areas of intense hunting and fishing as well as some boating. Both rivers contain salmon (see Section 7.2.5.3). It is not known if boaters navigate the Chakachatna River Canyon. The Trading Bay State Game Refuge, located at the mouths of both rivers, is the ninth most important waterfowl hunting area in the state.

Recreational impacts of project construction would include developing access into remote wilderness areas. This will likely result in increased use and related wilderness experience impacts to users of the adjacent National Park wilderness areas. In addition changes in water levels and associated shore instability in the lake may affect its usefulness as a recreational staging area and limit the ability of wheeled planes to land. Water level reductions in the Chakachatna River will reduce opportunities for boating and fishing and will reduce flow to the 15 miles of Chakachatna Canyon whitewater by 75 percent. Flow increases in the McArthur River will also adversely affect fish habitat, as will flow changes in the wetlands of the Trading Bay Game Refuge for wildlife.

Increases in population during construction and operation along with habitat alteration and new access resulting from project facilities, may reduce hunting opportunities and substantially change the patterns of recreation in the area. Additionally, views of project roads, about 130 miles of transmission lines, and other project facilities in this wilderness area may degrade the recreational experience for users of this area.

Aesthetics

The project area encompasses three categories of landform characteristics: steep mountainous terrain, vegetated uplands, and coastal wetlands. Lake Chakachamna, Chakachatna River Canyon, and the headwaters of the McArthur River are located in narrow glaciated valleys surrounded by steep, rugged mountains. Scenic quality is high, particularly on Lake Chakachamna and the Chakachatna River. The lake allows a long view that includes hanging glaciers that drop to lake level. Tributaries to the lake form symmetrical deltas. The Chakachatna River exits the lake into a canyon surrounded by steep mountains. At this point the river alternates between single-channel and braided systems, and has relatively continuous whitewater. The braided floodplain of the upper McArthur River is 0.75 of a mile wide, and is roughly 50 percent vegetated with contrasting exposed sandbars. Because of the twisting nature of the canyon, the length of viewshed is relatively short. Vegetation on the steep lower slopes of the lake and both drainages consists of a thick mixture of conifers and deciduous birch and alders, above which lies a bank of shrub thicket, and alpine vegetation. This vegetation provides a contrast to both the lake and river floodplains.

Upon leaving the mountains, both the Chakachatna and McArthur rivers enter well-vegetated uplands. Here, the broader river valleys fluctuate between braided and single channels. The dense vegetation often limits views from the rivers and screens out the backdrop of mountains. Two relatively unusual visual areas are located within the upland landform. An expanse of dry sand flats is found along the middle reach of the McArthur River. This dune-like area provides visual relief (texture and color) from the dense vegetation, and allows longer vistas of the surrounding mountains. A border of lichen-covered flats further contributes to the aesthetics of this area. Similar, but smaller, areas of lichen flats are located along the Chakachatna River.

The vegetated uplands gradually give way to open wetlands along both rivers. These coastal wetlands extend inland roughly five miles from the coast. The low vegetation of grasses and sedges and open water allows long vistas of the surrounding mountains, Cook Inlet, and the Kenai Peninsula across the Inlet. The primary river form in these wetlands is meandering single channels with steep mud banks. Tidal influence extends four or more miles upchannel in some instances. These coastal wetlands provide excellent waterfowl habitat, and have relatively high visitor use compared to other portions of the project area.

Visual impacts of project development focus mainly on the intrusion into the wilderness setting of roads, transmission lines and access roads, which will be highly visible, particularly from the air as recreationists fly over the area to the Lake Clark National Park. Changes in existing water level may detract from aesthetic value of the lake and Chakachatna River; this would be visible to people in airplanes and those using the lakes and rivers.

7 2.5.2 Terrestrial Resources

The vegetation on the steep slopes surrounding Lake Chakachamna can be generally classified as tall shrubland with alpine tundra and bare rock at higher elevations. The Chakachatna River canyon and the floodplain of rivers flowing into Lake Chakachamna are also covered by tall shrub communities. Large low-shrub bogs are found on flat, poorly drained areas as the topography flattens out to the Upper Cook Inlet coastal plain. Sedge-grass coastal marshes cover most of the area within eight miles of Cook Inlet, as well as some areas along the McArthur River. Intermediate between the coastal marshes and the bogs are poorly drained areas of black spruce forest. These areas differ from the bogs in the lack of floating vegetation mats and the absence of black cottonwood. The lake tap of Lake Chakachamna with a diversion tunnel to the McArthur River basin would not result in a permanent removal of large acreages of habitat; but modification of habitat would occur in the construction of about 130 miles of transmission line.

The Lake Chakachamna project involves wildlife communities in two distinct areas: (1) the animals around the lake itself and, (2) the wildlife occupying the river drainages flowing out of Lake Chakachamna and the McArthur River. Therefore the site analysis for this project will discuss the wildlife resources in both areas.

Lake Chakachamna. Moose in the lake region frequent the subalpine and alpine shrub communities in the spring, summer, and fall. In the winter, the animals descend into the riparian communities on the floodplains of rivers flowing into the lake, and in the riparian habitat adjacent to the lake (Bechtel 1983).

Brown Bear in the area heavily utilize the high altitude riparian zones and subalpine meadows found in the surrounding highlands and mountains. Black bears mainly use the upland alder thickets on the steep slopes along the lake and the riparian communities on floodplains of rivers flowing into the lake (Bechtel 1983).

Dall sheep occur at higher elevations, mainly in the mountainous areas north of the Chilligan River (AEIDC 1974).

The riparian zone around the lake and in stream drainages is important furbearer habitat--supporting mainly wolf, wolverine, mink, and otter. The lake provides nesting and resting habitat for local migrating waterfowl. Bald eagles nest in the stream drainages adjacent to the lake (AEIDC 1974).

Downstream in the Chakachatna and McArthur Rivers. Moose utilize the riparian habitat that occupies the floodplain of the Chakachatna River canyon, and black cottonwood riparian community found along the shores of the McArthur and Chakachatna River canyons and along the shores of most streams and sloughs. These areas are important as winter range, especially the upper McArthur River drainage and lower reaches of the Chakachatna drainage (Bechtel 1983; ADF&G 1976).

Black bear mainly use the upland alder thickets on the canyon walls above the McArthur, Chilligan and Nagishlamina rivers, and the high altitude riparian community in the Chakachatna River canyon. The bears use the upper reaches of the McArthur River (area south of Blockade Glacier) for salmon fishing in the spring. Brown bears mainly use the high altitude riparian habitat in the Chakachatna River, descending to the river floodplain in the summer to take advantage of spawning salmon in the drainage (Bechtel 1983; ADF&G 1976).

The black cottonwood riparian vegetation provides habitat for most of the furbearers present in the area. Mink, beaver, and muskrat are common in this vegetation community, while coyotes frequent the coastal riparian areas and wolves the high altitude riparian zones (Bechtel 1983; ADF&G 1976).

The upper reaches of the McArthur River provide nesting habitat for trumpeter swans and bald eagles (Faro 1984). The Tule's white-fronted goose has been reported to use the McArthur River as molting habitat (Faro 1984). This subspecies was proposed for threatened or endangered status in 1981 but was not accepted for either category (Money 1984). Because of the low population of this subspecies, the birds present in Alaska have been the subject of a monitoring program by state and federal resource agencies. The lower section of the Chakachatna River provides nesting habitat for many species of waterfowl, swans and bald eagles (Bechtel 1983; ADF&G 1976).

The amount of habitat lost or disturbed due to the Lake Chakachamna hydro project would be approximately 3,440 acres (Table 2). The project would adversely affect brown bear use of salmon spawning areas on the Chilligan and Chakachatna rivers. The reduced flow of water down the Chakachatna River would have eventual, long-term impacts on moose, furbearers, and waterfowl. The stabilization of river and slough banks would allow the vegetation to develop and mature. This would result in the eventual loss (through plant succession) of early successional vegetation - areas of critical importance to local moose and furbearers. The decrease in river flow may also result in a dewatering of areas used as nesting habitat by waterfowl and swans. Increased access, and the probable increase in hunting and other human activities, would impact local wildlife.

7.2.5.3 Aquatic Resources

Extensive fisheries studies have been conducted by the Power Authority in relation to e proposed Chakachamna project. The report prepared for the Power Authority in 1983 (Bechtel 1983) summarized these studies as follows:

"Field observations identified the following species in the waters of the project (Chakachamna) area:

Resident:	Rainbow trout	Artic grayling
	Lake trout	Slimy sculpin
	Dolly Varden	Ninespine stickleback
	Round Whitefish	Threespine stickleback
	Pygmy Whitefish	
Anadromous:	Chinook salmon	Pink salmon
	Chum salmon	Sockeye salmon
	Coho salmon	Dolly Varden
	Eulachon	Rainbow smelt
	Longfin smelt	Bering cisco

Salmon spawning in the Chakachatna River drainage and its tributaries (Exhibit 7) occurs primarily in tributaries and sloughs. A relatively small percentage of the 1982 estimated escapement was observed to occur in mainstem or side-channel habitats of the Chakachatna River.

The largest salmon escapement in the Chakachatna drainage was estimated to occur in the Chilligan and Igitna rivers upstream of Lake Chakachamna. (Some of the spawning areas are within the drawdown zone of the impoundment and would be impacted by water level changes). The escapement of those sockeye in 1982 was estimated to be approximately 41,000 fish (Table 3), or about 70 percent of the escapement within the Chakachatna drainage. Lake Chakachamna is the major rearing habitat for these sockeye. It also provides habitat for lake trout, Dolly Varden, round whitefish, and sculpins.

In the McArthur River, over 96 percent of the estimated salmon escapement occurred in tributaries during 1982. The estimated escapement of salmon of all species was slightly greater in the McArthur than the Chakachatna drainage. Other anadromous fish including eulachon, Bering cisco, longfin smelt, and rainbow smelt have been found in the McArthur River.

The contribution of salmon stocks originating in these systems to the Cook Inlet commercial catch is presently unknown. Although some commercial and subsistence fishing occurs, the extent to which the stock is exploited is also not known.

Rearing habitat for juvenile anadromous and resident fish is found throughout both rivers, although the waters within the Chakachatna River canyon below Lake Chakachamna and the headwaters of the McArthur River do not appear to be important rearing habitat. There appears to be extensive movement of fish within and between the two drainages, and seasonal changes in distribution have also been noted."

The Power Authority has concluded that fish passage facilities will be needed for this project to maintain the population of sockeye that spawn above Lake Chakachamna. The success of these facilities for maintaining upstream and downstream passage is uncertain. On a worst case basis, all of these fish would be eliminated.

The population estimate for adult salmon utilizing areas on the Chakachatna River downstream of the dam site and on the McArthur River is approximately 64,000 fish (Table 3). The Power Authority suspects that flow reductions in the Chakachatna River due to diversion of water to the MacArthur drainage will potentially have significant effects on mainstem and side-channel fish habitats in both rivers. For example, the Noaukta Slough in the lower

Chakachtna River is a known rearing area for salmonids. Changes in flow regimes through this area could significantly change this fish habitat. Information on the extent of habitat gains or losses have not been determined (Bechtel 1983). The diversion of water to the MacArthur River could also result in potential miscueing, straying, and/or delay of anadromous fish that normally spawn above Lake Chakachamna due to release of olfactory cues at the McArthur powerplant tailrace (Bechtel 1983). This could result in a significant impact to these fish.

The total number of adult salmon that could be impacted by this project is over 100,000. This includes both fish upstream and downstream of the project (Table 3).

7.3 Comparison of Hydro Alternatives with the Proposed Project

7.3.1 Social Sciences

Socioeconomics

The Proposed Project will have fewer socioeconomic impacts than a combination of the hydro alternatives (Table 4) because the number of immigrants, the factor that drives most other socioeconomic impacts, is expected to be less for Susitna. The alternatives would affect a larger number of small communities that are especially vulnerable to fiscal, community services, housing, and quality-of-life impacts. The number of predominantly Native American communities (including Tanacross, Dot Lake, and Tyonek) susceptible to quality of life changes is also greater for the alternatives.

Land Use

In general, the Proposed Project will have fewer land utilization impacts than the combination of the other hydro alternatives because the impacts on recreational as well as adjacent settlement lands will be contained in one area (Table 5). In contrast, under the DEIS preferred alternative, impacts on recreation and adjacent settlement lands would be widely dispersed throughout the State.

With regard to actual categories of land use, it is important to note that the Johnson site alone would inundate 94,500 acres of land, two communities (populations 67 and 200), portions of an existing highway, pipeline and telephone line, a highway maintenance station, three gravel pits, two gaging stations and a lodge. This is extremely severe compared to the Proposed Project's expected inundation of 43,000 acres for both Watana and Devil Canyon and six structures (four cabins, two of which are no longer in use, one lean-to, and one collapsed building).

With respect to land ownership, the Johnson and Browne projects would pose difficult problems due to the complex, multiple ownership patterns in and around the project sites. The Browne reservoir would almost completely inundate the Healy Agricultural Subdivision as well as many private tracts and one mining claim. In addition, the access and utility routes would cross private disposal tracts. Similar problems would occur with the Johnson site where the lands are owned by the State, Federal government, Native groups, and Native and non-Native individuals. Although land ownership around the Proposed Project site is also complex, ongoing negotiations are aimed at resolving issues of ownership and use. The complex and diverse ownerships of the access routes and utility corridors for all non-Susitna hydro alternatives may make outright purchases or rights-of-way difficult to acquire for any project-related purposes. This applies particularly to the Chakachamna hydro alternative where it is already known that the Tyonek Native Corporation has a policy of refusing easements and right-of-way on their land.

Ownership also affects area management plans. Where huge tracts around a site are in single ownership, as is the case for the Snow site, located in the Chugach National Forest, the project may pose less conflict with existing management plans. Where there is complex, small-tract ownership as with the Johnson and Browne sites, the development of the site would likely pose greater conflicts with the plans that some owners have for their properties.

Cultural Resources

Impacts to cultural resources from the non-Susitna hydro alternatives can be expected to far exceed those from the Proposed Project alone (Table 6). Only the Proposed Project area has been subjected to intensive field studies designed to locate all potentially significant historic and arcneological sites. However, a preliminary analysis of the otner hydro site locations indicates that all are likely to contain previously unrecorded resources. Tne Johnson site alone, by virtue of the size of the impoundment compared to that for the Proposed Project, and the gross environmental similarity between the areas, is likely to contain more arcneological sites than those recorded to date for the Proposed Project. Impacts and necessary mitigation measures can likewise be expected to be proportionately greater.

Impacts at the Browne, Keetna, and Snow sites, because of their smaller direct impact areas might be expected to affect fewer cultural resources. Impacts and mitigation would, however, be qualitatively similar to that at the Proposed Project. Chakachamna, because it does not include an impoundment, and directly affects a smaller area, can be expected to have the least significant impact on cultural resources.

Recreation

Summary comparisons of alternative impacts with impacts of the Proposed Project are presented in Table 7.

Impacts to recreational resources from the total non-Susitna hydro alternatives can be expected to far exceed those from the Proposed Project alone. Both individually and combined, the hydro alternatives would impact more existing recreation than the Proposed Project. This is due mainly to those areas scenic quality, proximity to travel routes, national parks and national forests. The hydro alternatives have the potential to impact two National Parks, one National Forest, three rivers recommended for State protection, and numerous small sites recommended for State recreation. In addition, boating activities would be impacted on five rivers instead of one and several state designated or recommended sites/areas would be impacted compared to none for the Proposed Project. Major sightseeing routes would be impacted by Browne and Johnson sites compared to none for the Proposed Project. Recreation demand for the combined hydro alternatives would be substantially increased over that for the Proposed Project. Furthermore, the costs associated with the operation, maintenance, and management of recreation facilities developed for the hydro alternatives would likely exceed those of the Proposed Project.

Aesthetic Resources

Summary comparisons of alternative aesthetic impacts with those of the Proposed Project are presented in Table 8.

Impacts to aesthetic resources and visual sensitivity impact to viewers from the total non-Susitna hydro alternatives would be much greater than that for the Proposed Project alone. The Browne and Johnson sites would present particularly significant visual impacts due to cutting and filling required to relocate the highways, railroad, transmission lines, and pipeline. Also, the severity of impacts would be greater due to the proximity of the major travel routes to the reservoirs, which would provide views of the extensive mud flats created by both Browne and Johnson. Furthermore, the Browne reservoir and associated facilities would be visible from areas in the Denali National Park and Preserve. The Snow site is probably the most scenic of all the hydro sites because the project would be located in a wilderness area with steep terrain, glaciers, and forests.

