Before the

FEDERAL POWER COMMISSION

APPLICATION FOR LICENSE

for the

GREEN LAKE PROJECT

EXHIBIT W

ENVIRONMENTAL REPORT

CITY AND BOROUGH OF SITKA

SITKA, ALASKA

SEPTEMBER 1977

GREEN LAKE PROJECT

SUMMARY OF ENVIRONMENTAL REPORT

1. PROJECT DESCRIPTION

The Green Lake Project is a conventional hydroelectric development which will meet the City of Sitka's growing energy needs. The Project is located at Green Lake, approximately 10 air miles southeast of Sitka. It will consist of the following features: a reservoir formed by a concrete arch dam at the outlet of Green Lake; power tunnel, a powerhouse and substation at tidewater on Silver Bay; access road and transmission line. The Project will have a rated output of 16.5 megawatts and develop an average gross head of approximately 369 feet.

2. ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

The proposed Green Lake Project will benefit man's environment by providing a reliable and economically stable power source to meet the local energy needs. In addition, the Project will perform a conservatory function by utilizing a renewable resource, which might otherwise be wasted while conserving non-renewable fossil fuels for use in other more productive capacities.

Formation of the reservoir will most likely result in the loss of the present spawning grounds of the resident brook trout population. Measures to minimize this loss will be considered following further consultation with the Alaska Department of Fish and Game. No other permanent or significant adverse effects on wildlife are anticipated to result from the construction or operation of the Project.

Air quality will be impaired only during construction and then only on a temporary and/or intermittent basis. Noise levels during construction are expected to increase as well. However, project operation will have no significant adverse effects on the existing ambient noise levels in the vicinity.

The major adverse effect on water quality will be the temporary high turbidity in Silver Bay as a result of the deposition of excavated material into the bay during construction. No significant adverse effect on water quality is expected from project operation.

Portions of the access road and transmission will be visible from Silver Bay as will the powerhouse and substation.

The Applicant believes that the construction and operation of the Green Lake Project will constitute a beneficial use of the environment and in particular, the land and water resources.

EXHIBIT W

ENVIRONMENTAL REPORT

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EXHIBIT W

ENVIRONMENTAL REPORT

1. DESCRIPTION OF PROPOSED ACTION

The City and Borough of Sitka, Alaska (Applicant) is seeking to license the proposed Green Lake Project (Project), a conventional hydroelectric development needed to meet the City of Sitka's growing power demand. The Project is located at Green Lake, approximately 10 air miles southeast of the City proper.

The Project consists of the following features: a concrete arch dam at the outlet of Green Lake; power tunnel; a powerhouse and substation located at the head of Silver Bay; a 69-kV transmission line extending to the upgraded Blue Lake substation at Sawmill Cove; and an access road from the project site to the terminus of Sawmill Creek State Highway at Herring Cove.

The Project will have an installed capacity of 16,500-kW and is expected to have a dependable capacity at the load center of 13,500-kW. The Project is expected to deliver 64,900,000-kWh of energy on an average annual basis and 44,500,000-kWh of firm annual energy.

1.1 Purpose

The purpose of the Project is to provide electric power to meet the growing power demands of the City and Borough of Sitka. The relocation of the Coast Guard Air Wing and Forest Service facilities to Sitka, and the proposed construction of two large hotel complexes, in addition to normal population growth, have severely taxed the Applicant's existing power generating capability. The projected demand for power is expected to reach nearly 60 million kilowatt/hours by late 1981. This additional demand can best be met by an additional base load hydroelectric facility such as the proposed Project.

Presently the Applicant's power generating resources consist of the 6,500-kW Blue Lake Hydroelectric Project (FPC Project No. 2230) plus approximately 3,150-kW of diesel generating capacity. To meet the projected demand before the Project can be brought on-line, an additional 5,500-kW of diesel capacity will have to be installed. Completion of the Project will allow the Applicant to retire this costly-to-operate diesel capacity to standby status.

The Project, in addition to serving the local power demands of Sitka, performs a conservatory function as well. Instead of utilizing exhaustible fossil fuel resources, the Project will develop an energy source that is renewable which is otherwise not utilized.

1.2 Location

The Project will be located on the western side of Baranof Island, approximately 10 air miles southeast of Sitka, Alaska. The only access to the Project by land will be the proposed access road which will run from the present terminus of Sawmill Creek State Highway to the project site. With the exception of the transmission line and access road, the major project features will be located on the Vodopad River at the southern tip of Silver Bay. The Project's 8-mile transmission line will connect the power generating facility on Silver Bay to the upgraded Blue Lake Project substation. Location of the Project is shown in Appendix W-4.

1.3 Land Requirements

Lands required for the Project will total approximately 1,500 acres. The Green Lake Reservoir, at its normal pool elevation of 390 feet above mean sea level, will have a surface area of 1,000 acres. The area enclosed by the project boundary around the reservoir will total approximately 1,300 acres. Other uses and affected areas of the various components of the Project are shown in Table W-1. Exhibit K describing the proposed project boundary is included as Appendix W-4.

A borrow area for aggregate production is planned to be established in the alluvial plain at the eastern end of the existing lake. The exact location and extent of the borrow area will be determined following further geotechnical investigation. Upon completion of the Project, this area will be inundated by the proposed reservoir.

Spoil areas will be developed for dry land disposal of overburden from access road construction. The overburden will be stripped and used for construction fill where possible. Excess stripped overburden will be wasted in dry land spoil areas to be determined following further field investigation of potential sites. In areas where the overburden cannot be technically or economically stripped, it will be spoiled into Silver Bay with excavated rock material.

All temporary construction roads will be located within the proposed reservoir area so that they will be inundated upon project completion.

The Project lies entirely within the Tongass National Forest, on lands presently owned by the United States and administered jointly by the U.S. Forest Service and the Federal Power Commission. The site is presently an FPC powersite withdrawal. The Applicant is currently seeking title, through Section 6(a) of the Alaska Statehood Act, to 5,693 acres of land, for the purpose of developing the Project. Upon completion of this action, this Application will be amended to reflect the new ownership of the lands involved.

1.4 Proposed Facilities

1.4.1 Project Works[1]

1.4.1.1 Green Lake Dam

The dam will be a double-curvature, concrete arch structure located about 80 feet downstream from the outlet of the existing Green Lake. The dam will have a maximum height of 230 feet above the estimated bottom of the foundation excavation and a crest length of 460 feet at El 400.0 (MSL). It will have a crest thickness of 10 feet, bottom thickness of 23 feet, and a centerline radius at the crest of 240 feet. Plan, elevation and section drawings of the Green Lake Dam are provided in Appendix W-5.

An ungated ogee spillway section 100-feet in length with a crest at El 390 (MSL) will be centrally located in the dam. The spillway is designed to flip the flows into the streambed downtream. Due to the excellent quality of the rock in the streambed, no stilling basin will be provided; however, a natural control section in the river channel just downstream of the dam, will cause a plunge pool which will assist in dissipating the energy of spills. The spillway will discharge 11,000 cfs at a reservoir elevation of 399.3 (MSL) for the adopted spillway design flood which has a peak inflow of 21,150 cfs and a volume of 21,500 acre-feet.

A power intake will be located on the upstream face of the dam to the north of the spillway section. The intake invert will be at El 260 (MSL). Trashracks will protect the power intake from trash and debris. A 7-foot by 9-foot fixed-wheel gate will be provided for emergency closure and to permit draining of the power conduit for inspection and maintenance. For operation and maintenance a single lane roadway will extend along the crest of the dam from the north abutment to a point immediately over the power intake.

A low level outlet works facility containing a 12-inch Howell-Bunger valve and a 14-inch butterfly guard valve will be located at El 250 (MSL) in the dam near the center of the stream channel.

1.4.1.2 Power Conduit

The power conduit is approximately 1,900-feet long from the power intake to the powerhouse. It will have a maximum hydraulic capacity of 744 cfs at the normal reservoir elevation of 390 (MSL). The power conduit will be a circular tunnel at approximately a 15% grade, partially concrete-lined at the portals and in areas of poorer quality rock, and unlined elsewhere. The "A" line diameter of the unlined section will be 11 feet, and the concrete-lined sections will have an inside diameter of 8 feet. The tunnel will contain a horizontal length of steel and concrete-lined tunnel about 50-feet upstream of the powerhouse. A steel-lined section, beginning about 50-feet upstream of the powerhouse, will bifurcate into a manifold of two 5.6-foot diameter steel-lined sections each extending to a generating unit within the powerhouse. A tunnel adit is provided at the lower end of the power tunnel for construction and maintenance purposes. Profile and section drawings are shown in Appendix W-5.

1.4.1.3 Powerhouse

The powerhouse will be an indoor-type surface installation, located on Silver Bay about 350-feet north of the mouth of the Vodopad River. It will set into a side-hill excavation and will be anchored to the rock slope. A rock trap, if required, will be provided at the top of the cut slope to provide additional protection of the powerhouse against rockfalls. The structure will be reinforced concrete, approximately 32-feet wide, 82-feet long, and 70-feet high. It will contain two unit bays and a service bay. The unit bays will house two vertical Francis turbines, each with a best gate output of 11,300 horsepower under a net head of 349 feet (average conditions), resulting in a total installed plant capacity of 16,500-kW. The discharge through each unit under these conditions will be 310 cfs. Generators will be umbrella-type operating at a speed of 514 rpm. A 54-inch butterfly valve, capable of operating under emergency shutdown conditions, will guard each unit. A small tailwater weir at El -2.3 (MSL) will be provided in the tailrace to protect the turbines against cavitation.

The substation will be located on a concrete deck over the tailrace. Single-phase transformers will transform the voltage from 13.8-kV to the 69-kV transmission voltage. A spare transformer will be provided. Current plans are for the plant to be remotely controlled from the Blue Lake Powerhouse. Plans and sections of the powerhouse are shown in Appendix W-5.

1.4.1.4 Access Road

The 7.4-mile access road will extend from the end of the existing Sawmill Creek State Highway at Herring Cove to the project site. For economic and environmental reasons, the road will be unpaved and single-lane construction with turnouts and will be constructed to standards adequate only for construction access and for maintenance of the Project. Since the road will not be built to public use standards, public vehicular access to the Project will not be allowed and a permanent barricade at Herring Cove will be provided to prevent unauthorized vehicular traffic.

The road alignment will generally follow the shoreline as shown in Exhibits K-1 and K-2. The first three miles will vary between a half-bench cut and a full embankment section. The remaining portion of the road will require a full-bench cut for most of its length. As the road approaches the project area, it will divide with one branch extending to the dam area and the other to the powerhouse. The roadway width will be 14 feet, maximum grade will be 13% and minimum curve radius will be 100 feet.

1.4.1.5 Transmission Line

The transmission line will be 69-kV generally paralleling the access road and extending from the powerhouse substation to its terminus at the Blue Lake Project substation. Structures will be single-wood poles with a wishbone crossarm configuration.

1.4.2 Reservoir

The normal water surface elevation of the reservoir will be 390-feet above mean sea level. The area of the reservoir at this elevation is about 1,000 acres. The normal minimum water surface elevation is 280 feet (MSL) with a corresponding reservoir area of 390 acres. The active storage capacity at normal reservoir elevation is 74,000 acre-feet. The area-capacity curve for the reservoir is shown in Figure W-1. The anticipated effect of the impoundment on area water quality, including thermal stratification in the reservoir, is provided in Appendix W-2.

1.4.3 Tailwater Features

Information concerning the tailwater features can be found in Appendix W-5.

1.4.4 Transmission Facilities

Necessary modifications to the Blue Lake Project to handle the added capacity of the Green Lake Project are not included as part of this Application, but are considered a necessary adjunct thereto. These modifications include:

The upgrading of the existing Blue Lake substation to handle the added capacity of the Green Lake Project.

The upgrading of the existing 34.5-kV Blue Lake transmission line to 69-kV.

The construction of the new Lot 4 transmission stepdown and distribution substation.

These modifications will be accomplished through amendment to the Blue Lake Project License.

1.5 Construction Procedures

Activities to be completed prior to or during construction of major project features include:

1.5.1 Land Acquisition

The project site is located in the Tongass National Forest on lands presently owned by the United States. The State of Alaska is currently in the process of selecting approximately 5,700 acres, of which the 1,500-acre project area is a part, under Section 6(a) of the Alaska Statehood Act. Details of the selection process and a legal description of the affected lands are presented in Appendix W-1.