Visual impacts associated with the alternatives transmission lines would be greater due to more miles of lines in proximity to major travel routes.

Visual impacts resulting from land clearing and disturbance would be much greater with the alternative hydro sites than with the Proposed Project because of the greater amount and higher visibility of the areas.

7.3.2 Terrestrial Resources

Construction of the various dams, impoundments, diversions, lake taps, and associated facilities at the Johnson, Keetna, Snow, Browne, and Lake Chakachamna sites would result in the permanent or temporary removal of about 125,000 acres of habitat (Tables 2 and 9). The Proposed Project would result in the inundation and complete or selective clearing of more than 56,000 acres of habitat (FERC 1984). Access, arising as a result of construction activities, may result in long-term or permanent impacts on the local wildlife. Animal populations in previously unroaded areas such as the proposed Keetna and Snow sites will become subject to greater hunting, poaching, and trapping pressures. Even with strict enforcement of existing fish and game laws, the specific impacts arising from increased accessibility would be difficult to assess; but changes in movement patterns and habitat use will occur for most species.

The main habitat type affected by the non-Susitna hydro alternatives is the riparian communities associated with river floodplains and stream drainages. These areas are especially important to moose in winter and during calving seasons. Loss of these habitat types will result in either increased mortalities, or emigrations from the areas. The Johnson hydroelectric project could seriously impact the moose population in the region. No recent burns have occurred near the impoundment area, therefore most win! browse is provided by streamside willow stands where the flooding and disturbance associated with the river maintains the early-successional shrub community. The Johnson project could drastically reduce the moose population in the Dot Lake region by eliminating critical winter food and calving areas.

The alternative impoundment zones and generation facilities were generally of limited importance to Dall sheep and caribou. The animals either occupied areas removed from the impoundment zones and facilities, or utilized such a wide range of territory that the impacted areas were little used.

The elimination of lowland shrub communities in each alternative project area would affect both species of bear. The loss of shrub habitat at the Johnson site would eliminate special use areas (e.g. the Billy Creek drainage) needed by the local black bear population.

The Proposed Project would not impact salmon spawning areas above the damsite, because virtually none exist. However, the Keetna project would severely impact the important salmon runs in the upper Talkeetna River and its tributaries, especially those on Disappointment Creek and Prairie Creek. Prairie Creek is considered a seasonally important critical habitat for brown bears in the middle Susitna Basin due to the chinook salmon fishery that the bears utilize. The Chakachamna project would affect salmon spawning areas in the Chilligan and Chakachatna Rivers, also areas of high importance to brown bears.

The riparian vegetation at all dam sites provides habitat to the majority of furbearer species found in the state. Loss of these areas would eliminate critical furbearer hunting habitat and movement corridors. Exact population data detailing the population level of major furbearers in the impoundment areas are not available.

The Johnson, Browne, Keetna, and Snow impoundments would inundate known or postulated raptor (including bald eagle) nest locations. Although transmission lines related to the Proposed Project would pass about 1.5 miles from a historic peregrine falcon nest location, this facility is not expected to affect peregrine falcons. However, the Johnson project may significantly impact up to four peregrine falcon nesting locations that occur along the shoreline of the impoundment. Three of these four locations were recorded as active in 1983.

Waterfowl use of the Proposed Project area is low, as is the waterfowl use of the Browne, Keetna, and Snow hydro sites. The Johnson site contains important waterfowl habitat for migrating and nesting ducks, geese, and sandhill cranes. The Chakachamna hydro site and associated river drainages encompass areas used as swan, duck, and goose nesting habitat.

7.3.3 Aquatic Resources

Table 10 presents a summary of fisheries resources associated with the non-Susitna hydro alternatives and the Proposed Project.

If all non-Susitna hydro alternatives are developed, the potential impact to aquatic resources would be significantly greater than potential impacts due to the Proposed Project. The reasons for this are:

1. Two of the sites (Chakachamna and Keetna) are known to have highly important anadromous fish runs upstream of the project site. These runs would require passage facilities for upstream and downstream migrants. The effectiveness of the facilities is uncertain. On a worst case basis, the facilities would not work and all anadromous runs upstream of the dams would be eliminated. The Chakachamna project also involves the diversion of water from one river system to another which would significantly disrupt migratory patterns. In contrast to the non-Susitna hydro alternatives, all of the anadromous salmon in the Susitna River spawn downstream of the Proposed Project site (except for a few chinook salmon that are able to pass through Devil Canyon). Therefore, passage facilities, with their potential risk for success, will not be needed for the Proposed Project site.

2. Anadromous fish also are known to spawn upstream of the Browne and Johnson impoundment zones. Although escapement numbers have not been estimated, it is highly likely that passage facilities would be required at both sites. As with other sites, it is uncertain if such facilities would be successful in passing fish. These fish contribute to the highly significant commercial, subsistence, and sport fisheries downstream of the site in the lower Tanana and Yukon rivers. The combined impacts of these two projects would also need to be considered.

3. Losses of known salmon spawning areas within the Keetna, Johnson, and Chakachamna impoundments may need to be mitigated.

4. Lower Paradise Lake, a site that supports an existing recreational fishery in the Snow River drainage, would likely be inundated by turbid waters of the impoundment.

5. Each alternative site would require mitigation for impacts to downstream spawning and rearing areas. These impacts could result from changes in flow, water quality, spawning and rearing habitats, gas supersaturation and others. The mitigation for these impacts could include either maintenance of instream flow requirements, habitat modification, or artificial propagation.

6. Each site presents potential impacts to fisheries resources that are as great or significantly greater than those of the Proposed Project site, particularly if the relative impacts to each individually proposed project area are considered. If all sites were developed, the potential impacts would be far more extensive than Proposed Project impacts and the mitigation required would also be much more extensive.

One of the Power Authority's key screening criteria (Acres 1981) was to avoid placing a dam at a point where upstream migration occurs, thereby completely avoiding the uncertainties of success of upstream and downstream passage facilities. The Proposed Project sites (Watana and Devil Canyon) meet this criterion. The hydro alternatives do not meet this criterion because highly significant salmon runs are known to exist above two of the sites (Keetna and Chakachamna), runs of unknown size exist above two other sites (Browne and Johnson) and runs may exist above the fifth site (Snow). Therefore, the alternative hydros carry the well-known risks associated with attempting to provide upstream and downstream passage. Although such facilities have been partially successful at other dams, there have also been significant failures where upstream passage is no longer viable and other means of mitigation, primarily hatcheries, have been required.

In summary, the Keetna and Chakachamna projects clearly put important salmon runs upstream of these sites in jeopardy of elimination. In addition, although no numbers can be estimated from current information, the Browne and Johnson sites place the anadromous salmon runs above these sites at risk of elimination. In contrast, the Proposed Project puts no upstream anadromous runs at risk because virtually none are present.

8.0 Cost Comparison - Alternative Sites vs. Proposed Project

8.1 Introduction

Project construction costs based on July 1980 levels were developed by the Applicant for the purpose of comparing different hydro project alternatives. These comparisons were presented in the "Development Selection Report" (DSR) (Acres 1981) which became part of the FERC License Application.

Subsequent to the selection process, the Power Authority proceeded to update and detail Susitna (Watana and Devil Canyon dams) construction costs to a January, 1982, level. Alternative project costs were not updated because the selection process, made on a common comparative basis, had already indicated that the Proposed Project was the most favorable alternative. The 1982 cost for the Proposed Project was approximately 95 percent higher than the 1980 estimate.

FERC Staff, in their preparation of the DEIS, used the January, 1982 level Proposed Project cost when presenting their cost comparisons. Alternative hydroelectric projects considered were Browne, Johnson, Keetna, Snow, and Chakachamna. In presenting those comparisons, FERC Staff did not revise the DSR alternatives' costs to make them comparable to the Proposed Project cost. Had they escalated the alternatives' costs to agree with the Proposed Project costs, a valid comparison could have been made.

8.2 DEIS 1982 Level Cost Development

The DSR and DEIS project construction costs are summarized below. The apparent escalation factors used for comparison purposes by FERC Staff are shown in the following table.

Project Alternatives	DSR Cost (1980 Level, $\$ \times 10^6$)	DEIS Cost 3/ (1982 Level, $\$ \times 10^6$)	Apparent Escalation, DSR to DEIS
Browne	624.51	681	9% increase
Johnson	896.92 1/	319 2/	64% decrease
Keetna	476.65	519	9% increase
Snow	254.61	305	20% increase
Chakachamna	1,480.41	905	39% decrease
Alternatives Total	3,733.10	2,729	27% decrease
Proposed Project	2,860	5,565	95% increase

1/ A cost for Johnson was not included in the Development Selection Report (DSR). The cost shown was computed using DSR quantity estimates and unit costs for Browne, Keetna and Snow.

2/ Basis for cost presented in DEIS unknown.

3/ DEIS costs used by FERC Staff; $5565 million cost for the Proposed Project is a check estimate which was included in the July 11 Supplement to the License Application for comparison purposes. A more current estimate (by the Power Authority) of $5150 million was presented as the License Application cost.

Two observations are apparent from the above comparison. First, there is no common escalation factor for the hydro alternatives. Second, the total alternatives cost has been decreased almost 30 percent from that presented in the DSR, while at the same time the escalated cost of the Proposed Project nearly doubled.

A valid conclusion based upon the DEIS cost comparison is not possible using the costs shown above.

8.3 Development of a Common Escalation Factor

The January 1982 level, escalated costs for the Proposed Project were based on a detailed cost analysis using more realistic unit prices. It would appear reasonable to assume that, if a cost reevaluation had been made for each of the alternative hydro projects using the same amount of detail and comparative unit prices, they also would have realized a similar total cost escalation of around 95 percent.

8.4 Additional Cost of Transmission Intertie

Inclusion of transmission intertie costs, which were omitted in the DEIS, would have a significant impact upon the economics of the non-Susitna hydro alternatives. The required transmission facility is considered to be comparable to that required for the Proposed Project, and will have a comparable cost as well. An exact cost is not available at the present time, although rough estimates indicate the cost would be in the range of $475 million. The additional transmission costs of the Susitna hydro projects is not included in the 1982 level cost comparison presented in the following conclusions.

8.5 Conclusions

Based on the more valid January, 1982, costs shown in Table 11, the alternative projects would cost $\$7,264 \times 10^6$, which is considerably more than the cost of Susitna ($\$5,565 \times 10^6$). Tables 11 and 12 compare the individual projects and the combined alternative and Proposed Project costs and statistics. It is readily seen that the January, 1982, level unit cost per installed Megawatt for the Proposed Project is $\$3.44 \times 10^6$ – less than half of the $\$9.05 \times 10^6$ for the alternatives.

9.0 Power And Energy Production

9.1 Introduction

The average energy production of the alternative sites shown on Table 1-18 of the DEIS was analyzed with the U.S. Army Corps of Engineers HEC-5 computer program using historic streamflow data for each river basin along with minimum summer flow requirements as given in Table 2-7 of the DEIS. FERC Staff information (letter dated August 7, 1984 from FERC to Applicant's Counsel) states that the HEC-5 program was used to simulate each project individually for the years of available streamflow data. Energy production was determined from a target monthly plant factor and projected minimum flow constraints were modelled. The HEC-5 program calculated monthly energy production as well as maximum available capacity. It is not known how the target monthly plant factor was selected and why it was set as it was.

Unless the production of capacity and energy by the various hydroelectric plants that were studied was related to the monthly and annual system load requirements presented in the License Application (Exhibit B Volume 2A Tables B.74 through B.77 and B.100), the results obtained probably are erroneous. Therefore, the studies described in this section were made to check the DEIS estimates of average annual energy production and to compute the dependable capacity of each alternative site given the minimum flow conditions presented in the DEIS. The Power Authority does not necessarily agree with the minimum flows presented in DEIS Table 2.7. However, for consistency and comparison purposes, the flows in Table 2-7 were used in the following power and energy analysis. The basic data for the five alternative sites and the Proposed Project are shown on Table 14. The power and energy production of the Proposed Project is based on flow regime C and the operating rule curve contained in the License Application Exhibit B Volume 2.

The power study for Chakachamna Alternative E could not be completed because the minimum flow requirements for Chakachatna River in the DEIS could not be satisfied. Therefore, the power study was made for Alternative D (Bechtel 1983). Alternative E, which was recommended in the Report, was considered in Sections 4.0, 5.0, 6.0, 7.0 and 8.0 of this Appendix for consistency and direct comparison to the DEIS. Alternative D consisted of a rockfill dam at the outlet of Chakachamna Lake, a powerhouse located 12 miles downstream on the Chakachatna River, and a tunnel connecting the reservoir and the powerhouse. The dam would have a crest length of about 600 ft. Vertical Francis turbines, with a total capacity of 300 MW, would be installed. The plant factor would be about 50 percent. The tunnel would be 12 miles long and 25 feet in diameter.

9.2 Historic Streamflow Record

The periods of historic monthly streamflow used in the power and energy simulations of the non-Susitna hydro alternatives are presented below:

Alternative Project	Simulation Period (yrs)
Browne	29
Johnson	22
Keetna	14
Snow	27
Chakachamna	30

9.3 Minimum Flow in Summer

Minimum summer flow requirements in June, July, and August were proposed in the DEIS to reduce impacts on fish migration and spawning activities. These minimum summer releases were based on the maximum of the historical Q_{90} value in those three months. (The maximum of the historical Q_{90} value is the flow for a given day which is exceeded 90 percent of the time (90 percentile flow) and which is greater than the 90 percentile flows for all other days of the three month period.) The monthly averages of historical flows and the minimum releases in June, July, and August for each alternative site are shown in Table 15. At Johnson and Chakachamna, the monthly average stream flow is less than or close to the minimum release. This means that there would be no water stored in the summer of an average year and there would be storage withdrawal in the summer of a dry year. At Browne and Keetna the summer minimum release is a large percentage of the average inflow, and little water would be stored in a year of average or low inflow. Therefore, the seasonal regulation of flows by the reservoirs would be limited and in low-flow years winter generation would be minimal. Only the smallest site, Snow, could store a reasonable percentage of summer inflow.

9.4 Energy Production in the Summer

Potential power and energy production during the summer is limited by the proposed installed capacity at most of the sites and has to be checked against the ability of the Railbelt power system to absorb the production. The total powerplant output for all five projects based on the minimum flow requirements in the summer is over 1,110 MW (Table 16). However, the installed capacity of the plants limits the total power produced to 773 MW which is 68% of the capacity obtained from the minimum summer releases at 100% load factor. Table 17 shows the maximum hydraulic capacity and the summer minimum release requirements for each alternative development. For the Browne, Johnson, and Chakachamna sites the installed hydraulic capacity is less than the minimum flow requirements. There would be a theoretical loss of energy due to limited capacity because part of the minimum flow must be released through valves or over a spillway. However, Table 18, which is discussed in the next section, shows that the system could not utilize additional energy even in the year 2010, and additional turbine discharge capacity would not increase energy production.

Under the Applicant's Reference Case forecast, the summer energy could not be completely used by the Railbelt system until some time after the year 2020, even as limited by installed capacity.

9.5 Monthly Distribution of Energy

The minimum release requirements for the alternative hydro sites selected in the DEIS correspond closely to the hydrologic cycles in these basins, which are characterized by high flow in the summer and low flow in the winter. However, the Railbelt energy requirement is the opposite; low in the summer and high in the winter. If the DEIS minimum flows constrain operation, seasonal regulation of flow would be limited and most of the energy from each site would be produced during the summer when the energy requirements are low. Since water stored in the reservoir for winter generation would be limited or non-existent, winter energy generation would be significantly reduced and the dependable capacity of the non-Susitna hydro alternative sites would be reduced. Therefore, the required amount of thermal capacity for winter operation may be as great as that required without the alternative hydro. Thus, most of the benefit of the alternative hydro sites would result from displacing fuel which otherwise would be used for thermal generation during the summer. Little or not thermal installed capacity would be displaced.

In order to simulate operation of the alternative hydro sites, the monthly Reservoir Operation Model (RESOP) was used. The energy required in year 2010, assuming the Applicant's Reference Case Forecast, was used as the upper limit for energy production. The year 2010 was selected for this study because by that year the non-Susitna hydro alternatives could all be constructed. The energy requirement included 10% transmission line and distribution losses and was adjusted to exclude the average energy generated from existing Railbelt hydroelectric projects (Eklutna; Cooper Lake; and Bradley assumed on-line in 1988). Each alternative was simulated separately, starting from the smallest volume reservoir (Snow) and ending with the largest (Johnson). As each reservoir is operated, the average monthly energies of the previously simulated reservoirs are subtracted from the system energy requirement. The reservoir being simulated has its energy production limited by this modified system energy requirement. This severely limited the energy that could be produced in the summer by Johnson, the last reservoir to be simulated, but Johnson has the largest volume of storage and the best ability to regulate flow to the winter months.

Table 18 shows the monthly alternative hydroelectric energy production with the five plants operated in order of increasing reservoir volume, starting with the smallest. System energy requirement, non-hydro requirement, and spilled energy on a monthly basis are also listed for comparison.

As a measure of sensitivity of output to the selected order of plants, two other combinations were analyzed. Table 19 shows an analysis in which plants are selected in order of storage size in terms of days of mean flow, starting with the smallest and successively introducing larger plants. The active storage in days of mean flow is shown in Table 14. In Table 20 the project order was rearranged with Chakachamna given first priority and following successively by Snow, Keetna, and Browne. Johnson is larger than the others but is listed at the end because of its undesirably large reservoir area and questionable foundation conditions. The total energy production and its monthly distribution are essentially the same as the results of the simulation in the order of storage volume (Table 18).

Table 21 shows a comparison of average annual energy as computed by HEC-5 (from DEIS Table 1-18) with that computed by RESOP for year 2010 load conditions.

The same results from three different arrangements in simulation shows that the priority of power generation within the five non-Susitna hydro alternatives will not affect either the total energy production or its distribution. The two factors governing the total energy production are: (1) low energy demand and high minimum release in summer, which limit the energy production in summer to the system requirement, and (2) insufficient reservoir storage at the end of the wet season, which severely limits the energy production in winter.

9.6 Dependable Capacity

The generating capacity at each of the non-Susitna hydro alternative sites is limited by both hydraulic capacity (as discussed in Section 9.4) and water supply.

The annual peak load demands occur in December and January in the Railbelt. The projected monthly distribution of energy demand (Exhibit B, Volume 2A Table B.75, License Application July 1983) shows that the annual peak is in December although it could be in January in some years.

In this study, the average plant output in December, which is the average energy production in December divided by the number of hours in the month, is considered as the dependable capacity of the plant. This definition was selected because the sites are on anadromous fish streams and hourly discharge fluctuation is not assumed. Table 22 shows the resulting dependable capacities for December.

As discussed in Section 9.5, the water release or energy production in winter is significantly reduced because of high releases in summer. Likewise, the dependable capacity in winter would be much less than the plant capability when available water supply is considered.

9.7 Conclusions

In general, the seasonal regulation of flows by the reservoirs would be limited by the high minimum flow requirements in summer. A large amount of energy would be spilled in the initial years of the alternative projects' operation because of low energy demand and high flow requirements in the summer. However, as energy requirements increase with time more summer energy can be absorbed in the Railbelt system. However, winter energy supplied by the non-Susitna hydro alternatives would not increase with load growth.

The average annual energy production by RESOP in 2010, as shown in Table 21, is 21 percent less than that estimated in the DEIS. The reason is that the simulation by RESOP considered the five alternatives as a system and limited the energy production to the monthly system energy requirement, whereas, the DEIS study considered the alternatives as individuals and did not relate energy production to system demand. However, as system energy requirements increase beyond the 2010 level, the energy output indicated by HEC-5 can be absorbed into the Railbelt. Rough calculation indicates that all the energy would be absorbed by year 2025.

From Table 18 it can be noted that only 27 percent of the monthly system energy requirement in December 2010 is supplied by the alternatives. This energy production translates directly into the dependable capacity of the alternatives. The total dependable capacity of all the non-Susitna hydroelectric alternatives is 260 MW or 34 percent of their total installed capacity. This value would not increase with time.

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TABLES

TABLE 1
ENGINEERING ASSESSMENT
ALTERNATIVES VS. SUSITNA

		Alternatives					Proposed Project	
	Project Feature	Browne	Johnson	Keetna	Snow	Chaka-chamna	Watana	Devil Canyon
1.	Access	+	+	+	+	-	-	+
2.	River Diversion	+	+	+	+	+	+	+
3.	Camp	+	+	-	+	+	+	+
4.	On-Site Roads	+	+	+	+	+	+	+
5.	Impervious Borrow	+	-	-	+	+	+	-
6.	Pervious Borrow	+	o	+	+	+	+	+
7.	Rock Borrow	+	+	+	+	+	+	+
8.	Relocations	-	-	+	+	+	+	+
9.	Transmission	+	-	+	-	-	+	+
10.	Dam	+	+	+	+	+	+	+
11.	Foundation	-	-	-	-	+	-	-
12.	Disposal	+	+	+	+	+	+	+
13.	Powerhouse	+	+	+	+	+	+	+
14.	Spillway	+	+	+	+	+	+	+
15.	Reservoir	-	-	-	-	+	+	+
16.	Schedule	-	-	+	+	-	+	+
17.	Fish Passage Facility	-	-	-	o	-	o	o
	Individual Net Rating	7+	2+	7+	10+	9+	12+	12+

Overall Rating: Alternatives $\frac{35+}{5} = 7+$; Proposed Project $\frac{24+}{2} = 12+$

LEGEND:

+ No foreseeable problems; condition better than normal; acceptable conditions

- Foreseeable problems or need; entails extensive work or cost

o Not applicable to scheme

Higher rating signifies preference from engineering standpoint.

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TABLE 2
COMPARISON OF
LAND AREA IMPACTED[A,B]

Project Feature	Johnson[C]	Browne[D]	Keetna[E]	Snow[F]	Chakachamna[G]	Watana[H]	Devil Canyon
	Acres Impacted by Non-Susitna Hydroelectric Alternative Sites					Acres Impacted by Proposed Project	
Reservoir	94,500	12,500	5,500	3,200	-	36,000	7,900
Transmission Lines[J]	1,640	50	130	1,050	3,150	10,600	-[K]
Camp Site	100	100	100	100	200	160	90
Borrow Areas	500	20	150	40	10	4,000	400
Access Roads	70	30	90	20	80	630	400
Highway	800	200	-	-	-	-	-
Railroad	-	190	-	-	-	-	70
Other	550	-	-	-	-	210	100
Total	98,160	13,090	5,970	4,110	3,440	51,900	8,960
Overall Totals			124,770			60,860	

Note: Figures represent estimated amount (acres) of surface area lost or disturbed by activities associated with the non-Susitna hydroelectric alternatives and the Proposed Project.

453410/TBL
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Footnotes to Table 2

A: The area estimates do not include acreages covered by physical structures such as spillways, powerhouses, dams, or saddle dams; nor does it include estimates for the relocation of any dwellings or communities inundated by a particular project. Unless otherwise noted, the amount of area disturbed by rights-of-way, borrow areas, and area inundated by each impoundment are based on estimates provided in this report.

B: Acreage estimates have been rounded to nearest 10 acres.

C: Highway estimate based on projected relocation of 23 miles of highway with a 200 foot right-of-way.
Transmission line area estimate based on twin 138 KV transmission lines 135 miles long with a 100 foot right-of-way.
Borrow area estimates based on an impervious borrow site measuring 5,500 x 4,000 feet and a rock borrow site measuring 500 x 500 feet.
Access road area based on estimated need for 20 miles of road 30 feet wide.
"Other" includes 8 acres for a new highway maintenance station and 23 miles of relocated pipeline with a 100 foot right-of-way.

D: Highway estimate is based on projected relocation of 8.5 miles of highway with a 200 foot right-of-way.
Transmission line area estimate based on a pair of 138 kilovolt (KV) transmission lines 4.5 miles long with a 100 foot right-of-way.
Access road area based on estimated need for 10 miles of road 30 feet wide.
Relocated railroad estimate based on 16 miles of railroad with a 100 foot right-of-way. Borrow area estimates based on an impervious borrow site measuring 1000 x 1000 feet and a rock borrow site measuring 500 x 500 feet.

E. Transmission line area estimate based on a pair of 138 KV transmission lines 11 miles long with a 100 foot right-of-way.

Footnotes to Table 2 (Cont'd)

Borrow area estimated based on impervious borrow sites measuring 2,000 x 1,000 feet, 4,000 x 800 feet, and 2,000 x 750 feet, and a rock borrow site measuring 500 x 500 feet.
Access road area based on estimated need for 25 miles of road 30 feet wide.

F: Transmission line area estimate based on: (1) one 115 KV line 30 miles long with a 100 foot right-of-way, and (2) one 115 KV line 60 miles long with a 100 foot right-of-way.
Borrow area estimates based on an impervious borrow site measuring 1,100 x 1,500 feet and a rock borrow site measuring 500 x 500 feet.
Access road area based on estimated need for 4 miles of road 30 feet wide.

G: Transmission line area estimate based on twin 230 KV transmission lines 130 miles long with a 200 foot right-of-way.
Borrow area estimated based on 2 rock borrow areas, each measuring 500 x 500 feet.
Access road area based on estimated need for 24 miles of road 30 feet wide.
Camp area based on land needed for two camps.

H: Area estimates given in this section are from the revised License Application tables appended to Response to Agency Comment I.370 (Reference I.370.2), submitted February 15, 1984.
Transmission line estimates are for joint dam operation for corridors from: Healy to Willow (3437 ac), Watana to Gold Creek (1538 ac), Healy to Fairbanks (3527 ac), and Willow to Cook Inlet (2056 ac).
'Other' includes estimates for the area impacted by permanent village and airstrip.

I: Area estimates given in this section are from the revised License Application tables appended to Response to Agency Comment I.370 (Reference I.370.2), submitted February 15, 1984.

Footnotes to Table 2 (Con't)

J. Area represents a worst-case estimate of area impacted since only forest and tall shrub types would require major clearing. Values do not include areas that would be affected by expansion of existing transmission lines.

K. Transmission line area estimates for the Devil Canyon project are included in acreage given for Watana (see footnote H).

TABLE 3

1982 SUMMARY
ESTIMATED CHAKACHAMNA SALMON ESCAPEMENT
BY WATERBODY AND DRAINAGE

Species	Chakachamna River Drainage: Upstream of Dam Site	Chakachamna River Drainage: Downstream of Dam site	McArthur River Drainage	Total
Sockeye	41,357	2,280	34,933	78,570
Chinook	---	---	2,107	2,107
Pink	---		19,777	19,777
Chum	---		29	29
Coho	---		4,729	4,729
Overall Total	41,357	2,280	61,575	105,212

Source: Bechtel 1983

Table 4-COMPARISONS OF SOCIOECONOMIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
1. COMMUNITIES AND AREAS AFFECTED	• Tok, Tanacross, Dot Lake, "The Living Word" at Dry Creek and Delta Junction.	Healy, and Nenana.	• Talkeetna and Trapper Creek.	• Seward, Eastern Peninsula of Kenai Peninsula Borough.	• Tyonek and surrounding small communities.		• Trapper Creek, Cantwell, and Talkeetna.
2. POPULATION	• During the peak construction period 1,300 persons would in-migrate to the area.	• Peak construction in-migration would total 660 persons. Construction work forces on the roads and railway would add substantially to in-migration and compound other impacts of Browne construction.	• In-migration to Talkeetna and Trapper Creek would total 880 persons.	• Peak construction in-migration would be 900 persons.	• Peak construction in-migration would be approximately 2,000 persons.	• The project would increase populations in a number of small communities; in some cases, the impacts would be substantial. Population impacts are likely to be underestimated because of little or no consideration to construction of ancillary facilities (roads, railroad, transmission lines) in addition, to greater populations due to increased access.	• Communities receiving major in-migration would include Trapper Creek, Cantwell, and Talkeetna Impacts are expected to peak in 1990.
3. INSTITUTIONAL / QUALITY OF LIFE	• A decrease in the rural, undeveloped nature of the area may occur with changes in scenic quality. The Native communities of Tanacross and Dot Lake may experience cultural conflicts and subsistence interference.	• The project would interfere with cultural and subsistence activities of Nenana residents.	• Rapid growth impacts would alter residents' quality of life and the rural nature of the area.	• Rapid growth impacts would alter residents' quality of life and the rural nature of the area.	• The project would interfere with the Native culture and subsistence activities of Tyonek and surrounding community residents.	• Impacts would be similar to Susitna and dispersed among a larger number of communities. Communities such as Dot Lake and Tyonek would experience potentially severe cultural and subsistence interference.	• The rural lifestyle of Trapper Creek, Cantwell, and (to a lesser degree) Talkeetna would be changed. Cantwell may experience increased cultural conflict.
4. ECONOMY / EMPLOYMENT	• Existing commercial operations might expand and others open. Commercial expansion and recreation opportunities at the impoundment may encourage tourism. Some local residents may fill support jobs.	• Commercial operations may have increased business in local communities and Fairbanks.	• Increased access would create opportunities for commercial development of recreation and tourist facilities.	• Some Seward residents may be hired leading to a reduction in Seward's high umployment.	• Commercial operations would expand and diversify.	• Existing commercial establishments in most communities would experience an increase in business and some would expand. New opportunities related to tourism and recreation would be created in some areas and local residents from a few communities may find project-related employment.	• Some local residents would gain employment, resulting in minor reduction of unemployment. Some tourist, construction, and service-related industries would be created or expanded. Some guiding businesses would be displaced. Periods between peak employment could increase unemployment.
5. HOUSING	• About 400 households would require temporary or permanent housing; most in-migrants would settle in Tok and Delta Junction.	• Considerable housing development would be needed to accommodate 300 new households.	• Substantial impacts similar to those from the Susitna Project would occur.	• Up to 300 housing units (permanent or temporary) would be needed.	• Considerable housing development would be required to accommodate the in-migration of 2,000 persons since little or no vacant housing is currently available.	• A small number of communities would require considerable housing development for permanent and / or temporary project-related in-migrants.	• Housing demand would require expansion in Talkeetna, Trapper Creek, Cantwell, and unincorporated Mat-Su Borough areas. Demand would be likely to exceed supply in the short-term.
6. COMMUNITY SERVICES	• Community services would have to be expanded considerably.	• Schools, sewer and water, police and fire, and health facilities and full-time personnel would need to be added.	• Substantial impacts similar to those from the Susitna Project would occur.	• Sewer, water and other community services would be needed. Schools are likely to be able to absorb new students but more teachers would be needed.	• Sewer, water, fire, police and health facilities would have to be added. The Tyonek school would have to be expanded by 50%.	• Most communities would require an expansion of community services including sewer and water, police and fire, health facilities and personnel.	• Services would require expansion in Talkeetna, Trapper Creek, Cantwell, and unincorporated Mat-Su Borough areas. Most notable needs would be in schools, fire departments, police departments and health services.
7. FISCAL STATUS	• Delta Junction would finance the costs of community expansion needs. The state would finance the costs of community expansion for Tok.	• Planning, financing and construction of added community services in Nenana would be funded by the town; in Healy such funding would be by the state.	• Improvements would be at expense of the Mat-Su Borough.	• Planning, financing, and construction costs for Seward would be funded by the city.	• Construction and planning of services would be funded by the Kenai Peninsula Borough.	• Funding for planning and construction of expanded community services would be required from many towns and cities while the state would incur costs for a number of unincorpoarated places.	• Responsibility for community service expansion would be with the towns, borough, or the state.
8. TRANSPORTATION	• The impoundment would inundate portions of the Alaska Highway, a highway maintenance station, 3 gravel pits, 2 stream gaging stations, a pipeline, telephone line, lodge, and two communities (Dot Lake and "The Living Word" at Dry Creek).	• 10 miles of the Parks Highway, Alaska Railroad, and transmission line right-of-way would be inundated.	• Additional roads would be needed to access the site and traffic volumes would likely increase on these and other nearby road.	• Additional roads would be needed to access the site and traffic volume would increase.	• Additional roads would be needed to access the site and traffic volumes would likely increase on these and other nearby roads.	• A number of new roads would be required to access the 5 hydro sites. Additionally, the inundation of miles of existing highway, railroad, pipeline and rights-of-way would require construction of new routes concurrent with proposed project construction. Generally traffic volumes would increase on all roads in and around impacted communities, several roads would likely reach capacity.	• All transportation modes and routes leading to the project area would be used more heavily. Only the highway junction at Cantwell the site access road junction with the Denali Highway, and the rail access junction and the main rail line could become conjested.