1.5.2 Permits and Authorizations

All necessary Federal, State, and local permits and authorization as identified in Section 9 of this exhibit will be obtained as required. Other pertinent authorizations that may be required will be identified during the final design phase of development.

1.5.3 Land Surveys

Land surveys to be completed prior to and during construction include: the final access road route survey to determine the final alignment of the access road; surveys as needed for the clearing and construction of the access road; and project boundary surveys to provide required monumentation of the project boundary and other key control points.

1.5.4 Geotechnical Investigation

Design level geotechnical investigations will be required for the final design of the access road, arch dam, powerhouse and appurtenant structures. These investigations will include additional geophysical surveys, construction material identification and evaluation, laboratory testing and seismicity evaluation of the site.

1.5.5 Environmental Planning

Inventories of the biotic, and archaeologic and historic resources in the project area were conducted during the summer of

1977 to identify potential adverse impacts of construction and operation. These studies were utilized in the preparation of this Application and will be further used for environmental planning during the final design phase of development. These studies are included in this exhibit as Appendices W-10 and W-11 respectively.

1.5.6 Final Design of the Project

Final design includes final structural and hydraulic design of the project features, the preparation of bid drawings and documents and the preparation of construction drawings.

1.5.7 Clearing

Clearing for the access road will begin as soon as practical after completion of the access road design and award of a contract for construction. Additionally, the reservoir will be cleared of all trees and brush within the area of normal reservoir fluctuation (El 390 [MSL] to El 294 [MSL]). All merchantable timber from both the access road and reservoir will be salvaged and sold.

1.5.8 Diversion Facilities

Schemes currently being considered for the diversion during construction include a tunnel through the north dam abutment and diversion by a flume through the dam site. Construction of diversion facilities as well as the arch dam below the natural stream channel will be scheduled to coincide with the historically low flow periods of the year.

1.5.9 Borrow Areas

A borrow area for aggregate production within the reservoir area has been tentatively identified in the alluvial plain at the eastern end of the existing lake. The exact location and extent of this borrow area will be determined following more detailed geotechnical investigations.

1.5.10 Construction Schedule

A schedule for the construction of the Project is provided as Appendix W-6. Severe climatic conditions are not felt to occur in this maritime climate and no unusual measures have been taken to include them in the timing of the construction. The on-line date of September, 1981 is considered to be the earliest possible date for completion, consistent with safe and proper design and construction techniques.

1.5.11 Construction Work Force

The number of construction workers will vary by season and year. The expected maximum would be approximately 150 during the fall of the third year of construction. By Alaska State law, 95% of the work force will be Alaska residents (if qualified). Further discussion of the source and make-up of the work force is provided in Section 3.1.3 of this exhibit.

1.6 Operation and Maintenance Procedures

The Project will be a conventional hydroelectric development operated in conjunction with the existing Blue Lake Project (FPC Project No. 2230). Details of operation are presented in Appendix W-2.

Normal maintenance of the Project will involve inspecting lubricating, cleaning, and overhauling the plant equipment on a regular basis according to a maintenance schedule.

While the Project is to be remotely operated from Blue Lake, it is anticipated that a traveling operator will inspect the Project several times a week to insure proper operation of plant equipment. As a part of this inpsection, all gates, valves, hoists, and emergency equipment will be periodically checked for proper operation.

A complete inspection of the project equipment and structures will be made annually to determine any leakage, seepage, cracking, deterioration of concrete, or other needed repairs which may have been overlooked in normal maintenance procedures. During this inspection the power tunnel, turbines, and draft tubes will be dewatered and inspected. Trashracks and water passages will be cleaned as required and turbine runners, guide vanes and steel draft tube liners will be inspected for cavitation, pitting and other damage. Annual inspections and needed repairs will be scheduled when the units could be shut down without loss of energy to the system. Any conditions which could affect the safety and permanence of the Project will be remedied as soon as possible.

Periodic maintenance of the access road will be required to clear the road of rockfalls.

1.7 Future Plans

The Applicant has no plans for the future expansion of the Project beyond the presently proposed construction. A limited potential does exist for future recreational development. However, with the number of more favorable sites available to the Applicant for expansion of its recreational facilities to meet its needs, extensive development of the Green Lake site for recreational purposes seems remote.

2. EXISTING ENVIRONMENT

2.1 Land Uses and Features

2.1.1 Land Uses

The Project lies in a remote and essentially undeveloped area of the Tongass National Forest approximately 10 air miles southeast of Sitka. The nearest road, Sawmill Creek State Highway, terminates shortly beyond the Alaska Lumber and Pulp Company (ALP) pulpmill in Sawmill Cove approximately 6.5 air miles north of Green Lake (see Appendix W-3) and a barrier falls at the mouth of the Vodopad River at Silver Bay makes passage by boat impossible. As a result, the only access to Green Lake is by air or on foot via a short (1/2-mile) but steep, hiking trail from Silver Bay. Due to the very limited access, little commercial development of the area has occurred. Current land uses include limited mineral extractions and recreation. The only potential uses currently being considered include timber production, power generation, recreation, and mineral extraction.

2.1.1.1 Power Generation

The hydroelectric potential of the Green Lake drainage has been recognized since 1929 when all land adjacent to the Vodopad River and Green Lake which lie below an altitude of 350 feet (MSL) were withdrawn and essentially reserved for use as a hydroelectric powersite and designated Powersite Classification No. 221. By Section 24 of the Federal Power Act, this classification subordinated all subsequent uses or entries on the land. In 1970, by Public Land Order 4958, the powersite was expanded to include all lands below an altitude of 400 feet (MSL). The newly defined powersite was designated Powersite Classification No. 459 and Powersite Classification No. 221 was cancelled.

2.1.1.2 Wood Products Industry

All of Baranof Island is currently in ALP's long-term timber sale contract with the U.S. Forest Service; however, little or no logging activity has occurred south of Sitka. To-date it has been more profitable to harvest lands north of Sitka where the terrain is more suitable to modern logging methods. Due to the limited access and precipitous terrain, the Green Lake-Vodopad River Drainage has never been timbered. Indications of logging sometime in the past were, however, noticed in the Bear Cove area during the Applicant's field investigations.

By U.S. Forest Service projections, there probably will be no timber harvest in the project area within the next 10 years should the Green Lake Hydroelectric Project development not occur.[(2)]

2.1.1.3 Mining

Sporadic mining activity has been the only recent commercial use of the lands around Silver Bay south of Herring Cove. The Bureau of Land Management (BLM) has reviewed 10 groups of mining claims in the Sitka Quadrangle for possible conflicts with the proposed Green Lake Project. Of these, only three groups as shown below were identified as requiring further investigation by the Applicant. The specific location of these claims will be determined, if possible, during the access road survey and the extent of conflict reassessed at that time.

Kx 114-11 Bonanza Placer - 1953-72 (Gold) - Edgecumbe Exploration Co. - Glenn A. Morgan - P.O. Box 758, Sitka, Alaska - approx. 10 mi. SE Town of Sitka; mouth of Bear Creek, head of Silver Bay, Baranof Island.

Kx 114-12 Bonanza Quartz Clms. 1-22 (Gold) - Bear Lode - Climax Quartz - Seaside Quartz - Queen Quartz - 1953-71 - Edgecumbe Exploration Co. - Glenn A. Morgan - P.O. Box 758, Sitka, Alaska - approx. 10 mi. SE Town of Sitka; head of Silver Bay, Baranof Island.

Kx 114-149 Joseph Gangolia 1970-76 (tungsten) - 2 claims - Bear Mt. halfway between Herring Cove and Bear Cove, meets Silver Bay tidewater.

Others, due to either location or inactivity, have been judged by the BLM as having only remote possibilities for conflict with development of the Project. All of the groups studied were found to be unpatented.

2.1.1.4 Recreation

The Tongass National Forest south of Green Lake is a relatively lightly developed recreational area. Hiking trails lead from Silver Bay to Salmon Lake, Lake Redoubt and several alpine lakes in the area. The only existing overnight facility in the area is a U.S. Forest Service hiker's cabin near the head of Lake Redoubt, a miromictic lake approximately 4 air miles southwest of the Project. Recreational use of the Green Lake drainage has been limited due in part to the difficulty of access. "Recreational fishing is not considered significant by Alaska Department of Fish and Game personnel stationed in Sitka. It appears from all available information that hunter use of the area immediately around Green Lake is low as well."[3]

Plans for future development of recreational facilities of the City and Borough of Sitka including Green Lake are presented in Appendix W-7.

2.1.2 Topography, Physiography and Geology

A discussion of this subject is presented in the preliminary geological report prepared by the Applicant's Geotechnical consultant and included in this exhibit as Appendix W-9.

2.1.3 Soils

A discussion of soil types, as classified by the U.S. Forest Service for Southeast Alaska, and their locations within the Green Lake drainage is provided in the description of the forest ecosystem in Appendix W-10.

2.2 Species and Ecosystems

An investigation of the biotic communities in and around the project site was conducted during June 1977. A report of that investigation is included as Appendix W-10.

2.3 Socio-Economic Conditions

2.3.1 Existing

The public lands of the Tongass National Forest surround the project site, consequently little development has occurred. There is no resident population in or near the project boundary and no need for the relocation of homes, businesses or industries. A small group of abandoned mining cabins are located at the head of Silver Bay approximately 2,000 feet west of the mouth of the Vodopad River.

The only substantially developed area within the effective range of the Project is within and immediately adjacent to the City of Sitka. By U.S. Census figures, the population of the City and Borough of Sitka was 6,100 in 1970. A projection of population growth through 1990 is given in Table W-2. The bulk of the population is within Sitka City limits or located on Japonski Island, both shown on Exhibit J in Appendix W-3. Family income information for Sitka and the similar Southeast Alaska population centers of Juneau and Ketchikan, is presented in Table W-3.

The economy of Sitka is fairly typical of Southeast Alaska communities. The commodity-producing industry which includes the wood products industry, amounts to approximately 34% of the total economy of Sitka. The distributive industry, which includes transportation, communication, trade, finance and services, amounts to 32% and the government makes up the remaining 34%. Employment by industry and a further breakdown of the previously mentioned industries is presented in Table W-4. The overall percentage of government has increased during the past 2 years with the addition of the district headquarters of the U.S. Forest Service and will be substantially increased again by the Coast Guard Air Station transfer to Sitka from Annette Island. The added responsibility of patrolling the recently enacted 200-mile fishing limit makes additional growth of the Coast Guard Station most likely.[(4)]

2.3.2 Potential

The forest products industry has traditionally been the mainstay of Sitka's economy and is expected to remain so. Although short-run difficulties will be encountered, long-term prospects remain good.

Sitka lost its marine products base in 1973 when a fire destroyed the Sitka Cold Storage Company plant. Since that time a large building project at Sitka Sound Seafoods has brought some of the market back to Sitka. It is felt that the 200-mile fishing limit, coupled with a growing awareness of the feasibility of harvesting and marketing bottom fish, will further increase the importance of this industry to Sitka's economy.[(4)]

Private business growth in Sitka occurred primarily in the retail sector. The overall growth in the resident population is seen as one contributing factor to business growth. However, increase in tourism is seen as the greatest potential contributing factor to future growth.

In late 1968, the State of Alaska commissioned a team of consultants to review the statewide economic potential of tourism. In this study, "A Program for Increasing the Contribution of Tourism to the Alaskan Economy", Sitka was chosen as a model of a community with major historical significance. As a prototype, it was suggested that major improvements could be made that would substantially increase Sitka's growth potential. Sitka has since begun to act on those suggestions with the construction of a convention center, the proposed construction of two major hotel complexes and a stepped-up public information program. If the development continues as planned, Sitka has the potential to become one of the most widely visited areas in Alaska.

"In the past, at present, and most certainly in the future, Sitka will continue to feel more economic impact from tourism. The distributive employment section, which includes services, went from 27.65% of the total economy in 1965 to an estimated 32.02% in 1975. Sitka is extremely suited to this type of growth. As the second oldest city in Alaska, the oldest in southeast, and the site of the Russian capital before Seward's purchase, the area contains a vast amount of historical and cultural lore ideal for tour boat stopovers."[(5)]

The need for additional power generating capability has been well documented. Much, if not all, of the previously mentioned potential economic growth for Sitka relies upon the development of an economically stable and reliable power source, such as the Green Lake Project.