Table 4

COMPARISONS OF SOCIOECONOMIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

Table 4-COMPARISONS OF SOCIOECONOMIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
9. ASSUMPTIONS	• Peak construction work force = 300 Construction period = 7 years	• Peak construction work force = 200 Construction period = 4 years It is assumed that in the worse case only 75% of the construction work force would commute from Fairbanks.	• Construction work force = 200 Construction period = 4 years	• Construction work force = 200 Construction period = 4 years	• Peak construction work force = 400 Construction period = 5 years		• Peak construction work force in 1990 = 3,500
10. COMMENTS	• During construction if there is no camp on-site housing, then severe impacts would occur in the area between Tok and Delta Junction. • The most serious impacts would be the inundation of two communities Dot Lake (population: 67) and "The Living Word" (population: 200). • A lodge may also be inundated. • The rapid growth impacts to Tok and Delta Junction would be exaggerated by road and pipeline work forces.	• Browne's location between Healy and Nenana would lead to construction and operation impacts mainly in those towns. • Due to the project's concurrence with Keetna construction (200 miles away) population impacts may be increased; shortages of supplies exacerbated, and supply routes (highway and railroads) may have difficulty with carrying capacity.	• In-migration would almost double existing population so impacts would be significant.	• Due to this project's concurrence with Browne's construction (200 miles away) population impacts would increase, shortages of supplies exacerbated, and supply routes (highways and railroads) may have difficulties with carrying capacity.	• Tyonek would experience significant impacts from the in-migrating construction population. • Permits to construct roads to the site may be difficult to obtain from the Tyonek Native Corporation.		• Population impacts used in this comparison are those entitled "Applicant (Rev.)" in the DEIS. In March 1984 the applicant submitted revised projections that decreased the impacts on Talkeetna but increased impacts on Healy and McKinley Park.

Table 4

COMPARISONS OF SOCIOECONOMIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

Table 5-COMPARISONS OF LAND USE AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
1. LAND USE	• The land in and around the site is primarily forest, wildlife habitat, and recreation land with isolated settlements, mineral and gravel extraction areas, and transportation and utility corridors. These uses would be greatly impacted by the inundation of approximately 84,000 acres of land and by access into new areas opened by project roads, the transmission line corridor, and rerouting of the highway and pipeline. • Portions of the Alaska Highway and an oil pipeline, a highway maintenance station, 3 gravel pits, 2 stream gaging stations, a telephone line and 2 communities (Dot Lake and another at Dry Creek) would be inundated.	• The land at the site is being disposed by the state to private individuals for settlement and agricultural uses. Significant impacts would occur from increased development pressures, increased competition for recreation and wildlife resources and disturbance of the natural, remote setting due to new access by project roads and utility corridors. • Portions of the George Parks Highway and Alaska Railroad would be inundated along with approximately 5,000 acres of the Healy Agricultural Subdivision, other private tracts and at least one mining claim.	• The land in and around the site is state land used primarily for hunting and other recreation purposes. Lands to the west are settlement lands for disposal by the state as homesteads, subdivisions, and remote parcels. Impacts resulting from the project's access road and transmission line corridor would significantly impact these settlement areas by increasing traffic, recreation pressures on state lands, and by reducing the quality of the remote natural setting. • The inundation would remove 4,800 acres from their present uses. Few impacts would result from the dam and impoundment since the land is in state ownership.	• Access due to new project roads and the reservoir would increase back country use, impacts on vegetation and wildlife resources, and affect the natural setting of the forest lands, particularly in areas closest to the highway. Approximately 2,600 acres of land would be removed from existing uses.	• The rugged terrain surrounding the site is used primarily for recreation including hunting. Increased access with roads and a transmission line corridor would significantly increase such uses of the area. • Since the project calls for a lake tap, a negligible amount of land would be required and overall land use impacts would be minimal.	• Access to recreation lands would be greatly increased leading to increased pressure on vegetation, wildlife resources, and the quality of the remote natural setting. Compared to recreation lands, the effects on settlement and agricultural lands would be significant. Also, a combined total of 115,640 acres would be lost from current uses.	• In the project area where dispersed recreation is the primary land use increased increased pressures from possible residential, commercial, and natural resources development and recreational activities could disturb vegetation and wildlife and fisheries resources. • Approximately 36,000 acres and 6 structures would be inundated with Watana; 7,900 acres with Devil Canyon. • The construction camps for the proposed dams and the temporary village and airstrip would cover approximately 425 acres.
2. LAND OWNERSHIP	• Land ownership at the site and through which access would occur includes state forest lands, Native lands, and private lands acquired from state land disposal programs.	• Land in and around the site is owned primarily by private individuals and the state which intends to transfer their lands to private ownership through disposed programs.	• The state owns the land at the dam and impoundment sites. The state and private individuals own the land to the west through which project roads and utilities would run.	• The land at the site is federal land within the Chugach National Forest. However, nearby sites through which the transmission line would run are in private ownership.	• The land at the site is state land. Land to the east through which access roads and the utility lines would run include Native, borough and state lands.	• Land ownership is complex and varied at many sites particularly where access routes and transmission corridors occur. Difficulties could result when negotiating purchases or easements across private land.	• Lands at the dam and impoundment sites are owned by the state and various Native entities including the Cook Inlet Region Native Corporation.
3. MANAGEMENT PLANS	• The inundation could greatly affect the management plans of the various landowners.	• Since the land has been, or is being disposed of, by the state for private use, project uses may be in conflict with those of a variety of private owners.	• The location of the project access roads and transmission corridor over disposal lands may create conflicts with private uses of those lands.	• National forest are usually managed for multiple use allowing for some development which could include construction similar to that of the project.	• Due to the multiple ownership of lands through which the access roads and transmission line corridor would run, conflicts with management plans may occur.	• Where multiple ownership exists, particularly along access and transmission line routes, conflicts may occur with existing or intended management plans.	• Since land management plans for the project area call for multiple use and actual management is essentially passive, the project would not appear to present conflicts.

Table 5
COMPARISONS OF LAND USE AND
IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND
THE SUSITNA PROJECT

Table 6-COMPARISONS OF CULTURAL RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
1. NUMBER OF KNOWN CULTURAL RESOURCES IN AREA	• None	• 50 +	• None	• Present but not quantified.	• None	• 50 +	• 250 +
2. LIKELIHOOD OF PREVIOUSLY UNKNOWN RESOURCES BEING DISCOVERED	• Very likely; numbers may exceed Susitna Project due to size of project and location near a major river corridor.	• Very likely; not quantifiable at this time	• Very likely, not quantifiable at this time; probably fewer than Susitna.	• Very likely, not quantifiable at this time; probably fewer than Susitna.	• Possible, but fewer than at other sites.	• Likely to exceed those known at the Susitna site.	• Possible, but not likely.
3. SCOPE OF NEEDED ADDITIONAL IDENTIFICATION STUDIES	• Very large-scale field studies necessary	• Large-scale field studies necessary.	• Large-scale field studies necessary	• Large-scale field studies necessary.	• Moderate-scale field studies necessary.	• Major undertaking necessary, exceeding studies done for the Susitna Project.	• Only small-scale additional studies needed.
4. SCOPE OF NECESSARY MITIGATION	• Likely to exceed that required for the Susitna Project.	• Likely to be less than that required for the Susitna Project.	• Likely to be less than that required for the Susitna Project.	• Likely to be less than that required for the Susitna Project.	• Likely to be limited and much less than other sites.	• May exceed that required for the Susitna Project.	• Large-scale data program necessary

Table 7 - COMPARISON OF RECREATION RESOURSES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
RECREATION RESOURCES	• Tanana River heavily used for private and commercial boating. • Charter boat service located at Dot Lake. • Tanana River proposed by the State as a multiple-use river. • Tanana River supports moderate level of sport fishing. • Intensive fishing occurs in number of small lakes in project area. • Significant amounts of hunting in project area. • Numerous multiple-use trails throughout project area. • Alaska Highway (a portion of which within impoundment zone) is major tourist route.	• Nenana River heavily used for river travel and moderately used for recreational boating and fishing. • Parks Highway and Alaska Railroad are major tourist routes. • Developed recreation facilities within impounament area include trails, rest area, and scenic overlooks • Moderate levels of hunting, fishing, and hiking occur in project area. • Impoundment approximately 3 miles from Denali National Park boundary. • Three areas within project area are recommended as State recreation sites and reserve.	• Talkeetna River considered one of the finest white water rafting areas in State. • Talkeetna River used heavily (a portion of which is within impoundment zone) by charter boats. • Heavy fishing occurs in Talkeetna River and its tributaries. • Talkeetna River corridor receives significant amounts of hiking and hunting use. • Talkeetna River recommended as a State Recreation River.	• Project site located within Chugach National Forest. • Area used for hunting, camping, fishing, and wilderness hiking. • Forest service recreational cabin located on Paradise Lake within impoundment zone. • Seward Highway and Alaska Railroad pass within 3 miles of dam site.	• Project site located within Merrill Pass — a major air corridor to Lake Clark National Park. • Lake Chakachamna used as staging area for access to surrounding area for hiking, fishing, and hunting. • Heavy fishing use in McArthur and Chakachatna Rivers. • Waterfowl hunting in Trading Bay State Game Refuge.	• Heavy boating use on three rivers. • Projects in close proximity to three major highways, railroad, and a major air corridor. • Two rivers, one stream, and three recreation areas within project areas are recommended for State protection. • Projects cover large areas used for hunting and dispersed recreational activities. • One project within a National Forest and two near National Parks.	• Large area with low level of dispersed recreational use (due to remoteness). • Moderate amounts of boating use below Devil Canyon and above Vee Canyon. • Limited white water boating of Devil and Vee Canyon Rapids • Devil Canyon Rapids considered world class white water resource. • Low levels of fishing use in area streams and lakes • Scattered cabins along river corridor used for hunting and trapping. • Area receives moderate amount of use for hunting. • Two lodges within project area used for hunting and fishing.
RECREATION IMPACTS	• 94,500 acres of land used for big and small game hunting, inundated. • Increase demand on hunting and fishing resources due to increase in access to remote areas. • Fishing opportunities lost in Tanana River and lakes within the impoundment zone. • Potential new opportunities in the impoundment for subsistence fishing but not recreational fishery due to turbid water. • Salmon above the site that contribute to downstream fisheries may be lost. • Loss of Tower Bluff rapids and white water boating. • Loss of popular commercial and private boating resource and transportation corridor with charter boats on Tanana River. • Limited reservoir boating opportunities available due to wind, turbid water, and extensive drawdowns. • Loss of land used for dispersed recreational activities. • Tanana River, recommended as state multiple-use river will be inundated. • Inundation of portion of Alaska Highway and loss of related recreation activities such as camping, sightseeing, and wildlife viewing. • Increase in competition for existing facilities and demand for additional facilities due to project induced population.	12,500 acres of moderately used hunting areas, inundated. • Fishing opportunities lost in Nenana River. • Potential new opportunities in the impoundment for subsistence fishing but not recreational fishing due to turbid water. • Salmon above the site that contribute to downstream fisheries may be lost. • Popular intermediate level kayaking course inundated. • Loss of free flowing section of Nenana River which is intensively used for river travel by all boaters. • Limited reservoir boating opportunities available due to wind, turbid water, and extensive drawdowns. • Loss of land used for dispersed recreational activities. • Loss of recommended state recreation areas (June Creek, Bear Creek and Kobe Hill). • Loss of rest area on George Parks Highway. • Relocation of parts of George Parks Highway and Alaska Railroad eliminating existing views and providing views of project. Increase in recreation demand due to loss of existing facilities / areas and increase in project-induced population.	• 5,500 acres of heavily used moose hunting area inundated. • Increased demand on hunting and fishing resources due to increase in access to a remote area. • Fishing opportunities lost for salmon upstream of dam. • Existing fishery in the impoundment zone would be lost; potential replacement by reservoir may occur. • Salmon above the site that contribute to downstream fisheries may be lost. • Dam would block significant white water boating corridor. • Loss of existing popular commercial and private boating opportunities. • New boating opportunities possible on reservoir, but limited due to wind, turbid water, and drawdowns. • Loss of land used heavily for trail-related and dispersed recreational activities. • Inundation of Talkeetna River which is recommended as a State Recreation River. • Inundation of Disappointment Creek which is also recommended for protection. • Potential to substantially increase use of the area via air and road access. • Increased use of area due to increase in project-induced population.	• 3,200 acres of moderately used moose hunting area inundated. • Increased demand on hunting and fishing resources due to increase in access to remote area. • Loss of fishing opportunities in lower Paradise Lake; no replacement by impoundment expected due to turbid waters. • Loss of forest service cabin located on Paradise Lake. • New boating opportunites possible on reservoir, but limited due to turbid waters, wind and drawdowns. • Intrusion on wilderness hiking experience in Chugach National Forest. • Impacts to views from Seward Highway and Alaska Railroad. • Potential to increase use of the area via increased access.	• Increase in hunting in Trading Bay State Game Refuge. • Increase in competition by hunters due to access to remote areas. • Fishing patterns altered due to changes in existing flow patterns and diversions. • Loss of boating potential in Chakachatna River. • Increased use to Lake Clark National Park by new access into wilderness. • Increased use of area due to increase in project-induced population.	• Loss of over 110,000 acres of hunting land, some heavily used. • New access to three remote areas increasing hunting pressure. • Fishing patterns altered at all sites. Some replacement may be possible by new impoundment; however, turbid reservoirs would reduce the opportunities. • Significant fishing areas lost. • Notable rapids lost on four rivers. Significant loss of white water boating on one river. • Impacts to boating opportunities on five rivers, significant impacts to boating on three rivers. • Loss of large areas of land used for land-based recreation. • Inundation of two rivers and one stream recommended for state protection and numerous small sites recommended for state recreation. • Impacts to sightseeing from three major travel roads, railroad, two National Parks, and one National Forest. • Substantial increase in recreation demand due to five projects in different areas of the state; project-induced population increases and proximity of sites to major travel routes.	• Loss of 46,00 acres of big game hunting area. • Increase in hunting and fishing pressure due to new access to remote area. • Existing fishery in the impoundment zone would be lost; some replacement may be possible; turbid reservoirs may reduce opportunities. • New access could decrease fishery resources by allowing over fishing of area streams and lakes. • Devil Canyon Rapids and Vee Canyon Rapids • inundated—significant white water boating opportunities. • Loss of potential river boating opportunities. • New opportunities possible on reservoir; but limited due to wind, turbid waters, and drawdowns. Loss of land used for dispersed recreational activities. • Increased in recreation demand due to new access and influx of people during construction and operation.