2.4 Air and Water Environment

2.4.1 Climate

The following discussion is based primarily upon climatic conditions at Sitka, 10 air miles to the northwest. The climate in the vicinity of the project site is classified as Coastal Maritime, characterized by moderate temperatures relatively high precipitation and little seasonal variation. The local weather pattern is shaped by three main factors; a pressure system that results in almost year-round southerly flow of air; proximity to the ocean and consequent exposure to warm, moisture-laden air masses; and the rugged, mountainous terrain of Baranof Island.

Typically, a low pressure system overlies the Northern Pacific throughout most of the fall, winter and early spring. The center of the disturbance is usually in the vicinity of Dutch Harbor in the Aleutian chain. The counter-clockwise circulation around the low results in southeasterly winds at Sitka during this period. In late spring and summer, as the land begins to warm, a high pressure area over the ocean further south begins to dominate. The clockwise circulation around this pressure area results in northwesterly winds during June, July, and August. Prevailing monthly wind directions are given in Table W-5, Climatological Summary.

The temperature pattern is influenced by the warm water current that flows northward along the eastern side of the Gulf of Alaska. The proximity of this current, together with the prevailing southerly winds, give the area a moderate and relatively uniform temperature structure characteristic of the oceanic environment. The average annual temperature for Sitka is about 43° F with extremes of -8° and 87° in January and July respectively. Complete monthly temperature data is given in Table W-5.

Precipitation is the most highly variable aspect of the local climate, depending chiefly on location of the site with respect to barrier mountains, prevailing wind direction, and elevation. Sitka, situated at sea level on the western coast of Baranof Island, receives an average annual precipitation of 96.7 inches. Precipitation data for Sitka, Port Alexander, Little Port Walter and Baranof are shown in Table W-5. The effects of location on the windward side of the barrier mountains can readily be seen in the substantially increased precipitation experienced at both Little Port Walter and Baranof (see Figure W-2).

Precipitation can also be expected to increase with an increase in elevation. While little data is available from high elevation gauges, in Southeast Alaska precipitation calculated from runoff measurements, has been found to be up to three times that experienced at sea level stations.

Monthly sea level precipitation data for Sitka is presented in Table W-5. Average runoff for the project site, calculated from Vodopad River discharge data, is estimated at 150 in./yr.

2.4.2 Hydrology and Hydrography

2.4.2.1 Green Lake

The Green Lake drainage area encompasses approximately 28.2 square miles. The basin is glacier formed and almost surrounded by steep, heavily-forested slopes. The surface area of Green Lake at its natural elevation of about 230 feet (MSL) is approximately 180 acres. The major tributary is the Vodopad River with its several branches. A bar divides the lake into east and west basins with the maximum depth of approximately 85 feet occurring in the center of the east basin. "Vertical profiles of the two basins are similar except that water in the west basin is warmer and exhibits slightly greater temperature stratification, probably due to the warming of the lake water as it passes over the shallow bar and to the smaller fetch in the west basin. Stratification is so weak in both basins that warming occurs to the bottom and wind action may mix the lake during periods of open water."[6]

The average annual runoff from the basin is approximately 310 cfs or 225,000 acre-feet per year. Runoff data for the Vodopad River is shown in Table W-6. Only 10 years of streamflow records (1915-1925) are available for the Vodopad River. Therefore the table also includes an extension of existing record by statistical means. Fifty-percent of the total annual runoff typically occurs mostly as snowmelt during the four month period from May through August. Annual runoff patterns for streams in this area are significantly affected by the relative elevation of their drainage basins and the nature of their tributaries. Streams, such as the Vodopad River, with basins at lower elevations or which have glacial runoff contributions tend to have more uniform runoff patterns throughout the year.

2.4.2.2 Silver Bay[7]

Silver Bay is an estuary connected with Sitka Sound by way of the Eastern Passage. The Bay is 6.5-miles long and varies in width from 0.4 to 0.9 miles. It is approximately 400-feet deep at the mouth decreasing to approximately 150-feet near the head. The Bay has an area of 4.2 square miles and has about 30 miles of shoreline. Several streams, including the Vodopad, serve as sources of freshwater to the Bay.

The freshwater input to Silver Bay mixes with saline waters and forms a very shallow surface layer of brackish water. Beneath this surface layer, horizontal and vertical salinity gradients are small and salinities are near oceanic levels.

Circulation patterns are determined by the amount of freshwater runoff, density differences between Silver Bay and Sitka Sound, wind stresses and to a lesser degree, tidal forces.

Silver Bay is very accessible and except for Sawmill Cove, where pollution levels are elevated due to discharge from the pulpmill located there, is used for recreational fishing and boating by local residents. Silver Bay also serves as a wintering and nursery ground for flatfish. Tributaries such as Bear Creek, support salmon runs and the Bay serves as a nursery area for young salmon as well.

2.5 Unique Features

No unique or unusual archaeological or historic sites were found to exist within, or in the immediate vicinity of the project boundary.[8] Silver Bay, while quite scenic, is typical of Southeast Alaska and is therefore not considered unique.

3. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

3.1 Construction

The construction phase of the Project is scheduled to last approximately 3 years during which time disruptions to the environment are expected to occur. Some of the disruptions are expected to be only intermittent and/or temporary, abating after the project construction is complete; others will represent permanent changes of the environment, lasting throughout the life of the Project and beyond. The people of Sitka and the land, wildlife, air and water resources within the project area will be affected both adversely and beneficially. The overall negative impact of the proposed action, however, is not anticipated to be significant.

3.1.1 Land Features and Uses

The Project upon completion will encompass approximately 1,500 acres. Due to the relative isolation of the site and the mountainous terrain therein, little or no commercial use has been made of the land.

3.1.1.1 Wood Products Industry

As discussed in Section 2.1.1 the Green Lake-Vodopad River drainage area is currently under lease to ALP for its timber resources. During construction, all merchantable timber cleared for access road construction or from within the reservoir area (El 390 [MSL] to El 230 [MSL]) will be salvaged and sold. Beyond this initial recovery, however, the 1,500-acre project area will be removed from use for timber production. This removal will represent an estimated future timber loss of between 20 and 40 million board feet during the next 100-year rotation.

3.1.1.2 Mining

Sporadic mining activity has been the only recent commercial use of lands in the project vicinity. While no in-depth assessment of the mineral resources of the impacted area has been made it is not anticipated that construction or operation of the Project will significantly impact this industry. Only the reservoir area will be removed from mining use and no claims are known to exist in that area.

3.1.1.3 Recreation

General access to the site will be prohibited during construction to safeguard public health and safety. This restriction is expected to have little impact on the limited existing recreational use of Green Lake. Most visitors will be deterred by the construction activity and increased noise levels. Boat traffic in the near shore waters of Silver Bay will be monitored during construction of the access road and powerhouse to safeguard public health and safety, especially while blasting operations are in progress.

3.1.1.4 Land, Air, and Marine Traffic

The Project will have a limited adverse effect on traffic patterns on Sawmill Creek State Highway. This road will serve as the only access from Sitka to both the Project access road and the ALP pulp mill; therefore some inconvenience to employees of ALP will occur. Methods to alleviate this impact will be considered if a problem develops during construction.

Intermittent increased usage of air and water transport systems will occur as personnel, materials and equipment arrive and depart Sitka during the various stages of construction.

3.1.2 Species and Ecosystems

A discussion of the impacts of the Project on species and ecosystems is presented in Appendix W-10.

3.1.3 Socio-Economic Impact of the Proposed Action

Consideration of the socio-economic impacts of the project construction will center on the City of Sitka. As the only developed population and commercial center in the vicinity of the Project, it will be most directly affected by construction.

The number of construction workers at the Project will vary by season and year. The expected maximum will be approximately 150 people during the fall of the third year of construction. In compliance with Alaska State labor laws, (Section 36.10.010), 95% of the labor force will be Alaska residents (if qualified).

Sitka is currently enjoying a period of growth and prosperity with very little unemployment. It is difficult to assess the number of Sitka residents, now employed, who might be attracted to employment on the Project or what portion of Sitka's resident construction industry might be directly involved in the construction. It would be unrealistic to assume either that the construction force would be drawn entirely from Sitka or that it would consist entirely of non-Sitka residents. Most of the more specialized labor will not be available in Sitka and will therefore be drawn from outside sources. To further determine the exact composition of the work force would involve a number of complex and, at this time, problematical variables and therefore no concentrated effort has been made to do so.

The adverse socio-economic impacts of such a construction force are expected to be slight and short-term. Housing for the construction workers is the area of chief concern. Housing in Sitka is currently at a premium and many rental units are reserved for the community's growing tourist industry. More detailed consideration of accommodation of these impacts will be undertaken by the Applicant during the licensing process.

The impact of project construction on the local school system is not anticipated to be significant. Due to the scheduled and periodic fluctuations in the size of the construction force and the rather transient nature of employment on many of the construction activities, it is unlikely that a significant portion of the work force will choose to relocate their families to Sitka. Assuming that 100% of the construction force will be non-Sitka residents and that 25% of the married personnel will relocate, a conservatively high estimate, it is estimated that 23 school age children will arrive in Sitka as a direct result of the project construction. This represents 1% of the present school enrollment in Sitka through grade twelve. The estimate was made using 150 people as the size of the construction force, statewide averages for ratio of married to single, number of people per household, and percent of population between ages 6 and 17.

While the private and public health care facilities in Sitka are somewhat limited, it is unlikely that an increase of 150 workers would cause significant hardship. The same can be said of the demands placed upon fire and police services. However, problems in providing adequate fire and police protection for the proposed construction areas could arise due to the relative isolation of the project area. Therefore, the contractor will be responsible for fire protection measures at the project site and initial control should a fire occur.

Employment in the local and regional construction industry will increase as a result of the Green Lake Project, and new workers will contribute to the local economy in both wages spent and taxes paid. Revenues from the City and Borough's 4% sales tax will be a direct benefit to Sitka.

3.1.4 Air and Water Quality

During the four-year construction phase, air quality in the project area will be impaired, and State and local standards will be intermittently, and/or temporarily violated.

Exhaust gases from combustion engines on construction vehicles and machinery will increase airborne particulate matter and gaseous oxides. Smoke from burning of slash will also affect the air quality to some extent. Surface blasting for the access road, tunnel portal, and power plant construction will generate dust as will the subsequent excavation and grading. Aggregate production, clearing, and normal access road use are further potential sources of dust generation.

However, the adverse construction-related impact on air quality is anticipated to be localized and temporary. The frequency of precipitation in the region will tend to "cleanse" the air and restore air quality to near pre-construction quality.

The operation of construction equipment, air compressors and vehicles will significantly increase noise levels in the area. Surface blasting would intermittently increase noise levels during the early stages of construction. Underground blasting would not have a significant effect on the noise levels on the surface.

Without adequate erosion control during construction of permanent and temporary facilities, runoff from these areas could carry sediments into the surface waters.

Excavated material from the power tunnel, powerhouse site, and access road is to be placed into Silver Bay. This action will result in temporary high turbidity levels in the Bay. Further discussion of this action and its effect on the aquatic life of Silver Bay is presented in Appendix W-10.

Without proper treatment, effluent from the aggregate plant and concrete batch plant could cause a degradation of water quality if allowed to directly enter Green Lake. Accidental fuel spills and improper disposal of oils, grease and chemicals used during the construction would have a severe impact on aquatic life should they reach water bodies in the project area.

Creation of the reservoir will inundate approximately 820 acres of cleared forest. Flooding organic materials on this land will increase biochemical oxygen demand (BOD) in the overlying waters and leaching of nutrients and other inorganic substances could occur. Biotic production will greatly increase initially in response to this readily available nutrient supply but would eventually decline and stabilize as these nutrients are consumed.

3.1.5 Waste Disposal

Waste material generated by construction activities will consist essentially of solid wastes such as timber and brush from reservoir clearing, scrap and forming lumber, paper containers, cans and scrap steel, and plastics. Combustible wastes will be burned in compliance with all pertinent local and State air pollution control regulations. All material left after burning will be buried. Non-combustible waste disposal sites have not as yet been identified. Waste disposal sites, both combustible and non-combustible, will be selected to meet State and local standards.