Table 7

COMPARISONS OF RECREATION RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

Table 8-COMPARISONS OF AESTHETIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
AESTHETIC RESOURCES	• Moderate scenic value. • Alaska Highway corridor recommended by state for scenic protection. • High visual sensitivity due to presence of Alaska Highway in project area. • Notable scenic attractions include Tower Bluff Rapids.	• High scenic value. • Very high visual sensitivity due to presence of Parks Highway, Alaska Railroad, river use, and proximity to Denali National Park. • Segments of Parks Highway recommended for scenic highway designation. • Notable scenic attractions are Kobe Hill, a state recommended scenic trail, and numerous overlooks on Parks Highway.	• Moderate to high scenic value. • Moderate visual sensitivity due to use of Talkeetna River corridor and recent land disposals. • Talkeetna River proposed as a State Recreation River. • Notable scenic attractions include Sentinel Rock and Granite George.	• Very high scenic value. • Moderate visual sensitivity due to Seward Highway and Alaska Railroad passing close by and recreational use of the area. • Notable scenic attractions include the Snow River Gorge, Paradise Lakes, and Paradise Peak.	• High scenic value. • Moderate visual sensitivity due to site being within Merrill Poss air corridor. • Notable scenic attractions include Chakachatna River Canyon, Chakachamna Lake, and surrounding mountains.	• Three sites located in areas of high scenic value, two sites in areas of moderate to high scenic value. • Two sites located in areas of high visual sensitivity and three sites in areas of moderate visual sensitivity. • Project sites include a number of notable scenic attractions.	Moderate to high scenic value. • Moderate to low visual sensitivity due to limited recreational activities in areas accessed via plane, or boat. • Notable scenic attractions include Devil and Vee canyons, Deadman and Devil Creek falls, and Big and Deadman lakes.
AESTHETIC IMPACTS	• Project facilities and dam would be highly visible from Alaska Highway. • Transmission lines would be visible from highway and other views from Tanana Valley. • Shoreline erosion could be extensive due to openness and size of reservoir. Large mudflats would be visible from Alaska Highway and to other recreational users. • Ice fogging could reduce visibility in valley. • 210 foot dam and associated facilities would dominate the valley's visual character and strongly contrast with the surrounding landscape. • Crest length of dam would be 6,400 feet and would be highly visible. • Extensive cuts due to relocation of Alaska Highway would be visible. • Alaska highway has been recommended for scenic protection. • Tanana River has been recommended as a multiple-use river corridor that provides for protection of visual resources. • Tower Bluff Rapids, which is of notable scenic quality, would be inundated. • Land in Tanana Valley which has moderate scenic quality, would be inundated.	• Project facilities would be highly visible from Denali National Park, George Parks Highway, and Alaska Railroad. • Transmission lines would be visible from Denali National Park and Nenana Valley. • Extensive mudflats would be visible from Parks Highway and Alaska Railroad. • Additional visual impacts could occur due to relocation of existing transmission line. • 265 foot dam and associated facilities would dominate the valley's visual character and strongly contrast with the surrounding landsacpe. • Crest length of dam which is 3,000 feet would be highly visible. Cuts and fills from relocation of Parks Highway and Alaska Railroad would be visible. Portions of Nenana River have been reommended as a State Recreation River. Portions of George Parks Highway which has been recommended as a scenic highway,would be inundated. Dam abutment would be constructed on Kobe Hill, recommended as a scenic state trail and Public Recreation Reserve.	• Project facilities would be visible to significant numbers of river corridor users and recent land disposal owners in the area. • Transmission line would be visible along Talkeetna River. • Some slumping and beach erosion visible to local users. • 415 foot dam and associated facilities would inundate part of a highly scenic valley. • Talkeetna River and Disappointment Creek, recommended as scenic river corridors, would be inundated. • Notable scenic attractions of Sentinel Rock and Granite Gorge would be inundated.	• Project facilities, including transmission lines and the dam, would be visible from Seward Highway and Alaska Railroad. • Minor amount of erosion and mudflats visible to users. • 90 miles of transmission line would be constructed in highly scenic valleys. • 310 foot dam and associated facilities would inundate part of a scenic valley that is predominantly wilderness. • Highly scenic South Fork Snow Valley would be inundated. • Snow River Gorge would be inundated. • Visual impacts would occur in National Forest Wilderness Areas.	• Project facilities and transmission lines would be visible to recreational users and air traffic in a major air traffic corridor. • Some shoreline erosion and mudflats would be visible to users. • 50 miles of transmission line would be constructed in a highly scenic area where no lines currently exist. • A significant reduction in flow through Chakachatna River Canyon, would diminish the scenic appeal of the area.	• Views of project facilities and reservoirs would be extensive due to disturbance of four major travel routes. • 102,000 acres of land would be inundated in areas of moderate to high scenic value. • Approximately 280 miles of transmission corridor routed in areas with high visual sensitivity. • Significant visual impacts would occur due to relocation of existing travel routes and utilities. • Direct and indirect effects would occur to several areas of scenic value located along scenic corridors. • Direct and indirect effects would occur to several state and nationally significant areas.	• Project facilities, except transmission lines, would only be visible from project access road. Mudflats and beach erosion would be visible to users of reservoirs. • 3,800 acres of land would be inundated in areas of moderate scenic value. • Two dams (Devil Canyon — 646 foot high and Watana — 385 foot high) would be visible in a scenic canyon area and would contrast with the surrounding landscape setting. • Devil and Vee canyons would be partially inundated. • Deadmen Creek Falls would be inundated. • Construction of facilities in an area that is predominantly wilderness.

Table 8
COMPARISONS OF AESTHETIC RESOURCES AND
IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND
THE SUSITNA PROJECT

Table 9-COMPARISON OF TERRESTRIAL RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
1. AREA INUNDATED OR AFFECTED (Acres)	98,160	• 13,090	• 6,140	• 4,110	• 1,870	• 123,370	• 57,620
2. MOOSE	• Approximately 1 moose/mi^2. Important year—round habitat especially winter range and calving area.	• Approximately 1—1.5 moose/mi^2. Important year—round habitat.	• Important year—round habitat.	• Important spring, fall, and winter range.	• Important winter areas in riparian habitat above lake and in river drainages.	• Important year—round habitat (especially calving and wintering areas). Johnson project would substantially impact local moose population.	• Approximately 1.5 moose/mi^2. Important year—round habitat especially winter range and calving area.
3. OTHER BIG GAME	• Little use of the area by caribou except in severe winters. Dall sheep mainly present at higher elevations in surrounding mountains.	• Caribou frequent the foothills near impoundment. Dall sheep mainly present at higher elevations in surrounding mountains.	• Little use of the area by caribou—small localized herds. Dall sheep mainly at higher elevations in surrounding mountains. Increased access may result in long—term impacts on local wildlife populations.	• Caribou not present. Dall sheep and mountain goats mainly at higher elevations in surrounding mountains. Increased access may result in long—term impacts on local wildlife populations.	• Little caribou use of area. Dall sheep mainly at higher elevations north of the Chilligan River.	• Little use of area by caribou. Little use of areas by Dall sheep. Increased access may result in long-term impacts on local wildlife populations.	• Caribou spring and fall migration crossing area. Important site specific area for Dall sheep (ie. lick). Increased access may result in long-term impacts on local wildlife populations.
4. BLACK / BROWN BEAR	• Brown bear use in early spring. High use of valley bottoms by black bears.	• Important brown bear habitat in surrounding foothills. Low black bear use of area.	• Black bear use of flood plain area. Brown bear use of high altitude riparian communities. Intensive brown bear use of anadromous fish streams that would be blocked by project.	• Black bear use of flood plain area. Brown bear use of high altitude riparian communities.	• High altitude riparian zones important to brown bear. High black bear use of riparian zone around lake and in river drainages. Brown bear seasonal specific use of drainage during salmon runs.	• No data on denning in areas. Keetna project will impact intensive brown bear use of critical salmon streams (eg. Prairie Creek). Lake Chakachamna project will impact brown bear use of Chilligan and Chakachatna Rivers salmon fisheries. All sites contain important year-round black bear habitat (especially riparian zones).	• Important year—round habitat for black bear including denning. Important spring habitat for brown bear.
5. FURBEARERS	• Important riparian habitat along river and in wetland and forested areas within the flood plain.	• Important riparian habitat along river.	• Important riparian and forested habitats along river.	• Important riparian habitat along river and on floodplain.	• Important riparian habitat around lake and along river.	• Important riparian habitat along rivers.	• Important riparian and forested habitats along river.
6. RAPTORS / WATERFOWL	• Important nesting area for bald eagles, golden eagles, and red-tailed hawks. Four peregrine falcon nest locations (three active) along shoreline of impoundment area. Important waterfowl nesting, molting, and resting habitat. Major migration corridor.	• Little raptor or waterfowl data available.	• Bald eagle nesting area. Low waterfowl use.	• Bald eagle nesting area. Waterfowl nesting and molting area.	• Trumpeter swan nesting areas in drainages. Molting area for Tule white—fronted goose. Drainages in major migration corridor.	• Nesting locations at all sites for raptors (especially bald eagles). Peregrine falcon nest locations at Johnson site. Important waterfowl nesting and resting areas at Johnson and Lake Chakachamna sites. Trumpeter swan nesting areas associated with Lake Chakachamna project.	• Nesting locations for bald eagles, golden eagles, and goshawks. Low waterfowl use.

Table 9
COMPARISON OF TERRESTRIAL RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

Table 10-COMPARISONS OF AQUATIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT [1]

SUBJECT	ALTERNATIVES						SUSITNA
	JOHNSON	BROWNE	KEETNA	SNOW	CHAKACHAMNA	TOTAL NON-SUSITNA HYDRO	
1. ANADROMOUS FISH UPSTREAM OF IMPOUNDMENT / PROJECT SITE	• Chum salmon spawn as far upstream as the Chisana River; escapement figures unknown.	• Coho, chum, and chinook present; coho spawn in Panguingne Creek; escapement figures unknown.	Coho, chum, sockeye, and chinook present, spawning by chinook in Prairie Creek is extensive and supports a significant brown bear population for certain periods of the year. 2/	• No spawning above impoundment zone.	• Large numbers of sockeye spawn in tributaries above the site; escapement estimated at 40,000 adults. 3/	• Salmon found upstream of all sites (except Snow). Highly significant numbers are known to exist upstream of Keetna and Chakachamna sites.	• None recorded; passage essentially prevented by Devil Canyon.
2. ANADROMOUS FISH / IMPOUNDMENT ZONE	• Chum, coho, chinook present; chum spawning observed; escapement figures unknown.	• Coho, chum, and chinook present; escapement figures unknown.	• Chum and chinook spawn in Disappointment Creek and potentially the mainstem.	• Reports indicate that sockeye are present in lower Paradise Lake (see text for details).	• Some sockeye spawning areas could be within the drawdown zone; juvenile sockeye use Chakachamna for rearing.	• Salmon present in all impoundment zones; Johnson and Keetna impoundments encompass known spawning sites.	• None except for a few chinook; passage to this area is essentially prevented by Devil Canyon.
3. ANADROMOUS FISH / DOWNSTREAM	• All five species utilize either downstream areas or tributaries.	• All five species utilize either downstream areas or tributaries.	• Chum spawn in mainstem immediately downstream of dam site; all five species utilize downstream areas or tributaries.	• Sockeye and coho spawn in lower Snow River; all five species utilize either downstream areas or tributaries, particularly in the Kenai River.	• All five salmon species utilize downstream areas in either the Chakachatna or McArthur Rivers. Total number of adults in these rivers are approximately 60,000.	• All sites have significant salmon habitat downstream.	• All species utilize either downstream areas or tributaries.
4. UTILIZATION OF ANADROMOUS FISH	• Extensively and extremely important commercial, subsistence, and sport fisheries in the lower Tanana and Yukon rivers. 4/	• Extensive and extremely important commercial, subsistence, and sport fisheries in the lower Tanana and Yukon rivers. 4/	• Significant and highly important sport and commercial fisheries in the lower Talkeetna and lower Susitna rivers and Cook Inlet.	• Significant and highly important sport and commercial fisheries in the Kenai River and Cook Inlet.	• Believed to be significant and important to sport and commercial fisheries downstream and in Cook Inlet.	• Salmon from all sites potentially contribute to significant and highly important commercial fisheries and in some cases to highly important sport (e.g., Kenai River) and subsistence fisheries.	• Significant and highly important sport and commercial fisheries in lower Susitna and Cook Inlet; no contribution by area upstream of Devil Canyon.
5. POTENTIAL IMPACTS OF PROJECT ON ANADROMOUS FISH	• Loss of spawning and rearing areas by inundation. • Disruption of upstream and downstream passage. • Changes in downstream spawning and rearing habitat. • Loss of chum salmon resource upstream of site.	• Disruption of upstream and downstream passage. • Changes in downstream spawning and rearing habitat. • Loss of chum salmon resource upstream of site.	• Loss of spawning and rearing habitat by inundation. • Disruption of upstream and downstream passage. • Changes in downstream spawning and rearing habitat. • Loss of chum salmon resource upstream of site.	• Tentative disruption of upstream and downstream passage (see text for clarification) • Tentative loss of spawning and rearing habitat by inundation. • Changes in downstream spawning and rearing habitat.	• Loss of spawning and rearing habitat by impoundment level changes. • Disruption on upstream and downstream passage, particularly for diversion from one river system to another. • Extensive changes in downstream spawning and rearing habitat.	• Loss of significant spawning and rearing habitat by inundation. • Disruption of upstream and downstream passage. • Extensive areas of downstream spawning and rearing habitat changed. • Loss of chum salmon resource above Johnson, Browne, and Keetna sites.	• Changes in downstream rearing and spawning habitat.

1/ This matrix only considers anadromous salmon—resident species are discussed in the text. Distributions for the anadromous species are taken from the Alaska Department of Fish and Game's Anadromous Waters Catalogue (1983).

2/ Source : Bentz, Jr., R. W. 1982. Inventory and cataloging of the sport fish and sport fish waters in upper Cook Inlet, Table 8, page 102.

3/ Source : Bechtel Civil and Minerals, Inc. 1983. Chakachamna hydroelectric project interim feasibility assessment report.

4/ Source : Alaska Department of Fish and Game, 1983. Annual Management Report 1983 – Yukon area. Division of Commercial Fisheries.

Table 10
COMPARISONS OF AQUATIC RESOURCES AND IMPACTS AMONG NON-SUSITNA HYDRO ALTERNATIVES AND THE SUSITNA PROJECT

The next two pages, Tables 11 and 12, are displayed in their original printed form followed by a copy of each table with handwritten notes. These notes indicate corrections that may be of interest to researchers.

TABLE 11: DEVELOPMENT OF JANUARY 1982 LEVEL HYDROELECTRIC COSTS

PROJECT	COST,[1] JULY 1980 LEVEL ($ x 10^6)	COMMON ESCALATION FACTOR, F[2]	COST, JANUARY 1982 LEVEL ($ x 10^6)
SUSITNA (WATANA & DEVIL CANYON)	2,860.00	BOTH 1980 AND 1982 COSTS ARE COMPUTED VALUES; THEY PROVIDE BASIS FOR ESCALATION FACTOR	5,565.00[3]
ALTERNATIVES			
BROWNE	624.51	x F	1,215.17
JOHNSON	476.65[4]	x F	927.47
KEETNA	254.61	x F	495.42
SNOW	896.92	x F	1,745.23
CHAKACHAMNA	1,480.41	x F	2,880.59
ALTERNATIVES TOTAL	3,733.10		7,263.88

1) COST PROVIDED IN LICENSE APPLICATION TO FERC, "DEVELOPMENT SELECTION REPORT," ACRES AMERICAN, INC., DECEMBER 1981

2) $F = \frac{\text{SUSITNA 1982 COST}}{\text{SUSITNA 1980 COST}} = \frac{\$5,565 \times 10^6}{\$2,860 \times 10^6} = 1.9458$

3) COST PROVIDED IN LICENSE APPLICATION TO FERC, "SUSITNA HYDROELECTRIC PROJECT, VOLUME I, INITIAL STATEMENT," ACRES AMERICAN., INC., FEBRUARY 1983

4) COST NOT INCLUDED IN LICENSE APPLICATION TO FERC, BUT COMPUTED FOR THIS STUDY USING ESTIMATED QUANTITIES AND JULY 1980 LEVEL UNIT PRICES FOR BROWNE, KEETNA, AND SNOW

TABLE 12: COMPARISON OF INDIVIDUAL HYDROELECTRIC ALTERNATIVES

PROJECT	TOTAL COST[1] JAN,1982 LEVEL ($x10^6)	INSTALLED[2] CAPACITY (MW)	AVERAGE ANNUAL OUTPUT (GWh)	COST PER INSTALLED MW ($x10^6/MW)	COST PER GWh ($x10^6/GWh)	MAXIMUM RESERVOIR SURFACE AREA (ACRES)	ACTIVE RESERVOIR VOLUME (ACRE-FT)	COST PER ACRE-FT OF ACTIVE STORAGE ($/ACRE-FT)	REQUIRED RESERVOIR AREA PER GWh (ACRES/GWh)	ACTIVE RESERVOIR REQUIRED PER MW (ACRE-FT/MW)
BROWNE	1,215.12	100	430	12.15	2.83	12,500	760,000	1,599	29.1	7,600
JOHNSON	927.47	210	920	4.42	1.01	94,500	5,300,000	175	102.7	25,238
KEETNA	495.42	100	420	4.95	1.18	5,500	500,000	991	13.1	5,000
SNOW	1,745.23	63	278	27.70	6.28	3,200	174,000	10,030	11.5	2,762
CHAKACHAMNA	2,880.59	330	1,301	8.73	2.21	17,290[3]	1,105,000	2,607	13.3	3,348
WATANA	3,619.20	1,040	3,200	3.48	1.11	38,000	3,000,000	1,206	11.7	2,885
DEVIL CANYON	1,445.80	580	2,310	2.35	0.59	7,900	350,000	5,559	3.4	603

1) TABLE 1

2) REPORT "NON-SUSITNA HYDROELECTRIC ALTERNATIVES," HARZA-EBASCO, JULY 1984

3) EXISTING LAKE

has to be changed

TABLE 11: DEVELOPMENT OF JANUARY 1982 LEVEL HYDROELECTRIC COSTS

PROJECT	COST,[1] JULY 1980 LEVEL ($ x 10^6)	COMMON ESCALATION FACTOR, F [2]	COST, JANUARY 1982 LEVEL ($ x 10^6)
SUSITNA (WATANA & DEVIL CANYON)	2,860.00	BOTH 1980 AND 1982 COSTS ARE COMPUTED VALUES; THEY PROVIDE BASIS FOR ESCALATION FACTOR	5,565.00 [3]
ALTERNATIVES			
BROWNE	624.51	x F	1,215.17
~~JOHNSON~~ KEETNA	476.65 [4]	x F	927.47
~~KEETNA~~ SNOW	254.61	x F	495.42
~~SNOW~~ JOHNSON	896.92	x F	1,745.23
CHAKACHAMNA	1,480.41	x F	2,880.59
ALTERNATIVES TOTAL	3,733.10		7,263.88