3.2 Operation and Maintenance

3.2.1 Land Features and Uses

The land occupied by the Project will be used primarily for the generation and transmission of power to the Applicant's service area.

Upon completion of the Project the only restrictions placed upon public access to the site will be those necessary to protect both public health and safety and the security of the project facilities. Log booms will restrict access to such potentially hazardous areas as the dam, spillway and intake structure in Green Lake and the tailrace area on Silver Bay. Unauthorized vehicular traffic on the access road will be prohibited for reasons discussed in Section 1.4.1.4.

Future secondary uses of the project lands that do not endanger the security or integrity of the Project will be considered by the Applicant as they arise.

3.2.2 Species and Ecosystems

It is expected that the major impact of the Project on the plant and animal life in the area will occur during the construction phase and when operations commence, conditions will gradually return to near pre-construction status (see Appendix W-10).

3.2.3 Socio-Economic Considerations

The most direct result of project operation would be to provide the City and Borough of Sitka with an economically stable and reliable power source with which to encourage and facilitate future growth.

3.2.4 Air and Water Environment

3.2.4.1 Air Quality

Project operation and maintenance should have little or no effect on air quality in the project area.

3.2.4.2 Noise Quality

Actions which would create noise during operation of the Project include: (1) operation of equipment of the power plant; (2) outflow of water to Silver Bay during generation; and (3) transmission line related noise. These activities should contribute no significant adverse effects on the existing ambient sound conditions in the vicinity of the Project.

3.2.4.3 Water Quality

The effect of project operation on the water quality of Green Lake and Silver Bay is presented in Section 7 of Exhibit H included in this exhibit as Appendix W-2.

3.2.5 Solid Wastes

The project operation, as proposed, will produce little solid waste. Oil used in the power generating equipment in the powerhouse will require disposal outside the project area. The waste oil will be trucked to Sitka for disposal or reclamation.

Wastes from maintenance procedures such as debris from the trashracks will be disposed of in accordance with all pertinent State and Federal regulations. Accumulation of vegetation from the maintenance of the transmission line right-of-way is expected to be negligible.

3.2.6 Use of Resources

The Project, including transmission facilities, will occupy approximately 1,500 acres of land. Virtually the entire natural runoff from the drainage basin above the dam will be utilized for the purpose of power generation. As a conventional hydroelectric development, project operation will require no power from outside sources.

The Project will require the use of a relatively small amount of material during operation such as lubricants for the machinery and replacement parts. The impacts on the environment of consuming the small amounts of lubricants and materials needed to manufacture replacement parts will be insignificant.

3.2.7 Accidents and Catastrophes

The Project is located in an area of moderate to high seismic activity. Project facilities, with special emphasis on the dam, will be designed to resist seismic forces using dynamic analysis procedures.

The spillway will be designed to pass a flood with peak inflow of 21,150 cfs and with volume of 21,500 acre-feet. This flood is equivalent to half the Probable Maximum Flood (PMF) and has a return frequency of approximately 5,000 years.

The PMF, when routed through the reservoir, results in a reservoir elevation of 405 feet (MSL), with the non-overflow sections of the dam being overtopped for about 15 hours. Because of the infrequency of occurrence of the PMF, it is considered that this nominal overtopping can be tolerated and the dam will be designed to accommodate it.

The transmission line will be vulnerable to major natural catastrophes, such as severe wind, fire, ice, landslides, and earthquakes, and to such man-caused vagaries as aircraft impacts. Failures resulting from catastrophes can be repaired in a relatively reasonable short time.

3.3 Termination and Abandonment

Should it become necessary or desirable to retire the Project, it is not anticipated that significant long-term impacts would result. If all project facilities were removed and topography restored when terminated, the area would eventually return to its natural state. Revegetation of the previously inundated portion of the reservoir would, however, take 50-100 years.

4. MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL EFFECTS

4.1 Preventative Measures and Monitoring

4.1.1 Air Quality and Noise Levels

Some deterioration in air quality will be an unavoidable consequence of construction of the Project. The Applicant will require compliance with all EPA and OSHA criteria for air quality. During final design of the Project, specifications will be developed to safeguard against any undue degradation of air quality during construction. Due to frequent precipitation in the area which will tend to "cleanse" the air, no air quality monitoring is proposed.

Noise levels can be expected to increase substantially during the construction period. Due to the relative isolation of the construction sites the only noise level control measures employed will be those necessary to meet OSHA standards. No measures to monitor noise levels are felt to be necessary.

4.1.2 Water Quality

The most significant impact to local water quality would be the temporary higher turbidity levels in Silver Bay as a result of the disposal of excavated material from access road, power tunnel, and powerhouse construction.

Project roads will be designed and constructed so that runoff and natural drainage patterns will not be adversely affected. Watershed protection techniques such as contour ditching, water check and culverts will be used to help minimize the effects on water quality from the access road during construction and operation of the Project.

Specifications will be developed during final design to prohibit the introduction of any toxic substances such as grease, oils, fuels and chemicals into either Green Lake or Silver Bay. Specific procedures to be followed will be the responsibility of the Contractor.

4.1.3 Wildlife

The major impact on wildlife is expected to occur during the construction phase of the Project. Proper scheduling of various construction activities could substantially reduce potential adverse impacts.

All statutes concerning construction in the vicinity of eagle trees and recommendations from the U.S. Department of Fish and Wildlife will be observed. Insulators on power transmission poles will be spaced so as to prevent electrocution of eagles and other large birds that might use the poles as perching sites.

The only critical habitat that occurs in the project area is Bear Creek which supports annual salmon migration. The creek will be bridged, as requested by Alaska Department of Fish and Game, so as not to inhibit the passage of anadromous fish and construction will be accomplished in coordination with the Department.

4.2 Environmental Restoration and Enhancement

As both an erosion control and restoration measure, those lands disturbed during construction and not subject to rapid natural revegetation, will be reseeded. Overburden will be stripped from the contractor's work area and stockpiled for later use during restoration. Exposed soil cut slopes will be reseeded as soon as possible to lessen erosion potential. Upon completion of construction, the contractor's work area will be re-graded, recovered with stockpiled topsoil and re-seeded. A comprehensive erosion control plan, conforming with local standards, will be required of the contractor for all phases of construction.

In view of the large overall recreational resources available in the greater Sitka area, the Project is not considered to be a major recreational resource. However, the increased nutrient source made available by the raising of the lake level will provide an increased food source for the existing brook trout population. During the early years of project operation, trout fishing should be better than presently exists but is expected to diminish with time as the nutrient source diminishes. Lake stocking by the Alaska Department of Fish and Game will be considered should an increased recreational use of the lake warrant it. To facilitate access to this resource a small boat mooring buoy will be placed in Silver Bay north of the powerhouse. Hiking access to the reservoir from tidewater will be available along the access road and the existing trail.

The Applicant's plans for the recreational use of the Project are detailed in Exhibit R, included in this exhibit as Appendix W-7.

Plans for the restoration or mitigation of the aesthetic impacts of the Project are presented in Exhibit V, included in this exhibit as Appendix W-8.

5. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

5.1 Human Resources and Values Impacted

No people, businesses or industries will be displaced by any phase of the construction or operation of the Project. The needs of the labor force over the three-year construction period will, in fact, necessitate the development of additional housing in Sitka which might later benefit the community's long-term growth needs.

Safety considerations will limit recreational use of the lake and near shore waters of Silver Bay during construction. The construction activity and increased noise levels will deter some recreationists from use of Silver Bay during construction but other similar recreational areas are available in the vicinity of Sitka.

The project area is not part of any designated wilderness area; however, it does lie in an inventoried roadless area of the Tongass National Forest. The aesthetic impact of the access road may well be the most significant adverse impact of the Project. While environmental and aesthetic considerations may influence route selection, topography and fish and wildlife considerations will, in the end, dictate the final alignment. As a result, large portions of the access road will be visible from Silver Bay.

5.2 Biotic Resources

A discussion of the unavoidable adverse effects on the biotic community is presented in Appendix W-10.

6. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Project will make a major contribution to meeting the electrical power needs of the City and Borough of Sitka thereby satisfying basic needs of the community and enhancing the long-term productivity of the region served. In addition to the production of power, the Project will provide an efficient use of the water resources in the area and allow non-renewable fossil fuels to be used in other more productive capacities.

The short-term use of man's environment will involve several changes in the site area. The major changes will be the construction of roads, excavation for powerhouse and power conduit and normal reservoir fluctuation during operation. These changes and their effect on the biotic community in the vicinity of the Project are discussed in Appendix W-10.

The Project, with replacements and repairs as needed, is expected to remain in operation for many years, serving recognized needs by utilizing small land areas and renewable natural resources without adversely affecting long-term productivity of the region.

7. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

7.1 Land Use and Features

The major irreversible impact would be the presence of the access road in a previously unroaded area. Due to the precipitous and rocky terrain, blasting will be required for road construction. The effects of blasting and the presence of the road itself will permanently alter the visual quality of the shoreline along Silver Bay.

7.2 Biotic Community

The irreversible commitment of biotic resources is discussed in Appendix W-10.

7.3 Socio-economic Considerations

A firm, reliable and economically stable power source such as the Project will facilitate and encourage growth in the City and Borough of Sitka. This unassessed growth may result in the commitment of an indeterminable amount of other resources.

7.4 Resources Lost or Uses Preempted

Few irreversible and irretrievable commitments of resources would occur as a result of the proposed action.

The placement of spoil material in Silver Bay would result in an irrevocable commitment of resources. Lands occupied by the reservoir, access road and project facilities would be committed to use for power generation and as such would be lost to use as wildlife habitat or timber resources.

No economically significant minerals are known to underlie the site.

7.5 Finite Resources

Construction materials needed to construct the dam, power conduit, powerhouse and transmission line would be irretrievably committed. Most of the electric and mechanical equipment would have salvage values. Construction of the Project would require excavation of approximately 135,000 cubic yards of material and the placement of approximately 40,000 cubic yards of concrete.

8. NEED FOR POWER AND ALTERNATIVES TO THE PROPOSED ACTION

8.1 Need for Power

Sitka is one of the fastest growing communities of its size in Alaska today. Its current population is approximately 6,000 and increasing rapidly. An expanding tourist industry, the recent transfer of the U.S. Coast Guard Air Wing from Annette Island to Sitka, and normal population increases are expected to consume the existing power resources.

8.1.1 Load Growth Projection

Power projections in the Alaska Power Survey of 1969[11] predict an average growth rate in Southeast Alaska of about 13% up to the 1980's and about 7% from the 1980's to year 2000. Short-term projections of load growth made by the Sitka Electric Department averaged about 10% in capacity and energy growth. These projections included 2,500-kW of demand which will be required before 1978 by the new Coast Guard facility and by various other planned major business developments. Considering historic growth, a reasonable long-term growth rate projection of 6% from 1978 on was utilized by the Applicant.

8.1.2 Present Resources

Sitka's existing generating capacity consists of 6,500-kW of generation delivered from the Blue Lake Project and 3,150-kW of diesel capacity. The City also has a 2,500-kVA tie with ALP but the amounts of capacity and energy available from ALP are diminishing rapidly as it expands toward full capacity and this resource is no longer considered dependable.

8.1.3 Future Resource Requirements

Historical and projected peak and energy loads are shown in Fig. W-3. Required capacity reserves have been set to be equal to the largest single generating unit in the system. As can be seen, presently Sitka has very limited peaking reserves and without additional generating capacity would not be able to meet load demands by the end of 1978. It is therefore planned to install two 2,500-kW diesel units (2,750-kW peak capacity) to be on-line by late 1978. These new units will meet the demand until the Project can be placed in service, scheduled for the latter part of 1981. However, up until the time the Project is on-line, reserve capacity will continue to be marginal. When the Project comes into service, the diesels will be used as standby reserve and to firm up hydroelectric secondary energy generation when required. Based on the projected power needs, it is expected that the Project will satisfy the system load requirements, with little diesel generation, until about 1994.

During the early years of operation, the output of the Project will exceed Sitka's load requirements. During this period it is planned to sell the excess power to ALP on a retractable sales basis. ALP has recently expressed its intention in principle to purchase the excess power and is proceeding with expansion of the intertie capacity with Sitka to permit delivery.

8.2 Energy Alternatives

There are other potential energy sources which need to be recognized even though some cannot, at this time, be considered as feasible alternatives to the Project. These include additional diesel-electric units, fossil fuel fired steam plants, and nuclear energy.

For Sitka, the most economic alternative to the Project is a diesel-electric unit located near the load center.

The cost of power of average annual energy generated by the Project is estimated to be 47.6 mills/kWh at its on-line date of September 1981. This cost is significantly less than 61.2 mills/kWh cost of generating an equivalent amount of energy from the alternative diesel power source, and is close to the projected cost of diesel fuel alone (41.9 mills/kWh) at that time.[1]

Steam generating plants are not economic for the magnitude of the loads which the system has now or in the foreseeable future. From an environmental standpoint, the continued use of non-renewable fossil fuels such as oil or coal is not rational where renewable resources are available.

Nuclear plants of a size adaptable to the Applicant's needs are not competitive with the Project. Also, since the planning, licensing and construction lead time for nuclear power plants now involves a minimum of ten years, nuclear power could not be considered at this time. The significant environmental problems which would occur as a result of the nuclear option would include disposal of waste heat and insuring the safe storage of radioactive waste material.

Potential energy sources which cannot at this time be considered as feasible alternatives (due to factors such as costs, timing of development, location relative to energy demand, lack of proven technology and environmental impacts), include magneto hydrodynamics, wind, geothermal, and solar generation.

8.3 Consideration of Alternative Hydro Sites

It is important to note that the alternative selected to proceed with, should first provide a significant amount of energy and capacity in view of Sitka's load growth situation, and second, should be economically, technically, and environmentally feasible in light of that load growth. By mid-1981, when the Project is brought on-line, the demand for energy will have reached nearly 60,000 Megawatt-hours, based on the 6% growth rate plus additional block loads. Hence, the next hydro project should, in combination with existing resources, be capable of accommodating this growth plus some reasonable period beyond.

The following is a discussion of the characteristics of each alternative site considered and the scheme of development proposed for it. Project data is summarized in Table W-7. The energy quoted as being available from each project is estimated average annual energy.

8.3.1 Carbon Lake

Carbon Lake is located on the east side of Baranof Island (see Figure W-4) almost due east of Sitka where it empties via a short length of falls directly into Cascade Bay. To date, Carbon Lake has not received a great deal of consideration as a powersite; the only significant mention being in Water Powers of Southeast Alaska. The elevation of Carbon Basin is the lowest of those considered herein and the basin is glacier-fed which tends to stabilize the flow. Water Powers of Southeast Alaska estimates that 53,000 acre-feet of storage would firm-up approximately 270 cfs of the estimated annual average 444 cfs of runoff available. On this basis it is estimated that an average annual flow of 333 cfs, or 75% of the long-term average, could be regulated by the 53,000 acre-feet of storage. Development of this storage would require the construction of four dams ranging in height from 10 feet to 65 feet. A 4,800-foot power conduit would include 2,000-feet of tunnel and the remainder in penstock. The powerhouse would be located at tidewater developing an average gross head of 230 feet.

This arrangement would permit the installation of 13,500 kW of capacity at a 40% annual plant factor. Allowing for losses over a 31.4-mile transmission line to Sitka, 12,150-kW of capacity and 43,674,000-kWh of energy would be delivered to the load center. The line would extend through a 2,800-foot high pass near the center of the island considerably complicating construction, maintenance and reliability. Development of a port facility and short access road from tidewater to the Project would be required.

The estimated capital investment required for development of Carbon Lake was based on comparison with development costs for Green Lake, and those developed by the U.S. Bureau of Reclamation for the Swan Lake Project near Ketchikan. Carbon Lake will have a complex arrangement with four dams and a port facility. Based on these considerations, the per kilowatt capital investment for Carbon Lake was estimated at $3,175/kW, which amounts to a total capital investment of $42,863,000.

The available power at Carbon Lake is not sufficient for the Applicant's needs and was the primary reason for its rejection. Secondly the length, elevation and relative inaccessibility of the transmission line from Carbon Lake to Sitka would have compromised its reliability and intensified the ecological impact of the Project.

8.3.2 Takatz Lake

Takatz Lake is located on the east side of Baranof Island, approximately 20 air miles east of Sitka. It is situated approximately 4,000 feet upstream of the mouth of Takatz Creek which flows into Chatham Straight by way of Takatz Bay. Takatz Lake was considered the most favorable alternative to Green Lake and as such was the most intensely studied alternative.

The Alaska Power Administration (APA) investigated the geology at the site and concluded that conditions were adequate for construction of a concrete arch dam. The topography appears to have been greatly influenced by glaciation, probably during Pleistocene Time. Slopes are precipitous and covered by a thin mantle of soil with heavy growths of underbrush.

The bedrock formation at the dam site is a massive quartz diorite which is dense and indurated. The rock is medium-to-coarse grained and is equigranular. This is typical of rocks associated with the Coastal Range Batholith which generally is located along the coast of the mainland of Southeast Alaska. The Coastal Range rocks are considered to be competent foundation materials and if the geology at the site is indeed of that formation, the foundation conditions should be entirely adequate. Further investigations would be required to verify the site conditions.

The drainage basin of Takatz Lake has an area of about 10.6 square miles. Streamflow records for 15 complete water years are available at a point on Takatz Creek downstream of the dam site with a drainage area of 17.5 square miles. The average annual runoff at the gage was 199,800 acre-feet or an average of 11,417 acre-feet per square mile which is significantly higher than Green Lake. The annual average precipitation at Baranof Warm Springs, however, is approximately 143 inches which is about 154% of the long-term average at Sitka. The average annual inflow into Takatz Lake is estimated to be about 121,000 acre-feet which would produce an average annual discharge of about 166 cfs.

It is estimated that an average net head of approximately 950 feet can be developed at the site which would produce an average output of about 11,080 kW which would deliver approximately 91,200,000 kWh of firm energy to the load center. At 40% plant factor, the peak output would be 27,700 kW, which would deliver 25,000 kW of dependable peak capacity to the load center.

It is anticipated that raising the lake level to El 1040 (MSL) by construction of a dam at the existing outlet of the lake will provide sufficient storage for regulation of inflow and adequate head to develop the potential of the Project.

A concrete arch dam approximately 200-feet high will be required to control the reservoir and to provide regulation of the annual runoff. A dam of this size would provide a normal maximum reservoir level at El 1040 (MSL), and contain an active storage volume of 82,400 acre-feet. The power conduit is tentatively proposed as a 6.5-foot by 7.0-foot modified horseshoe tunnel approximately 2,800-feet long with a downstream portal approximately 1,000 feet from the powerhouse. A 72-inch steel penstock would connect the portal to the powerhouse. A surface powerhouse would be constructed at ground level near Takatz Bay. It is anticipated that two Francis turbines would be installed, each delivering about 18,600 horsepower at best gate, under average net head, and connected to a generator rated at 15,400 kVA, with a 90% power factor (13,850 kW).

With an installed plant capacity of 27,700 kW at 41% plant factor, approximately 25,000-kW of capacity and 93,330,000-kWh of average annual energy would be delivered to Sitka after allowing for station service and losses over approximately 31.2 miles of 69-kV transmission line. The transmission line route would be generally the same as that for the Carbon Lake alternative and a similar port facility and access road would be required.

The per kilowatt capital investment for Takatz Lake was estimated to be $2,433/kW which amounts to a total capital investment of $67,400,000.

The Takatz Lake Project shows great promise as a potential source of electrical generation to meet future long-range City and Borough of Sitka needs, if the transmission line difficulties can be resolved. However, the load forecasts for the Applicant's service area do not warrant the construction of a project of this magnitude at this time.

8.4 Alternative Project Arrangements[2]

8.4.1 General

A number of alternative project arrangements have been considered resulting in the selected project arrangement. Specifically the following alternatives were considered: power conduit alignment and type; powerhouse configuration; dam type; reservoir size; transmission line type; and access road alignment.

8.4.2 Power Conduit Alternatives

8.4.2.1 Surface Power Conduit Alignments

Two alternative surface power conduit alignments were considered, one leading to a powerhouse site located about 400 feet north of the Vodopad River outlet to Silver Bay and one about 500 feet to the south of the river outlet. Both arrangements would be very similar. Typically, from the power intake at the dam a saddle-supported 8-foot diameter steel penstock would be located in a 650-foot long unlined rock tunnel, and upon reaching more suitable terrain, the penstock would emerge into an open cut excavation with a single-lane access road alongside. Because of the topography immediately above the powerhouse, the penstock would terminate in a vertical concrete-lined shaft extending to a manifold of two horizontal steel-lined penstocks to the powerhouse.

A field reconnaissance of the proposed conduit alignments revealed that this concept is not practical because the rugged topography posed unacceptable construction and maintenance problems for the exposed penstock and may inhibit wildlife movement in the area. These two schemes were therefore eliminated from further consideration and all power conduit schemes considered involved tunnels.

8.4.2.2 Power Tunnel - South Side of the Vodopad River

The alignment on the south side of Vodopad River (Alternative 1) would consist of a tunnel which begins at a power intake in the south abutment of the dam and terminates at a powerhouse situated about 500 feet south of the mouth of the Vodopad River. The tunnel would be concrete-lined for its entire length except for the short steel-lined penstock section immediately ahead of the powerhouse. The powerhouse would be a concrete structure set in a side-hill cut. Since the powerhouse site is south of the river, this scheme would require an extended access road and bridge across the river to provide access to the plant. This alternative would also require a bridge across the spillway section of the dam for access to the power intake. The powerhouse site is feasible from a geologic standpoint; however, site development would require removal of the talus and landslide debris on the north side of the site. Advantages of this alternative are two-fold: (1) powerhouse excavation costs are less because of flatter topography and (2) the power conduit is slightly shorter than the other alternatives to the north of the river.

8.4.2.3 Power Tunnels - North Side of the Vodopad River

To the north of the Vodopad River, two power tunnel and powerhouse locations were investigated. One powerhouse site would be located about 800 feet north of the mouth of the river. This site has the advantage of a shorter access road but the disadvantage of a longer power conduit. The power tunnel (Alternative 2) would originate at a power intake located in the north abutment of the dam and extend approximately 2,050 feet to the powerhouse. However, geotechnical investigations have shown this site to be situated in a landslide debris area. Because construction and stabilization measures would be costly and there would be no assurance that future sliding would not occur, this scheme was eliminated from further consideration.

Alternative 3 would begin at the same power intake location at the dam as Alternative 2, but would terminate at a powerhouse site located about 350-feet north of the mouth of the Vodopad River. The resulting power tunnel would be approximately 1,900-feet in length. From a geologic standpoint, this powerhouse location is the most favorable of all the sites investigated. The power tunnel would be slightly longer than Alternative 1 but would require less reinforcement because of greater rock cover. The access road would be shorter and it would not require a bridge across the river or the spillway as would be necessary for Alternative 1. However, powerhouse excavation costs are greater because of the steeper topography.

8.4.2.4 Comparison of Alternative Alignments

There is no significant difference in cost between the scheme with the power tunnel alignment on the south side (Alternative 1) and the alignment on the north side with the powerhouse situated 350-feet north of the mouth of Vodopad River (Alternative 3). Because of the more favorable geologic conditions and the elimination of a bridge across the Vodopad River and the spillway section of the dam, Alternative 3 was selected.

8.4.2.5 Tunnel Lining

A cost comparison was made for Alternative 3 between a totally concrete-lined tunnel and a partially lined tunnel. The tunnel would be unlined where it is considered there would be adequate cover of sound rock. The cost savings with partial lining was $800,000 in direct construction cost based on January 1977 bid price level. The partially lined tunnel will of course result in a slight reduction in output due to greater friction losses in the power conduit, but this is insignificant and the tunnel arrangement adopted contemplates partial lining only.

8.4.3 Powerhouse Alternatives

Having determined that Alternative 3 would be the most favorable power conduit alignment, a comparison was made between a surface and an underground powerhouse.

The surface powerhouse would be set in a side-hill excavation. It would be reinforced concrete and would be approximately 32-feet wide and 80-feet long with two unit bays and one service bay. It would be protected against rockfalls by a sloping concrete roof. The switchyard would be located on a concrete deck over the tailrace.