1] COST PROVIDED IN LICENSE APPLICATION TO FERC, "DEVELOPMENT SELECTION REPORT," ACRES AMERICAN, INC., DECEMBER 1981 — Not cost 5,15 - Etc. — This was figure used by FERC staff DEIS

2] $F = \frac{\text{SUSITNA 1982 COST}}{\text{SUSITNA 1980 COST}} = \frac{\$5,565 \times 10^6}{\$2,860 \times 10^6} = 1.9458$

3] COST PROVIDED IN LICENSE APPLICATION TO FERC, "SUSITNA HYDROELECTRIC PROJECT, VOLUME I, INITIAL STATEMENT," ACRES AMERICAN., INC., FEBRUARY 1983

4] COST NOT INCLUDED IN LICENSE APPLICATION TO FERC, BUT COMPUTED FOR THIS STUDY USING ESTIMATED QUANTITIES AND JULY 1980 LEVEL UNIT PRICES FOR BROWNE, KEETNA, AND SNOW

Johnson not appropriate here — costs for Browne, Keetna, and Snow used to derive Johnson costs

TABLE 12: COMPARISON OF INDIVIDUAL HYDROELECTRIC ALTERNATIVES

PROJECT	TOTAL COST,[1] JAN,1982 LEVEL ($x10^6)	INSTALLED[2] CAPACITY (MW)	AVERAGE ANNUAL OUTPUT (GWh)	COST PER INSTALLED MW ($x10^6/MW)	COST PER GWh ($x10^6/GWh)	MAXIMUM RESERVOIR SURFACE AREA (ACRES)	ACTIVE RESERVOIR VOLUME (ACRE-FT)	COST PER ACRE-FT OF ACTIVE STORAGE ($/ACRE-FT)	REQUIRED RESERVOIR AREA PER GWh (ACRES/GWh)	ACTIVE RESERVOIR REQUIRED PER MW (ACRE-FT/MW)
BROWNE	1,215.17	100	430	12.15	2.83	12,500	760,000	1,599	29.1	7,600
JOHNSON	~~927.47~~ 1745.23	210	920	4.42	1.01	94,500	5,300,000	175	102.7	25,238
KEETNA	~~496.42~~ 927.47	100	420	4.95	1.18	5,500	500,000	991	13.1	5,000
SNOW	~~1,746.29~~ 1495.42	63	278	27.70	6.26	3,200	174,000	10,030	11.5	2,762
CHAKACHAMNA	2,880.59	330	1,301	8.73	2.21	17,280[3]	1,105,000	2,607	13.3	3,348
WATANA	3,619.20	1,040	3,260	3.48	1.11	38,000	3,000,000	1,206	11.7	2,885
DEVIL CANYON	1,945.80	580	3,310	3.35	0.59	7,800	350,000	5,559	2.4	603

1) TABLE 14

2) REPORT "NON-SUSITNA HYDROELECTRIC ALTERNATIVES", HARZA-EBASCO, JULY 1984

3) EXISTING LAKE

TABLE 13: ALTERNATIVES VS. SUSITNA
JANUARY 1982 LEVEL FIGURES

COMPARISON	ALTERNATIVES [1]	SUSITNA [2]
COST ($ x 10^6)	7,263.88	5,565.00
INSTALLED CAPACITY (MW)	803	1,620
AVERAGE ANNUAL OUTPUT (GWh)	3,349	6,570
MAXIMUM RESERVOIR [3] SURFACE AREA (ACRES)	115,700	45,800
ACTIVE RESERVOIR VOLUME (ACRE-FT)	7,839,000	3,350,000
UNIT COST PER INSTALLED CAPACITY ($ x 10^6/MW)	9.05	3.44
UNIT COST PER AVERAGE ANNUAL OUTPUT ($ x 10^6/GWh)	2.17	0.85
COST PER ACRE-FT OF ACTIVE STORAGE ($/ACRE-FT)	927	1,661
REQUIRED RESERVOIR SURFACE AREA [4] PER GWh (ACRES/GWh)	40	7
ACTIVE RESERVOIR REQUIRED PER MW (ACRE-FT/MW)	9,762	2,068

1) BROWNE,JOHNSON,KEETNA,SNOW,CHAKACHAMNA;TABLES 1 AND 2

2) WATANA,DEVIL CANYON;TABLES 1 AND 2

3) EXCLUDING CHAKACHAMNA LAKE

4) INCLUDING CHAKACHAMNA LAKE

TABLE 14

BASIC DATA FOR FIVE ALTERNATIVE SITES AND THE PROPOSED SUSITNA PROJECT

	Alternative Sites					Proposed Project		
	Browne	Johnson	Keetna	Snow	Chaka-Chamna*	Watana	Devil Canyon	
RESERVOIR ELEVATIONS (ft)								
Maximum	975	1,470	945	1,200	1,128	2,185	1,455	
Minimum	890	1,390	820	1,050	1,014	2,065	1,405	
AREA (1000 ac-ft)								
Maximum	12.5	94.5	5.5	3.2	15.2	38.0	7.8	
STORAGE (1000 ac-ft)								
Maximum	1,100	7,000	850	179	4,033	9,469	1,092	
Minimum	340	1,700	350	6	2,424	5,732	741	
Active Storage								
(1000 ac-ft)	760	5,300	500	173	1,609	3,737	351	
(Days of mean flow)	85	273	101	132	216	237	20	
POWER PLANT								
Power Tunnel (mi)	-	-	-	2.3	12.0	-	-	
Rated Head (ft)	170	149	286	620	663	680	590	
Installed Capacity (MW)	100	210	100	63	300	1,020	600	
Hydr. Capacity (cfs)	8,750	21,500	5,210	1,500	6,404	20,000	15,000	
Energy Prod. (GWh/yr)	444	423	429	266	1,152	3,499	3,435	
December Avg. Cap. (MW)	27	79	21	26	107	720	500	
T.W. Level (ft)	780	1,290	615	500	400	1,455	850	
STREAMFLOW							(Intervening)	(Total)
Drainage Area (sq. mi)	2,450	10,500	1,260	105	1,120	5,180	630	5,810
Yearly Avg. (cfs)	4,500	9,800	2,500	660	3,750	7,990	1,101	9,080
Jun to Aug Avg. (cfs)	11,600	23,400	6,500	1,820	10,280	20,598	2,553	23,151
Sep to May Avg. (cfs)	2,100	5,300	1,200	270	1,570	3,694	612	4,300
MINIMUM FLOW REQ. (cfs)								
Jun to Aug	9,300	24,000	5,000	740	9,900	-	8,180	
Sep to May	1,400	3,200	720	210	1,100	-	5,685	

*Alternative D

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TABLE 15

ALTERNATIVE HYDRO PROJECTS
MONTHLY AVERAGE FLOW AND MINIMUM RELEASE IN SUMMER

Non-Susitna Hydro Alternative Sites	DEIS[1/] Summer Minimum Release (cfs)	Mean Annual Runoff (cfs)	Average Monthly Streamflow (cfs) June	July	August	Data Source
Browne	9,300	4,500	12,608	12,180	10,077	Browne Hydro Alt. by Battelle, Aug 1982 [2/]
Johnson	24,000	9.800	18,328	26,452	25,468	USGS Streamflow Data
Keetna	5,000	2,500	7,214	6,318	5,855	Responses to Additional Data Request by APA Aug. 18 1983 License App. for Major Project
Snow	740	660	1,632	2,116	1,692	Surface Water Records, Cook Inlet, thru 1975, USGS [2/]
Chakachamna	9,900	3,750	8,938	11,818	10,098	Bechtel 1983

1/ Source Table 2-7, DEIS, May 1984.
2 The USGS flow records at the nearest gaging station were used to estimate flows at the damsite.

TABLE 16

ALTERNATIVE HYDRO MINIMUM SUMMER CAPACITY IN DEIS

Non-Susitna Alternative Hydro Project	Installed Capacity (MW)	Capacity Based On Min. Discharge (MW
Browne	100	118
Johnson	210	256
Keetna	100	103
Snow[1/]	100	33
Chakachamna[2/]	300	624
Total	773	1134

1/ Installed capacity of 100 MW in DEIS was revsed by Applicant to 63 MW.

2/ Based on Alternative D.

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TABLE 17

ALTERNATIVE HYDRO HYDRAULIC CAPACITY
COMPUTED FROM INSTALLED CAPACITY IN DEIS

Non-Susitna Alternative Hydro Project	Maximum Hydraulic Capacity		Summer Minimum Flow Requirement	Average Percent Spilled
	(cfs)	(% mean flow)	(cfs)	(%)
Browne	8,750	174	9,300	6
Johnson	21,500	219	24,000	10
Keetna	5,210	208	5,000	0
Snow	2,380	227	740	0
Chakachamna	6,404	171	9,900	35

TABLE 18

ALTERNATIVE HYDRO ENERGY PRODUCTION (GWh)
YEAR 2010 LOAD CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
System Requirement	659	582	575	491	459	427	420	446	465	563	640	717	6444
Existing Hydro	51	45	44	38	43	44	49	53	47	51	51	52	568
Alternative Sites 1/													
Snow	17	15	14	12	14	35	37	39	25	19	20	19	266
Keetna	15	12	13	12	17	80	84	84	55	26	15	16	429
Browne	18	15	15	13	17	78	83	83	55	26	21	20	444
Chakachamna	72	64	63	54	62	189	166	187	81	65	70	80	1152
Johnson	54	48	47	40	35	1	1	0	43	43	52	59	423
Subtotal	176	154	152	131	145	383	371	383	259	179	178	194	2714
Total Hydro	227	199	196	169	188	427	420	446	306	230	229	246	3282
Non-Hydro Requirement	432	383	379	322	271	0	0	0	159	333	411	471	3162
Spilled Energy 2/	0	0	0	0	0	379	421	395	9	4	0	0	1208

1/ Alternative plants are listed in the order of simulation, that is, starting from the smallest reservoir storage volume and ending with the largest.

2/ Spills due to valve release for minimum release requirement or during floods.

TABLE 19

ALTERNATIVE HYDRO ENERGY PRODUCTION (GWh)
YEAR 2010 LOAD CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
System Requirement	659	582	575	491	459	427	420	446	465	563	640	717	6444
Existing Hydro	51	45	44	38	43	44	49	53	47	51	51	52	568
Alternative Sites 1/													
Browne	18	15	15	13	17	78	83	83	55	26	21	20	444
Keetna	15	13	13	12	17	80	84	84	55	26	15	16	430
Snow	17	15	14	13	13	35	38	39	23	20	19	20	266
Chakachamna	73	64	63	53	62	189	165	187	81	65	70	79	1151
Johnson	54	48	47	40	34	1	1	0	42	43	51	59	420
Subtotal	177	155	152	131	143	383	371	393	256	180	176	194	2711
Total Hydro	228	200	196	169	186	427	420	446	303	231	227	246	3279
Non-Hydro Requirement	431	382	379	322	273	0	0	0	162	332	413	471	3165
Spilled Energy 2/	0	0	0	0	0	377	420	394	9	4	0	0	1204

1/ Alternative plants are listed in the order of simulation, that is, starting from the smallest reservoir and ending with the largest (measured in days of mean flow).

2/ Spills due to valve release for minimum release requirement or during floods.

TABLE 20

ALTERNATIVE HYDRO ENERGY PRODUCTION (GWh)
YEAR 2010 LOAD CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
System Requirement	659	582	575	491	459	427	420	446	465	563	640	717	6444
Existing Hydro	51	45	44	38	43	44	49	53	47	51	51	52	568
Alternative Sites 1/													
Chakachamna	70	62	62	52	63	207	215	217	89	67	69	77	1249
Snow	17	15	14	12	13	35	38	39	24	20	20	19	266
Keetna	15	12	13	12	17	80	85	84	55	26	15	16	430
Browne	18	15	15	13	17	61	33	53	54	26	21	20	346
Johnson	54	48	47	40	35	1	1	0	43	42	51	59	419
Subtotal	174	152	150	129	145	383	371	393	265	181	176	191	2710
Total Hydro	225	197	194	167	188	427	420	446	312	232	227	243	3279
Non-Hydro Requirement	434	385	381	324	271	0	0	0	153	331	413	474	3166
Spilled Energy 2/	0	0	0	0	0	380	415	397	9	4	0	0	1205

1/ Alternative plants are listed in the order of simulation. The Chakachamna site, as the overall most favorable site among the five, was put in first and the Johnson site, the least favorable among the five, was put in last.

2/ Spills due to valve release for minimum release requirement or during floods.

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TABLE 21

COMPARISON OF ALTERNATIVE HYDRO ENERGY PRODUCTION - YEAR 2010 LOAD CONDITION (GWh/yr)

Project	Average Annual Energy by HEC-5[1/]	Average Annual Energy by RESOP[2/]
Browne	418	444
Johnson	920	423[3/]
Keetna	420	429
Snow	375	266
Chakachamna	1,300	1,152
Total	3,433	2,714

1/ Table 1-18, DEIS, May 1984

2/ Power Authority data

3/ Limited by system energy requirements. Without system energy limitation, Johnson could produce 946 GWh.

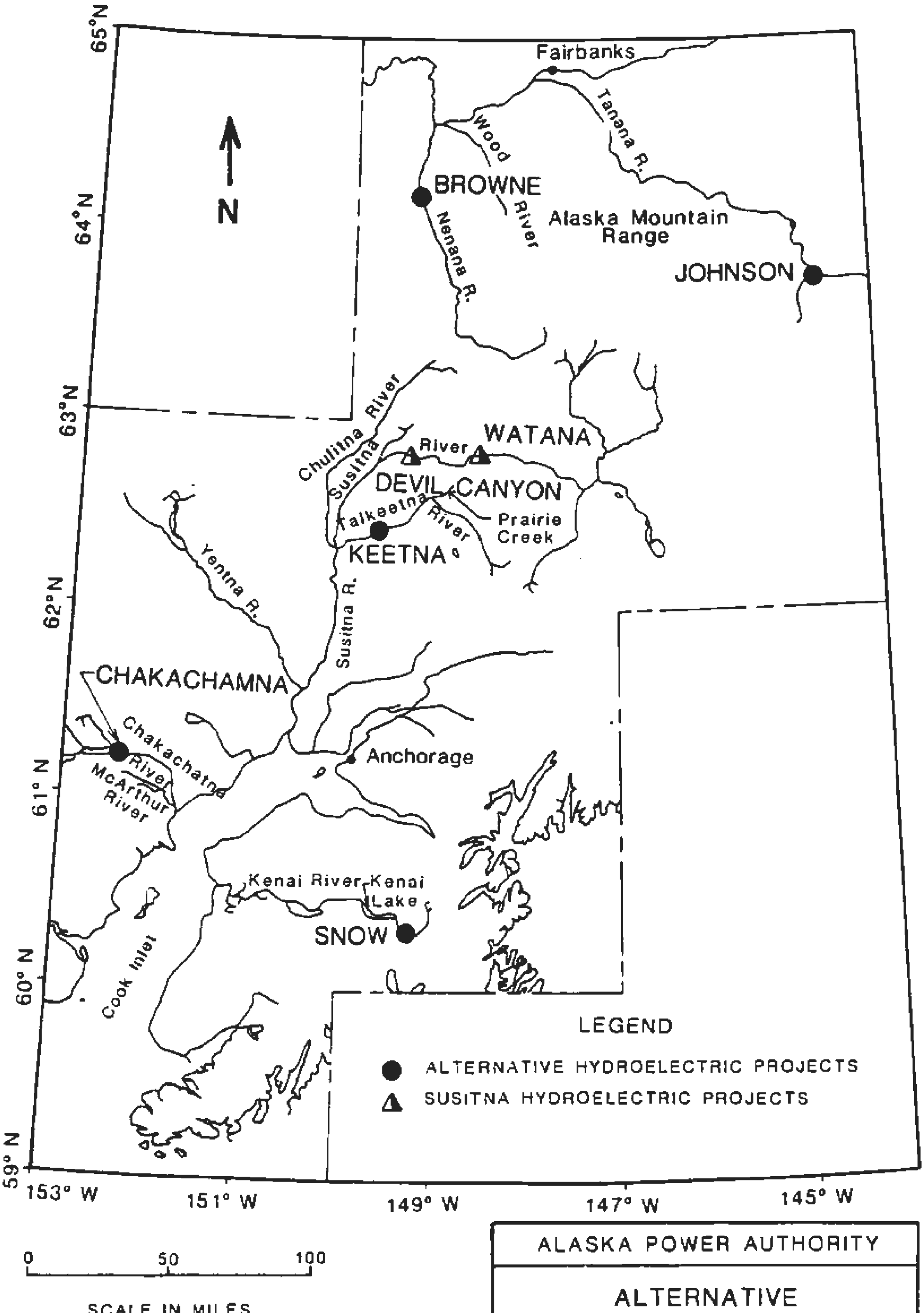
TABLE 22

DEPENDABLE CAPACITY BY SIMULATION WITH RESOP

Project	Dependable Capacity (December) (MW)
Browne	27
Johnson	79
Keetna	21
Snow	26
Chakachamna	107
Total	260

Note: Based on projected Railbelt peak demand in year 2010.