The underground powerhouse would be in a rock cavern set inside the hillside and be similar in size to the surface powerhouse. Access to the powerhouse would be through a tunnel

15-feet wide and approximately 160-feet long. The equipment arrangement would be similar to the surface installation except that the switchyard would be located in open cut excavation adjacent to the access tunnel entrance. The draft tubes in the powerhouse would merge to a common concrete-lined tailrace tunnel approximately 150-feet long. A ventilation tunnel 5 feet by 7 feet which would also serve as emergency exit would connect from the powerhouse to a portal on the surface above the tailrace tunnel portal.

The surface powerhouse is less expensive by about $600,000 in direct construction cost based on 1977 bid prices. Because of this, and since the surface powerhouse can be designed to provide the protection inherent in the underground arrangement, it was selected.

8.4.4 Dam Alternatives

Two types of dams were considered, a rockfill dam with an upstream concrete face, and a concrete arch dam.

The rockfill dam would consist of a compacted rockfill main embankment with a selected zone of compacted rockfill on the upstream side beneath the concrete face. The slopes would be 1.4:1. The upstream slope would be faced with reinforced concrete with thicknesses varying from 12 inches at the top to 20 inches at the bottom. A gated spillway 32-feet high by 45-feet wide would be provided in the left abutment. For the reservoir El 420 (MSL) alternative, it was estimated that the direct construction cost for the rockfill dam alternative would exceed that of a double curvature thin concrete arch by approximately 1.1 million dollars for a January 1977 bid price level. Because of its high cost this alternative was eliminated in favor of the concrete arch structure.

8.4.5 Reservoir Alternatives

Following the selection of the power conduit alignment, powerhouse and dam arrangements, four alternative reservoir sizes were considered to determine the most economic project size. Layouts were made for normal reservoir elevations of 370, 390, 420 and 440 (MSL), and complete cost estimates were developed for each.

The analysis shows that the project with an installed capacity of 16.5 MW (reservoir El 390 [MSL]) would be the most economic installation. Thus, the selected project arrangement consists of a concrete arch dam with normal reservoir elevation at 390 (MSL), a partially lined power tunnel alignment on the north side of the river, and a surface powerhouse containing two units with a combined installed capacity of 16.5 MW.

8.4.6 Transmission Line and Access Road Alternatives

8.4.6.1 General

Several basic alternatives were considered for the access road and transmission line. Since these two features are dependent upon each other in regard to initial construction cost, maintenance and project reliability, they were considered concurrently. The alternatives which were evaluated are as follows: access road with transmission line built along its right-of-way (selected arrangement); overland transmission line with no access road; and underwater transmission line with no access road.

8.4.6.2 Overland Transmission Line in Access Road Right-of-Way

This alternative would consist of an access road which would start at the end of the existing State Highway at Herring Cove and extend south, generally remaining as close to tidewater as possible, to the Green Lake powerhouse site. A short branch would extend from the main alignment to the dam. The 69-kV transmission line would be located along the road alignment closely paralleling the road as much as possible to reduce required clearing and provide quick direct access for repair and maintenance, and terminate at the switchyard at the Blue Lake Project powerhouse. The access road will be of minimum construction and will have a 14-foot width, no pavement and no guard rail. The primary functions of the road will be to provide access for construction, operation and maintenance of the major project features, and for construction and maintenance of the transmission line. For safety and liability reasons, public vehicular access on the road would be prohibited for its entire length by a barricade installed at Herring Cove. The transmission line would be a conventional single-circuit line with single wood pole construction and a wishbone crossarm configuration.

This alternative would provide an overall system reliability equivalent to that which now exists, as access to the dam, power plant and transmission line would be by normal vehicular means, not dependent on clear weather conditions. Outages at the power plant, because of malfunction of equipment and transmission line outages which normally occur during severe inclement weather situations, would be held to a minimum because of the direct positive access for quick repair and maintenance provided by this alternative.

8.4.6.3 Overland Transmission Line With No Access Road

This alternative, without an access road, would involve an alignment somewhat different than that described above. The alignment followed would range from tidewater elevation to several hundred feet higher in areas where the lower elevation land near tidewater is too precipitous. The transmission line construction would be similar to that described above. The right-of-way would be selectively cleared of trees and brush for a width of at least 80-feet to provide adequate clearance for sagging conductors and "danger trees" that could fall on the conductors. In addition, a small 20-foot width would be clearcut at the center of the right-of-way to facilitate stringing the conductors. All access for construction and maintenance would of necessity be by water and air.

Elimination of the access road has a very significant effect on construction of the major project features. All construction access would have to be by water and a port facility would have to be developed to facilitate unloading equipment, materials and personnel. In addition, a construction camp would have to be provided at the project site to house construction workers and project personnel. The use of a construction camp at the site was found to be less expensive than ferrying in personnel daily by boat. Transport of materials and equipment to the site by water would also cause an increase in overall costs.

In terms of access for maintenance, this would be the second best alternative, but normal access would be much less convenient and emergency access would not be possible during stormy weather. The Applicant's total system reliability would be reduced by this alternative.

8.4.6.4 Underwater Transmission Line With No Access Road

This alternative would involve an underwater transmission line laid on the bottom of Silver Bay. The transmission line would become an overland line just north of Herring Cove to connect with the switchyard at the Blue Lake Project powerhouse. The alternative of continuing the underwater line on into Sitka was ruled out because it would cross the shipping lane to the ALP mill which would expose it to the additional hazard of ship and barge anchors. For reliability it would be necessary for the underwater transmission line to have two separate circuits each consisting of a three-conductor armoured copper cable laid in parallel, directly on the bottom an average distance of 250-feet apart with a minimum of 50-feet apart where necessary. Elimination of the access road has the same effect on the cost of construction of the major project features of this alternative as the previous alternative.

This alternative has the same disadvantage for maintenance of the dam and power plant in the event of an outage as does the previous alternative. In addition, this alternative has a greater disadvantage in that maintenance of underwater transmission lines is very expensive and requires a long period to accomplish repair work. It is estimated that at mid-1977 cost level, a single repair of one of the cables would cost $250,000 and would take approximately 30 days to complete under the best conditions of availability of equipment and labor. A specialized cable laying boat and equipment is required which must be brought in and difficulties are frequently encountered in locating the cable on the bottom and hauling it to the surface for repair. As with the previous alternative, the Applicant's total system reliability would also be reduced by this alternative.

8.4.6.5 Evaluation of Alternatives

On a capital investment basis, the underwater alternative would be an estimated $8,900,000 more expensive than the proposed selected project arrangement. The overland alternative is estimated to be $4,851,000 more expensive than the selected arrangement.

On the basis of the significantly lower first costs overall superior system reliability, and ease and lower cost of operation and maintenance, the alternative involving an access road with the adjacent overland transmission line was selected.

8.4.7 Access Road Alternative Alignments

The access road alignment from the end of the existing highway at Herring Cove to Bear Cove would generally follow the shoreline near tidewater level. However, from Bear Cove to the dam and powerhouse locations, two basic alternative alignments were considered. One alignment would generally follow contour El 500 (MSL) and for the most part be in a full-bench cut because of the steep side-hill topography. The other alignment would generally be near tidewater level. About 1,000 feet of this latter alignment near Bear Cove would vary between a cut and fill section and a full embankment section. The remainder of the alignment to the dam and powerhouse locations would generally be a full-bench cut. Because of cost advantages, the tidewater alignment was tentatively chosen. Final alignment for construction will be subject to the results of continuing field investigations and final alignment surveys.

9. PERMITS AND COMPLIANCE WITH OTHER REGULATIONS AND CODES

9.1 Permits

The following is a list of permits known to be required before the proposed action can be completed:

Required Permits and Authorization

STATE

Permit	Controlling Statute	Governmental Regulation
State Tidelands Permit	AS-38.05.20	11 AAC 62.810
Title 16 Permit	AS-16.05.870	
Access to Navigable or Public Waters	AS-38.05.135	(Regulation Under Preparation)
Water Rights Application	AS-46.15.040	11 AAC 72.050
Section 401 Permit	PL 92-500	33 CFR 209.120

FEDERAL

Permit	Controlling Statute	Governmental Regulation
Section 10 Permit	30 STAT. 1151; 33 USC 403	33 CFR 209.120

Section 404 Permit	Federal Water Pollution Control Act (FWPCA) PL 92-500	40 CFR 209.120
National Pollutant Discharge Elimination System Permit	FWPCA PL 92-500 86 STAT. 816 33 USC 1251	40 CFR 125
U.S. Forest Service Special Use Permit	34 STAT. 225; 16 USC 431, 432	36 CFR 251

The Water Rights Application has been submitted. The remainder of the above and any other permits or licenses as may be required will be prepared and submitted during the licensing process. The Commission will be informed as approval of the permits are granted.

9.2 Authorities Consulted

(1) U.S. Army Corps of Engineers (COE), Alaska District

Date/Time: March 8, 1977/10:00 a.m.

Location: COE Offices, Elmendorf Air Force Base, Anchorage, Alaska

Participants: R. W. Beck and Associates, Inc. (RWB) representing the City and Borough of Sitka.
Steen & Matlock, Inc. (S&M), Access Road Consultants

Permits discussed: Section 10 of River and Harbor Act of 1899
Section 404 of Federal Water Pollution Control Act (FWPCA)
Section 401 of FWPCA

*   *   *   *   *   *

Date: April 14, 1977

Location: COE Offices, Elmendorf Air Force Base, Anchorage, Alaska

Participants: RWB representing City and Borough of Sitka
S & M

Permits discussed: Section 10 of River and Harbor Acts
Section 404 of FWPCA
Section 401 of FWPCA

*   *   *   *   *   *

(2) <u>Alaska Division of Lands and Water Management (ADL)</u>

Date: March 9, 1977

Location: State Office, 323 E. 4th St., Anchorage, Alaska

Participants: RWB representing the City and Borough of Sitka
S & M

Permits discussed: Water Rights Application
State Tidelands Permit
Access to Navigable or Public Waters
Section 401 of FWPCA

*   *   *   *   *   *

(3) <u>Alaska Department of Fish and Game</u>

Date: March 18, 1977

Location: Telephone Conference

Participants: RWB representing City and Borough of Sitka

Permit
discussed: Title 16 permit

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(4) Environmental Protection Agency, Region X, Alaska Operations Office (EPA)

Date: April 14, 1977
Location: EPA Offices, 605 W. Fourth Ave., Anchorage, Alaska
Participants: RWB representing the City and Borough of Sitka
S & M
Permit
discussed: National Pollution Discharge Elimination System (NPDES)

* * * * * *

9.3 Compliance with Other Regulations

Regulations and Codes dealing with health, safety and general construction techniques and procedures will be identified and submitted to the Commission during the final design phase of the Project.

10. SOURCES OF INFORMATION

10.1 Public Hearings

(1) Sitka Conservation Society

Date/Time: July 6, 1977/1:00 p.m.

Location: Sitka, Alaska

Participants: Fermin Gutierrez, Administrator - City and Borough of Sitka

R. W. Beck and Associates, Inc.

David T. Hoopes - Environmental Consultant

Steen and Matlock, Inc. - Access Road Consultant

Summary: After a thorough presentation on the Green Lake Project and the various environmental and archaeological studies, the discussion centered around the access road and the alternatives to the road. The Society seemed to generally accept the Applicant's project arrangement.

(2) General Public

Date/Time: July 6, 1977/7:30 p.m.

Location: Sitka, Alaska

Participants: Fermin Gutierrez, Administrator - City and Borough of Sitka

R. W. Beck and Associates, Inc.

David T. Hoopes

Steen and Matlock, Inc.

Members of the Sitka Assembly

Summary: A thorough explanation of the Green Lake Project and its alternatives was given, followed by a discussion of the access road and project capacity studies. There were no adverse comments on the project arrangement.

10.2 Other Sources

10.2.1 Meetings With Governmental and Other Entities

The following is a list of meetings with Federal and State agencies in the preparation of this exhibit:

(1) Alaska Division of Lands and Water Management

Date: March 9, 1977
Location: State Offices, 323 E. 4th St., Anchorage, Alaska
Participants: R. W. Beck and Associates, Inc. (RWB), representing the City and Borough of Sitka
Steen & Matlock, Inc. (S&M) - Access Road Consultants
Topic: Environmental effects of construction on State tidelands.
Conclusion: Project construction should have minimal adverse impact on State tidelands.

* * * * * * *

(2) Alaska Division of Parks

Date: March 9, 1977
Location: State Office, 617 Warehouse Avenue, Anchorage, Alaska
Participants: RWB representing the City and Borough of Sitka
S & M

Subject: Archaeological and Historic Effect of Project

Conclusion: No known items of archaeological or historic significance within area affected by Project. However, initial archaeological investigations should be undertaken prior to construction to verify.

Subject: Project Recreational Development

Preliminary Conclusion: Recreational development should be consistent with Borough and State plans.

* * * * * * *

(3) Alaska Division of Highways, S.E. District

Date: March 10, 1977

Location: State Highway Offices, Juneau

Participants: RWB representing the City and Borough of Sitka
S & M

Subject: Possible Effects of Federal Eagle Protection Laws on Project Development

* * * * * * *

(4) Alaska Division of Lands and Water Management - Southeastern Land District

Date: March 10, 1977

Location: State Office Building, Juneau, Alaska

Participants: RWB representing the City and Borough of Sitka
S & M

Subject: Unpatented Mining Claims in Project Area
Land Selection Process
Water Rights
Potential for State Involvement if an FPC License Application was not filed.

Conclusions: This meeting was of an information gathering nature and no conclusions were sought or advanced.

* * * * * * * *

(5) National Marine Fisheries Service (NMFS)
Alaska Department of Fish and Game (F&G)
Habitat Protection Service (HP)
Fisheries Rehabilitation Enhancement and Development (FRED)
Division of Sport Fisheries (DSF)

Date: March 10, 1977
Location: Subport Building, Juneau, Alaska
Participants: RWB representing the City and Borough of Sitka
S & M
Subject: The effect of the proposed project on fish and wildlife resources in the Green Lake and Silver Bay vicinity.
Conclusions: Effect of Project Development on Green Lake

The enlargement of Green Lake and construction activities should increase nutrient sources temporarily in the lake and with stocking should cause significant improvements in trout fishing for 8 to 10 years after Project completion.

Effect of Project Development on Silver Bay

Because topography along the east side of the bay is largely very steep, it does not support a major fish population. Thus, disposal of excavated material, largely from access road excavation, will probably not have significant harmful effects on marine life. In the areas near Bear Cove where the bottom is flatter and muddy, rock excavation from access road construction could well improve marine habitat.

(6) Alaska Power Administration

Date:	March 11, 1977
Location:	Federal Building, Juneau, Alaska
Participants:	RWB representing the City and Borough of Sitka
	S & M
Subject:	General project briefing

The following governmental agencies and personnel provided assistance and advice throughout the preparation of this exhibit. As their aid was sought on almost a day by day basis, no attempt is made here to provide dates of contact.

Federal

Bureau of Land Management
Environmental Protection Agency
National Marine Fisheries Service
U.S. Corps of Engineers
National Oceanographic and Atmospheric Administration
U.S. Fish and Wildlife
U.S. Forest Service
U.S. Geological Survey
Alaska Power Administration
Federal Power Commission

State

Department of Commerce
Department of Environmental Conservation
Department of Fish and Game

Fisheries Rehabilitation, Enhancement and Development
Habitat Protection Service
Division of Sport Fisheries

Department of Natural Resources
Office of History and Archaeology

Division of Lands and Water Management

Local

City and Borough of Sitka

10.2.2 Studies Conducted

(1) Analysis of Electric System Requirements, Electric Utility System, City and Borough of Sitka, Prepared by R. W. Beck and Associates, Inc., April 1974.

(2) "Preliminary Geologic Investigation. Proposed Green Lake Hydroelectric Project" by Converse Davis Dixon Associates, Inc. November 19, 1974.

(3) Re-evaluation of Alternatives for Electric Generation Program, City and Borough of Sitka, Prepared by R. W. Beck and Associates, Inc., September, 1976.

(4) "Phase II Geotechnical Investigation, Green Lake Hydroelectric Project, Sitka, Alaska", by Converse Davis Dixon Associates, Inc., February 1, 1977.

(5) Green Lake Project - Evaluation Report, City and Borough of Sitka, Prepared by R. W. Beck and Associates, Inc., June, 1977.

10.2.3 Consultants

Engineer and Primary Consultant	-	R. W. Beck and Associates, Inc. 200 Tower Building Seattle, Washington 98101
Geotechnical Investigation	-	Converse Davis Dixon Associates, Inc. 126 W. Del Mar Boulevard Box 2268D Pasadena, California 91105
Fish and Wildlife Studies	-	David Townsend Hoopes, Ph.D. Post Office Box 373 Clark Fork, Idaho 83811
Archaeological Investigations	-	Robert E. Ackerman, Ph.D. Laboratory of Anthropology Washington State University Pullman, Washington 99164
Access Road Investigations	-	Steen & Matlock, Inc. 1549 E. Tudor Road Post Office Box 4-2666 Anchorage, Alaska 99509

The professional vitae of the above consultants are provided in Appendix W-12.

10.2.4 Technical Reports

(1) "An Investigation of the Biotic Communities in the Vicinity of Green Lake, Baranof Island, Alaska." by David T. Hoopes, July 15, 1977.

(2) "Silver Bay - Green Lake Archaeological Survey" by Robert E. Ackerman, July, 1977.

Both of these studies have been included in the Exhibit as appendices.

10.3 Bibliography

10.3.1 Cited References

(1) City and Borough of Sitka, Green Lake Project Evaluation Report, Prepared by R. W. Beck and Associates, Inc., June, 1977.

(2) Letter from Alan J. Aitken, Acting Timber Manager, Chatham Area - Tongass National Forest to Donald R. Melnick, Project Engineer, R. W. Beck and Associates, Inc., March 11, 1976.

(3) An Investigation of the Biotic Communities in the Vicinity of Green Lake, Baranof Island, Alaska, Prepared for R. W. Beck and Associates, Inc., by David T. Hoopes, July 15, 1977.

(4) City and Borough of Sitka, Alaska, Comprehensive Plan, Prepared by the Planning Department, City and Borough of Sitka, November, 1976.

(5) "A Program for Increasing the Contribution of Tourism to the Alaskan Economy", Cresap, Harris, Spencer, co-consultant, December, 1968.

(6) Water Resources in Alaska, "Limnological Investigation of Six Lakes in Southeast Alaska", WRI 76-122, prepared by the U.S. Department of the Interior, Geological Survey in cooperation with the Alaska Department of Fish and Game.

(7) U.S. Environmental Protection Agency, "Water Quality Data During September 16-19, 1974 at Silver Bay, Sawmill Cove and Eastern Channel, Sitka, Alaska", Working Paper No. EPA-910-8-76-096, May, 1975.

(8) "Archaeological Survey of Proposed Access Road and Dam Impoundment Area: Silver Bay - Green Lake Region, Baranof Island, Alaska", prepared for R. W. Beck and Associates, Inc. by Robert E. Ackerman.

(9) Alaska Power Survey, A Report of the Technical Advisory Committee on Economic Analysis and Load Projections for the Alaska Power Survey and the Federal Power Commission, in four volumes, 1974.

(10) University of Alaska, Arctic Environmental Information and Data Center, Alaska Regional Profiles - Southeast Region, Lidia L. Selkregg, ed.

10.3.2 General References

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U.S. Department of Agriculture, Forest Service, USDA Forest Service General Technical Report PNW-12, The Forest Ecosystem of Southeast Alaska, Volumes 1-9:

1. The Setting
2. Forest Insects
3. Fish Habitats
4. Wildlife Habitats
5. Soil Mass Movement
6. Forest Diseases
7. Forest Ecology and Timber Management
8. Water
9. Timber Inventory, Harvesting, Marketing, and Trends

U.S. Department of the Army, Office of the Chief of Engineers, Preparation and Coordination of Environmental Statements, April, 1974.

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U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report - Fisheries #321 - Herring Spawning Surveys in Southeastern Alaska, December, 1959.

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U.S. Department of Interior, Fish and Wildlife Service, Fred Robards, Bald Eagles in Alaska, undated.

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Tables

TABLE W-1

GREEN LAKE PROJECT

ESTIMATED LAND REQUIREMENTS

Feature	Length	Width	Area[(1)]	Cleared Area
Power Tunnel	1,910 ft.	200 ft.	8.8 acres	0
Powerhouse	200 ft.	200 ft.	1.0 acre	0.5 acre
Access Road/ Transmission Line	8.0 mi.	200 ft.	194 acres	54 acres
Reservoir	N/A	N/A	1,280 acres	830 acres
TOTAL PROJECT AREA	N/A	N/A	1,480 acres	885 acres

Note: (1) Area within project boundary.

TABLE W-2

GREEN LAKE PROJECT

POPULATION PROJECTIONS - SITKA CENSUS DISTRICT

BASE YEAR 1970-6109 (U.S. Census)

YEAR	POPULATION LOW	POPULATION HIGH	YEAR	POPULATION LOW	POPULATION HIGH
1971	5977(1)	6232(10)	1981	7170(9)	8050(15)
1972	6069	6355	1982	7290	8200
1973	6159(2)	6478	1983	7410	8350
1974	6279(3)	6775(11)	1984	7530	8500
1975	6532(4)	6940(12)	1985	7650	8650
1976	6785(4)	7100(13)	1986	7770	8800
1977	7000(5)	7375(14)	1987	7890	8950
1978	7120(6)	7650(14)	1988	8010	9100
1979	6950(7)	7773(10)	1989	8130	9250
1980	7050(8)	7896	1990	8250	9400

Notes:

(1) State of Alaska, Department of Labor
(2) Estimate 140 Forest Service less 50 from Cold Storage loss, ALP
(3) Estimate 120 for natural growth
(4) Beginning of Coast Guard, 153 per year for two years
(5) 100 increased Coast Guard 115 miscellaneous growth
(6) 120 natural growth
(7) Some loss predicted by ALP in less wood preparation
(8) 100 increase and re-stabilization at ALP
(9) Straight line 120 per year-long term average 1960-1970
(10) Natural increase
(11) 198 estimated for Forest Service move to Sitka
(12) Estimated 42 additional from review of utility hookups
(13) The Coast Guard move to Sitka begins
(14) 152 Coast Guard and 123 additional growth average
(15) Additional births of greater size population brings average yearly growth to 150 per year

Source: City and Borough of Sitka, Comprehensive Plan, November 1976.

TABLE W-3

GREEN LAKE PROJECT

FAMILY INCOME

Income:	Sitka Amount	Sitka %	Juneau Amount	Juneau %	Ketchikan Amount	Ketchikan %
Less than $1000	16	1.10	44	1.35	58	2.48
$1000 - 1999	14	.96	15	.46	56	2.39
2000 - 2999	6	.41	38	1.16	57	2.60
3000 - 3999	36	2.47	50	1.53	61	2.60
4000 - 4999	38	2.61	51	1.57	74	3.16
5000 - 5999	27	1.85	92	2.82	75	3.20
6000 - 6999	26	1.78	99	3.03	100	4.27
7000 - 7999	53	3.63	88	2.70	82	3.50
8000 - 8999	50	3.43	97	2.97	97	4.14
9000 - 9999	77	5.28	116	3.55	89	3.80
10,000 - 11,999	172	11.80	288	8.82	294	12.56
12,000 - 14,999	307	21.06	527	16.15	478	20.23
15,000 - 24,999	524	37.17	1253	38.39	661	28.23
25,000 - 49,999	94	6.45	506	15.50	160	6.83

	Sitka	Juneau	Ketchikan
Median Income	$14,091	$ 16,073	$ 12,816
Mean Income	14,399	18,093	13,333
Per Capita Income	3,899	5,053	3,720
Total Families	1458 (100.00)	3264 (100.00)	2342 (100.00)

Source: City and Borough of Sitka, Comprehensive Plan, November 1976.

September, 1977

TABLE W-4

GREEN LAKE PROJECT

EMPLOYMENT BY INDUSTRY

			1970		1976
1.	Commodity Producing	32.81%	828	34.15%	1040
	Agriculture, Forestry, Fishing		70		92
	Mining		5		8
	Construction		77		120
	Manufacturing		676		820
	Durable Goods	197		261	
	Non-durable Goods	479		559	
II.	Distributive	34.66%	875	32.02%	975
	Transportation		92		104
	Communication, Utilities		67		76
	Wholesale Trade		14		21
	Retail Trade		381		407
	Finance, Insurance, Real Estate		58		70
	Services		263		297
	Business & Repair	41		51	
	Personal	127		132	
	Private Medical	23		36	
	Private Educational	72		78	
III.	Government	32.53%	821	33.83%	1030
	Medical & Health		306		315
	Educational		214		240
	Other Professional		57		106
	Public Administration		244		369
	Federal	396		496	
	Stage	140		176	
	Local	285		358	
	TOTALS		2,524		3,045

Source: City and Borough of Sitka, Comprehensive Plan, November 1976.