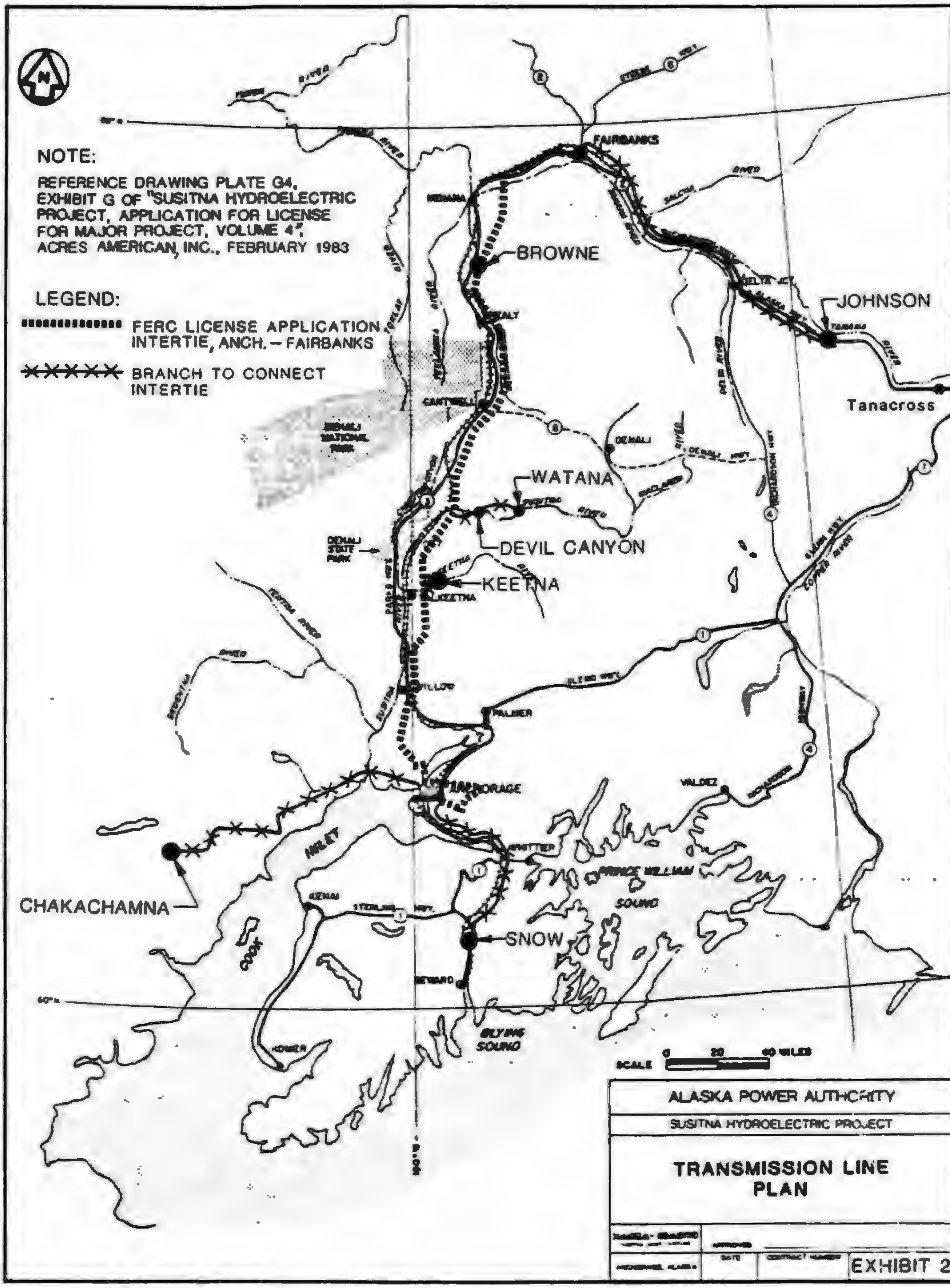
EXHIBITS

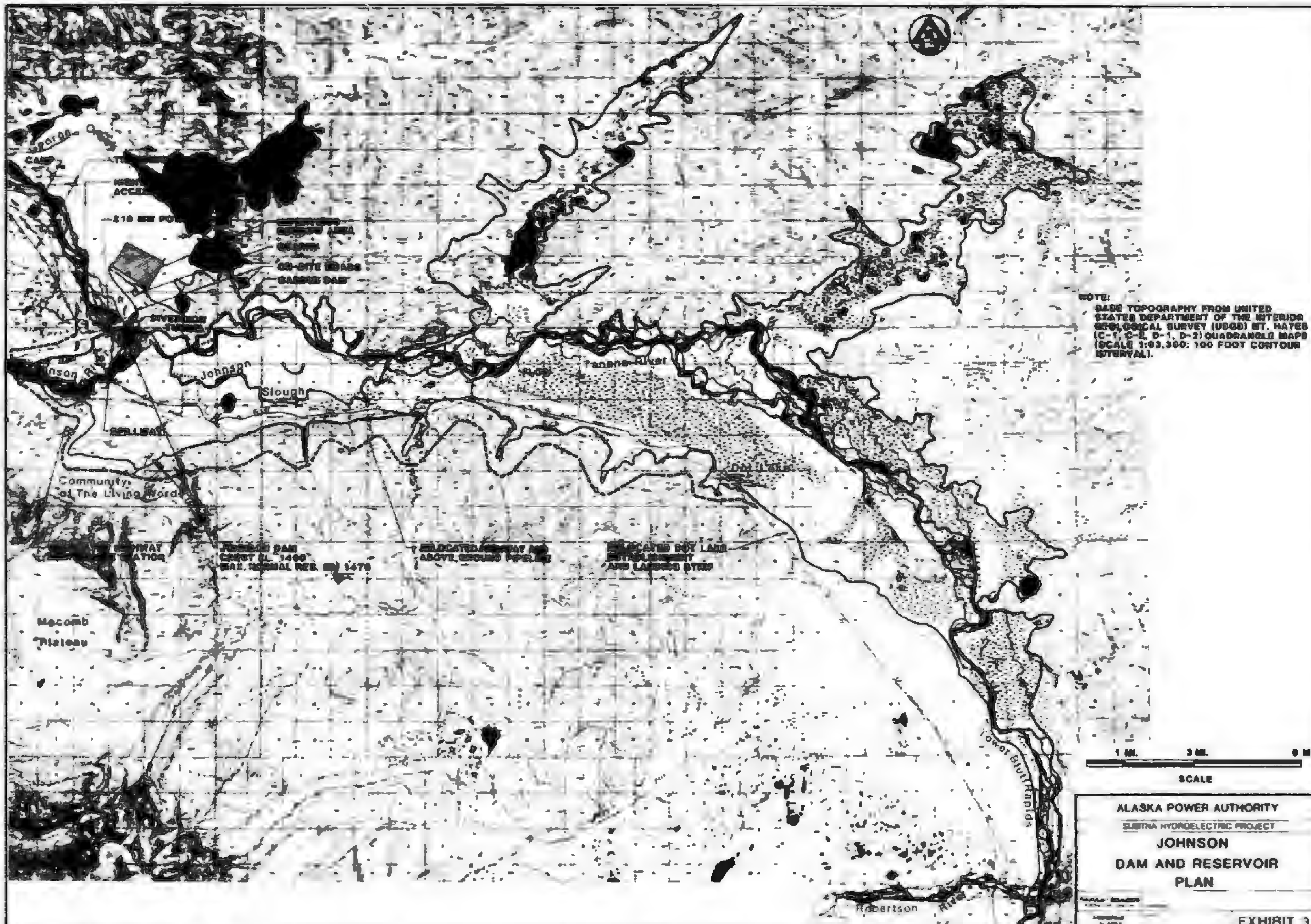


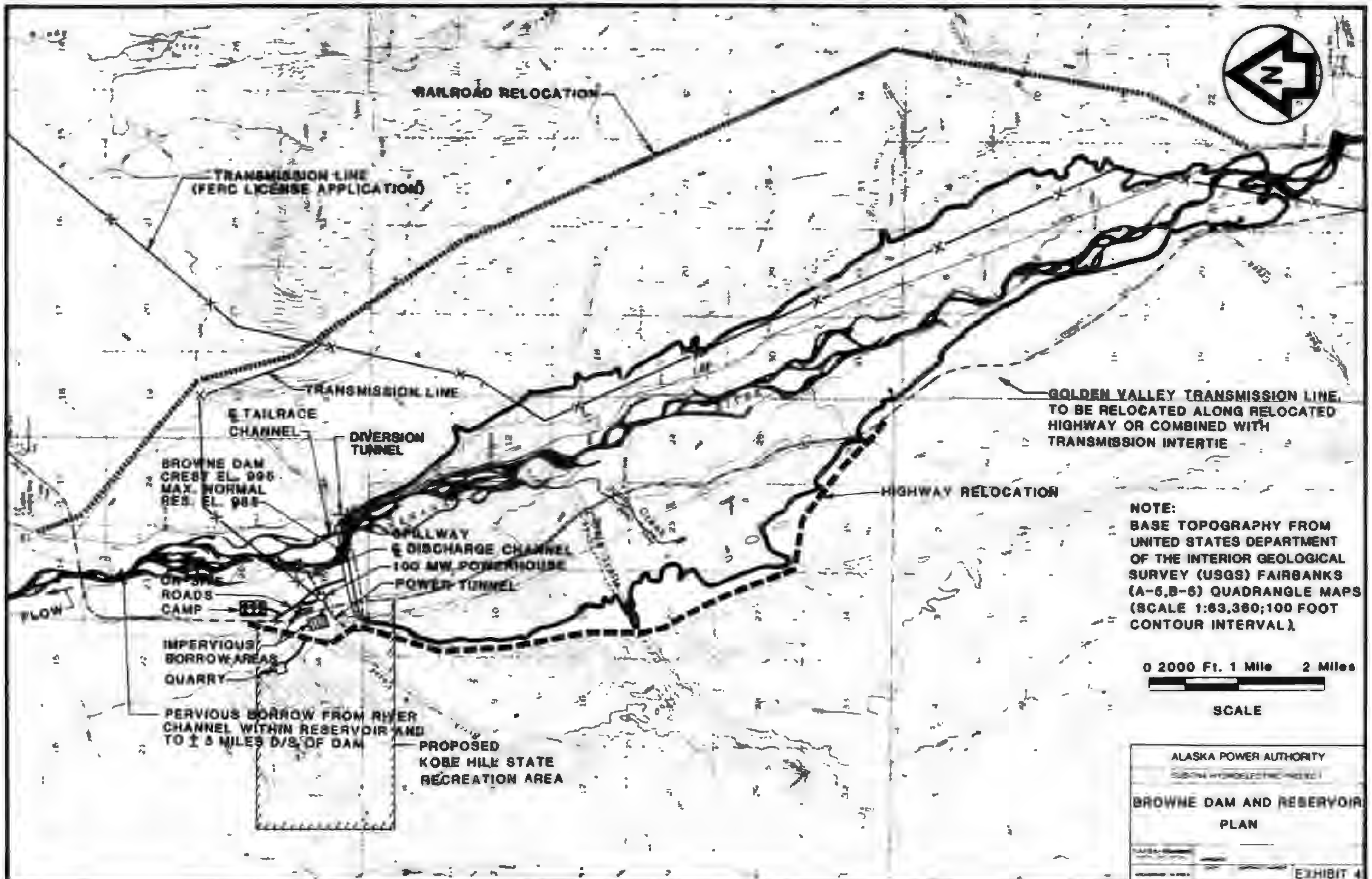
ALASKA POWER AUTHORITY

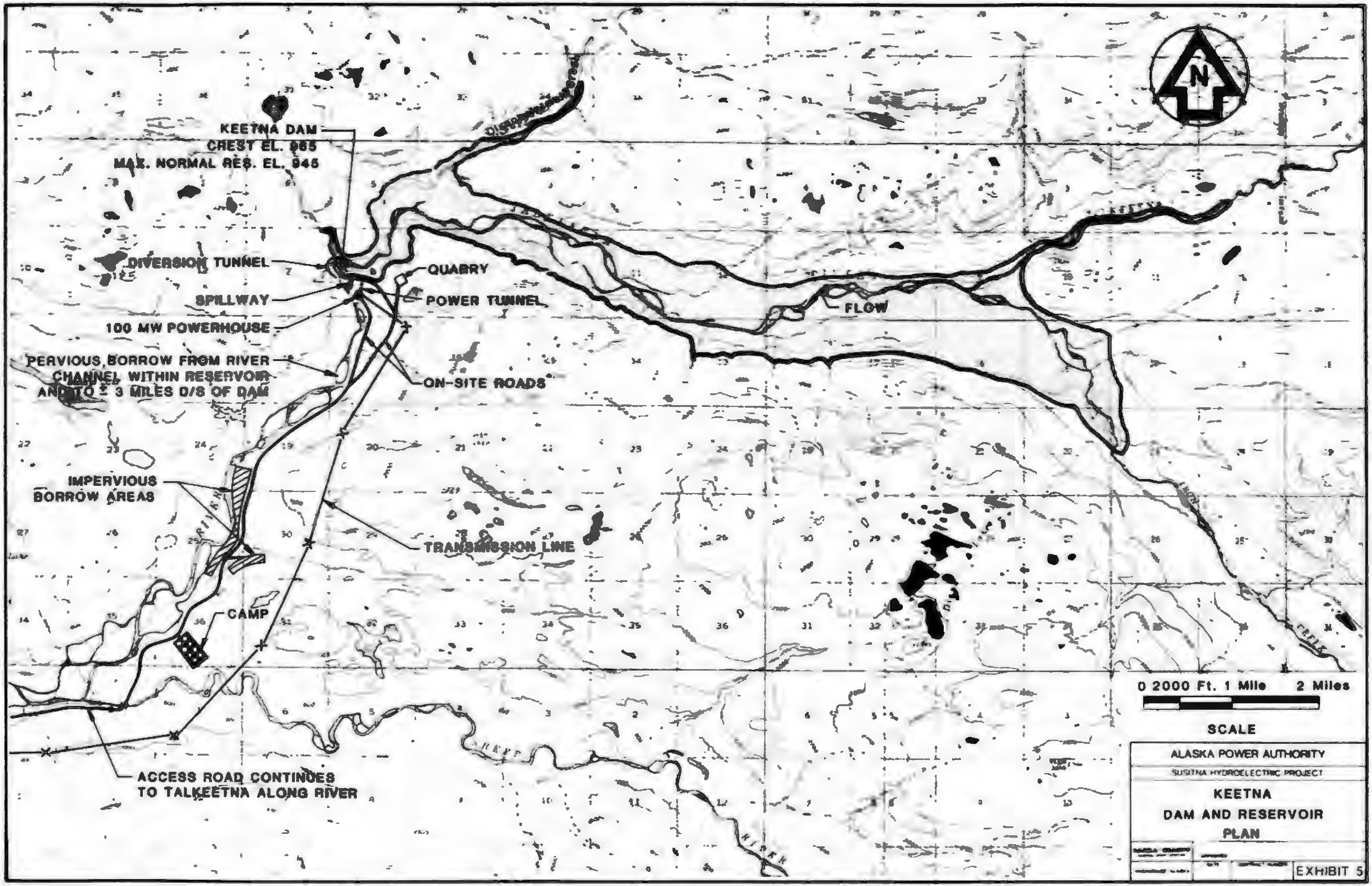
ALTERNATIVE HYDROELECTRIC PROJECTS LOCATION PLAN

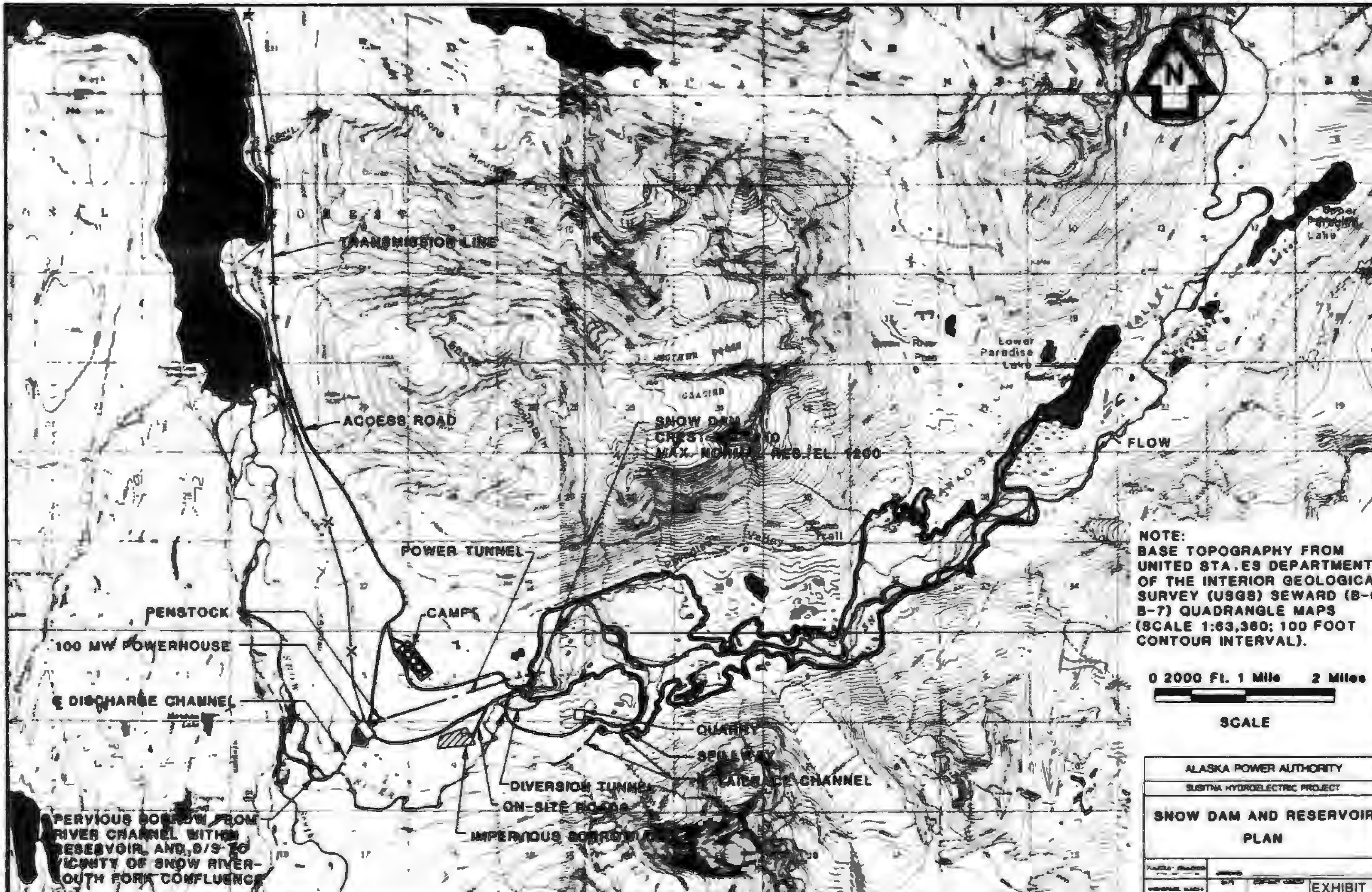
	6/1984	EXHIBIT 1


NOTE:
REFERENCE DRAWING PLATE G4, EXHIBIT G OF "SUSITNA HYDROELECTRIC PROJECT, APPLICATION FOR LICENSE FOR MAJOR PROJECT, VOLUME 4", ACRES AMERICAN, INC., FEBRUARY 1983
LEGEND:
FERC LICENSE APPLICATION INTERTIE, ANCH. – FAIRBANKS
BRANCH TO CONNECT INTERTIE
FAIRBANKS
BROWNE
JOHNSON
Tanacross
CANTWELL
DENALI
WATANA
DEVIL CANYON
KEETNA
WILLOW
PALMER
ANCHORAGE
VALDEZ
CHAKACHAMNA
SNOW
SEWARD
HOMER
PRINCE WILLIAM SOUND
COOK INLET
STERLING HWY.
GLENN HWY
DENALI HWY
SCALE 0 20 40 MILES
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
TRANSMISSION LINE PLAN
EXHIBIT 2


Johnson Slough
Tanana River
Dot Lake
Community of The Living Word
Macomb Plateau
Tower Bluff Rapids
Robertson River
NOTE:
BASE TOPOGRAPHY FROM UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (USGS) MT. HAYES (C-1, C-2, D-1, D-2) QUADRANGLE MAPS (SCALE 1:63,360; 100 FOOT CONTOUR INTERVAL).
SCALE
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
JOHNSON
DAM AND RESERVOIR
PLAN
EXHIBIT 3


RAILROAD RELOCATION
TRANSMISSION LINE (FERC LICENSE APPLICATION)
TRANSMISSION LINE
GOLDEN VALLEY TRANSMISSION LINE, TO BE RELOCATED ALONG RELOCATED HIGHWAY OR COMBINED WITH TRANSMISSION INTERTIE
℄ TAILRACE CHANNEL
DIVERSION TUNNEL
BROWNE DAM CREST EL. 995 MAX. NORMAL RES. EL. 985
SPILLWAY
℄ DISCHARGE CHANNEL
100 MW POWERHOUSE
POWER TUNNEL
ON-SITE ROADS
CAMP
FLOW
IMPERVIOUS BORROW AREAS
QUARRY
PERVIOUS BORROW FROM RIVER CHANNEL WITHIN RESERVOIR AND TO ± 5 MILES D/S OF DAM
PROPOSED KOBE HILL STATE RECREATION AREA
HIGHWAY RELOCATION
NOTE:
BASE TOPOGRAPHY FROM UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (USGS) FAIRBANKS (A-5,B-5) QUADRANGLE MAPS (SCALE 1:63,360;100 FOOT CONTOUR INTERVAL).
0 2000 Ft. 1 Mile 2 Miles
SCALE
N
ALASKA POWER AUTHORITY
BROWNE DAM AND RESERVOIR PLAN
EXHIBIT 4


KEETNA DAM
CREST EL. 965
MAX. NORMAL RES. EL. 945
DIVERSION TUNNEL
SPILLWAY
100 MW POWERHOUSE
QUARRY
POWER TUNNEL
PERVIOUS BORROW FROM RIVER CHANNEL WITHIN RESERVOIR AND TO ± 3 MILES D/S OF DAM
ON-SITE ROADS
FLOW
IMPERVIOUS BORROW AREAS
TRANSMISSION LINE
CAMP
ACCESS ROAD CONTINUES TO TALKEETNA ALONG RIVER
N
0 2000 Ft. 1 Mile 2 Miles
SCALE
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
KEETNA
DAM AND RESERVOIR
PLAN
EXHIBIT 5


TRANSMISSION LINE
ACCESS ROAD
SNOW DAM
MAX. NORMAL RES. EL. 1200
Lower Paradise Lake
FLOW
POWER TUNNEL
PENSTOCK
CAMP
100 MW POWERHOUSE
℄ DISCHARGE CHANNEL
QUARRY
SPILLWAY
TAILRACE CHANNEL
DIVERSION TUNNEL
ON-SITE ROADS
IMPERVIOUS BORROW
PERVIOUS BORROW FROM RIVER CHANNEL WITHIN RESERVOIR AND D/S TO VICINITY OF SNOW RIVER-SOUTH FORK CONFLUENCE
NOTE:
BASE TOPOGRAPHY FROM UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (USGS) SEWARD (B-6, B-7) QUADRANGLE MAPS (SCALE 1:63,360; 100 FOOT CONTOUR INTERVAL).
0 2000 Ft. 1 Mile 2 Miles
SCALE
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
SNOW DAM AND RESERVOIR PLAN
EXHIBIT 6

NOTES:

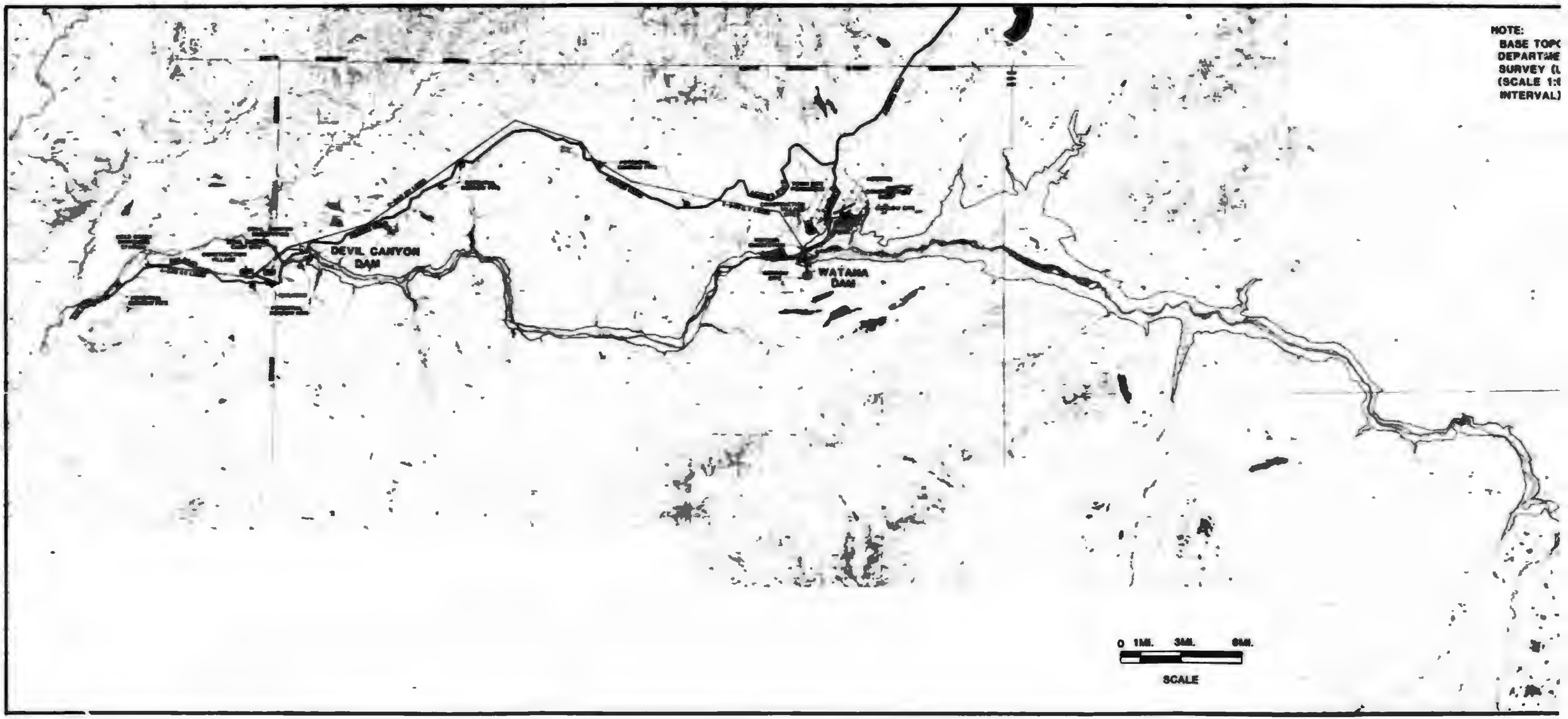
1. BASE TOPOGRAPHY FROM UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (USGS) TYONEK (A-6,A-7,A-8) QUADRANGLE MAPS (SCALE 1:63,360; 100 FOOT CONTOUR INTERVAL)
2. LAYOUT OF PROJECT FEATURES IS BASED ON "CHAKACHAMNA HYDROELECTRIC PROJECT, INTERIM FEASIBILITY ASSESSMENT REPORT, VOLUMES I,II,III," BECHTEL CIVIL AND MINERALS INC., MARCH 1983.
3. A SECOND CONSTRUCTION CAMP WILL BE LOCATED OUTSIDE BUT CLOSE TO THE MOUTH OF THE McARTHUR CANYON FOR THOSE WORKING ON THE DOWNSTREAM HEADING OF THE POWER TUNNEL, POWERHOUSE AND ASSOCIATED STRUCTURES.

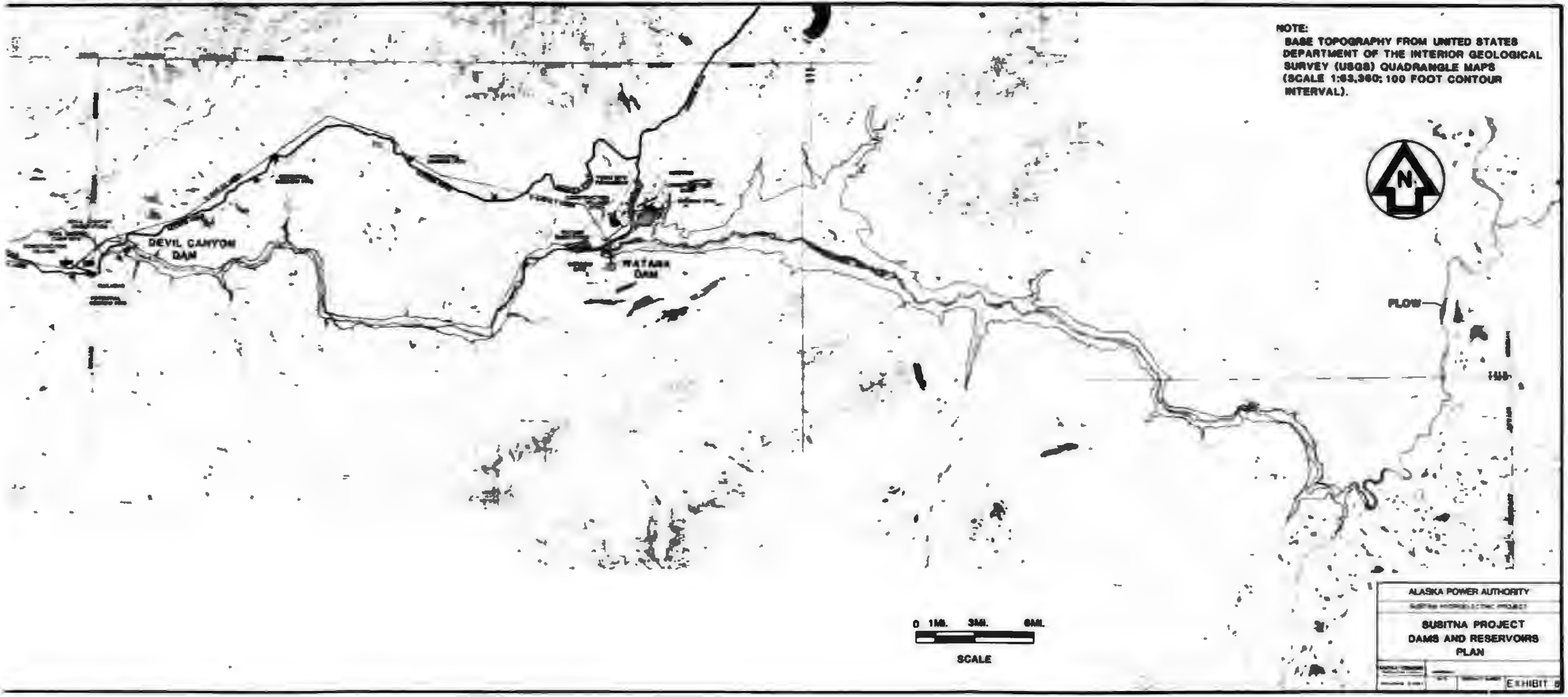
ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

CHAKACHAMNA DAM AND RESERVOIR PLAN

	APPROVED		
ANCHORAGE, ALASKA	DATE	CONTRACT NUMBER	EXHIBIT 7


DEVIL CANYON DAM
WATANA DAM
NOTE:
0 1MI. 3MI. 6MI.
SCALE


NOTE:
BASE TOPOGRAPHY FROM UNITED STATES
DEPARTMENT OF THE INTERIOR GEOLOGICAL
SURVEY (USGS) QUADRANGLE MAPS
(SCALE 1:63,360; 100 FOOT CONTOUR
INTERVAL).
N
DEVIL CANYON
DAM
WATANA
DAM
FLOW
0 1MI. 3MI. 6MI.
SCALE
ALASKA POWER AUTHORITY
SUSITNA PROJECT
DAMS AND RESERVOIRS
PLAN
EXHIBIT