GREEN LAKE PROJECT

CLIMATOLOGICAL SUMMARY(1)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Years
Mean Precipitation, Inches														
Baranof	14.25	11.37	13.09	11.12	7.34	4.09	4.05	6.28	12.80	25.80	21.96	20.05	152.20	23
Little Port Walter	20.36	15.54	16.29	13.53	11.61	7.56	9.37	13.83	22.26	35.13	29.18	25.17	219.83	24
Port Alexander	15.56	14.55	13.74	10.13	9.22	6.71	7.74	13.06	15.70	23.03	20.14	19.52	169.10	10
Sitka (Magnetic)	7.77	6.38	6.95	5.35	4.66	3.46	5.20	7.86	11.49	15.27	12.01	10.17	96.57	99
Mean Temperature, °F														
Baranof	28.6	29.7	33.7	38.5	44.5	51.2	54.3	54.3	50.2	43.0	36.2	31.5	41.3	21
Little Port Walter	32.6	33.1	35.6	39.7	45.5	51.2	54.9	54.8	50.9	44.9	38.7	34.6	43.0	24
Port Alexander	31.9	34.5	35.9	41.4	47.1	52.2	56.0	55.2	51.0	44.6	40.0	35.8	43.8	10
Sitka (Magnetic)	32.3	33.3	35.8	40.8	46.4	51.4	54.8	55.5	51.9	45.2	38.6	33.6	43.3	74
Normal Maximum Temperature, °F														
Baranof	33.2	34.9	39.8	45.3	52.4	58.8	61.0	60.4	55.5	47.7	40.3	35.5	47.1	20
Little Port Walter	36.3	37.0	40.0	45.0	51.7	57.6	60.8	60.5	55.8	48.9	42.4	38.3	47.9	24
Port Alexander	35.4	38.1	40.4	47.1	53.7	59.8	64.2	62.2	56.9	48.9	43.6	39.2	49.1	9
Sitka (Magnetic)	37.7	40.2	43.0	48.0	54.0	58.7	61.1	62.1	58.8	51.8	44.3	39.6	49.9	63
Normal Minimum Temperature, °F														
Baranof	24.0	24.5	27.6	31.5	36.5	43.6	47.8	48.1	44.8	38.3	32.0	27.6	35.5	20
Little Port Walter	28.9	29.2	31.1	34.3	39.3	44.7	48.9	49.0	46.0	40.8	35.0	31.0	38.2	24
Port Alexander	28.3	30.7	31.4	35.6	40.4	44.6	47.9	48.2	45.0	40.4	36.3	32.4	38.6	9
Sitka (Magnetic)	26.4	28.0	29.4	33.4	38.8	44.3	48.1	48.9	44.9	39.3	32.8	29.4	37.0	63
Mean Snowfall, Inches														
Baranof	51.3	46.0	39.2	7.1	0.5	0.0	0.0	0.0	0.0	0.7	19.5	50.0	214.3	15
Little Port Walter	30.4	32.7	23.1	5.2	0.1	T	0.0	0.0	T	0.5	0.8	25.7	125.7	24
Port Alexander	22.0	21.0	17.5	2.4	0.0	0.0	0.0	0.0	T	T	1.6	14.2	78.7	8
Sitka (Magnetic)	11.1	9.4	9.5	3.2	0.1	0.0	0.0	0.0	0.0	0.1	3.1	10.9	47.4	52
Prevailing Wind Direction														
Sitka (FAA)	ESE	SE	SE	SE	SE	NW	NW	NW	SE	SE	ESE	ESE	SE	N/A

(1) - See General References.

TABLE W-5

September, 1977

GREEN LAKE PROJECT

GREEN LAKE MONTHLY INFLOWS
(cfs)

YEAR	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	AVERAGE
1915-16*	452	510	573	487	188	117	23	73	41	116	283	568	286
1916-17*	445	499	564	471	210	97	82	120	50	74	310	475	283
1917-18*	491	526	620	652	636	78	127	40	18	75	296	582	345
1918-19*	600	489	492	420	378	190	231	38	15	126	255	358	299
1919-20*	488	452	500	392	181	128	217	83	27	41	172	479	263
1920-21*	445	437	330	282	254	74	64	112	58	69	285	542	246
1921-22*	387	309	416	571	160	293	91	36	27	83	352	466	266
1922-23*	462	500	551	246	400	82	31	110	117	219	341	510	297
1923-24*	390	250	648	292	484	182	98	119	90	159	479	688	323
1924-25*	674	539	698	437	285	162	34	25	50	86	474	520	332
1925-26	560	395	340	434	299	184	155	78	49	124	296	492	284
1926-27	484	441	547	400	276	169	143	72	46	114	273	454	285
1927-28	446	407	504	460	317	195	165	83	52	131	314	522	300
1928-29	512	468	580	458	316	194	164	82	52	131	313	520	316
1929-30	510	466	577	449	529	118	106	74	47	110	358	590	328
1930-31	590	480	553	484	570	127	115	80	51	118	386	636	349
1931-32	637	518	597	470	324	199	168	85	54	134	321	533	337
1932-33	524	478	592	398	215	90	53	100	47	83	286	517	282
1933-34	429	429	514	456	314	193	163	82	52	130	311	517	299
1934-35	508	464	575	523	616	138	124	86	55	128	417	687	360
1935-36	688	560	645	612	721	161	145	101	64	150	488	804	428
1936-37	805	655	754	614	723	162	145	101	65	150	490	807	456
1937-38	808	657	757	468	322	198	167	84	53	134	320	531	375
1938-39	521	476	590	502	592	132	119	83	53	123	401	660	354
1939-40	661	538	619	446	307	189	160	80	51	127	305	506	332
1940-41	497	453	562	319	172	72	42	80	37	67	229	414	245
1941-42	343	343	411	458	316	194	164	82	52	131	313	520	277
1942-43	510	466	577	432	298	183	155	78	49	123	295	490	305
1943-44	481	439	545	414	285	175	148	75	47	118	283	470	290
1944-45	461	421	522	449	529	118	106	74	47	110	358	590	315
1945-46	590	480	553	400	276	169	143	72	46	114	273	454	298
1946-47	446	407	504	517	610	136	123	85	54	127	413	680	342
1947-48	681	554	638	480	566	126	114	79	51	118	383	631	368
1948-49	632	514	592	497	586	131	118	82	52	122	397	653	365
1949-50	654	532	613	412	223	93	55	103	48	87	296	536	304
1950-51	444	444	532	277	150	63	37	69	32	58	199	360	222
1951-52	299	299	358	406	220	92	54	102	48	85	292	528	232
1952-53	438	438	524	478	329	202	171	86	54	137	327	542	311
1953-54	533	486	603	404	278	171	145	73	46	115	276	458	299
1954-55	450	411	509	442	305	187	158	80	50	126	302	501	293
1955-56	492	449	557	360	195	82	48	90	42	76	259	468	260
1956-57	388	388	465	404	278	171	145	73	46	115	276	458	267
AVERAGE	520	464	552	442	363	148	119	81	50	113	326	541	310

* Recorded flows. All others are synthesized.

September, 1977

TABLE W-(

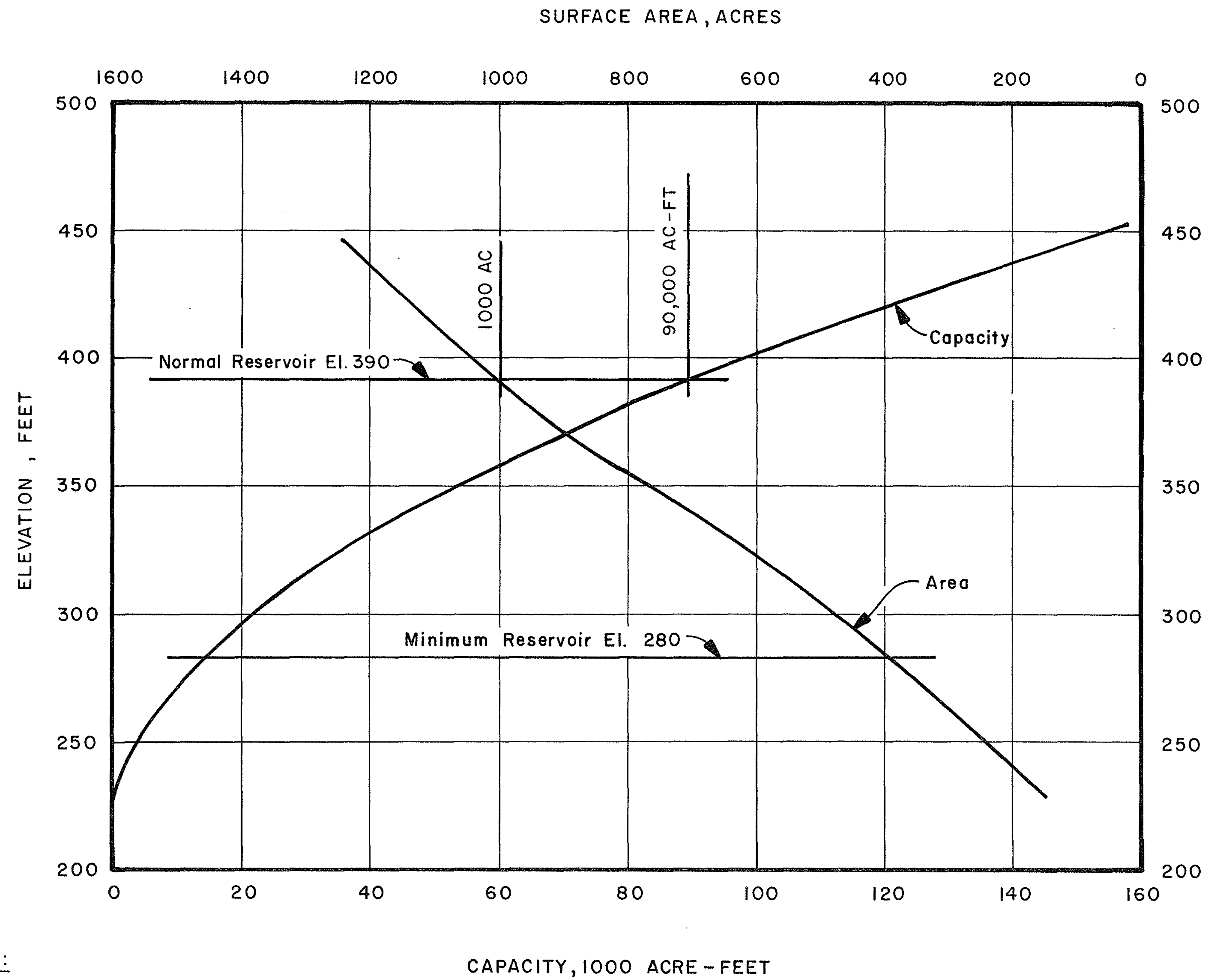
GREEN LAKE PROJECT

ALTERNATIVE PROJECT CHARACTERISTICS

	Takatz Lake	Carbon Lake	Green Lake
Drainage Area (mi^2)	10.6	26.6	28.2
Ave. Drainage Area El (MSL)	2,480	2,000	2,150
Ave. Annual Runoff (cfs)	166	444	310
Active Reservoir Storage (AF)...	82,400	53,000	74,000
Ave. Annual Regulated Discharge (cfs)	162	333	294
Average Head (ft.)	950(Net)	230(Gross)	349(Net)
Installed Generating Capacity (kW)	27,700	13,500	16,500
Capacity Delivered at Load Center (kW)	25,000	12,150	15,770
Average Annual Generation (kWh)	99,864,000	46,962,000	65,866,000
Ave. Annual Energy Delivered at Load Center (kWh)	93,330,000	43,674,000	64,900,000
Annual Plant Factor (at Plant)	0.41	0.40	0.45

Figures

GREEN LAKE PROJECT
RESERVOIR AREA-CAPACITY CURVE



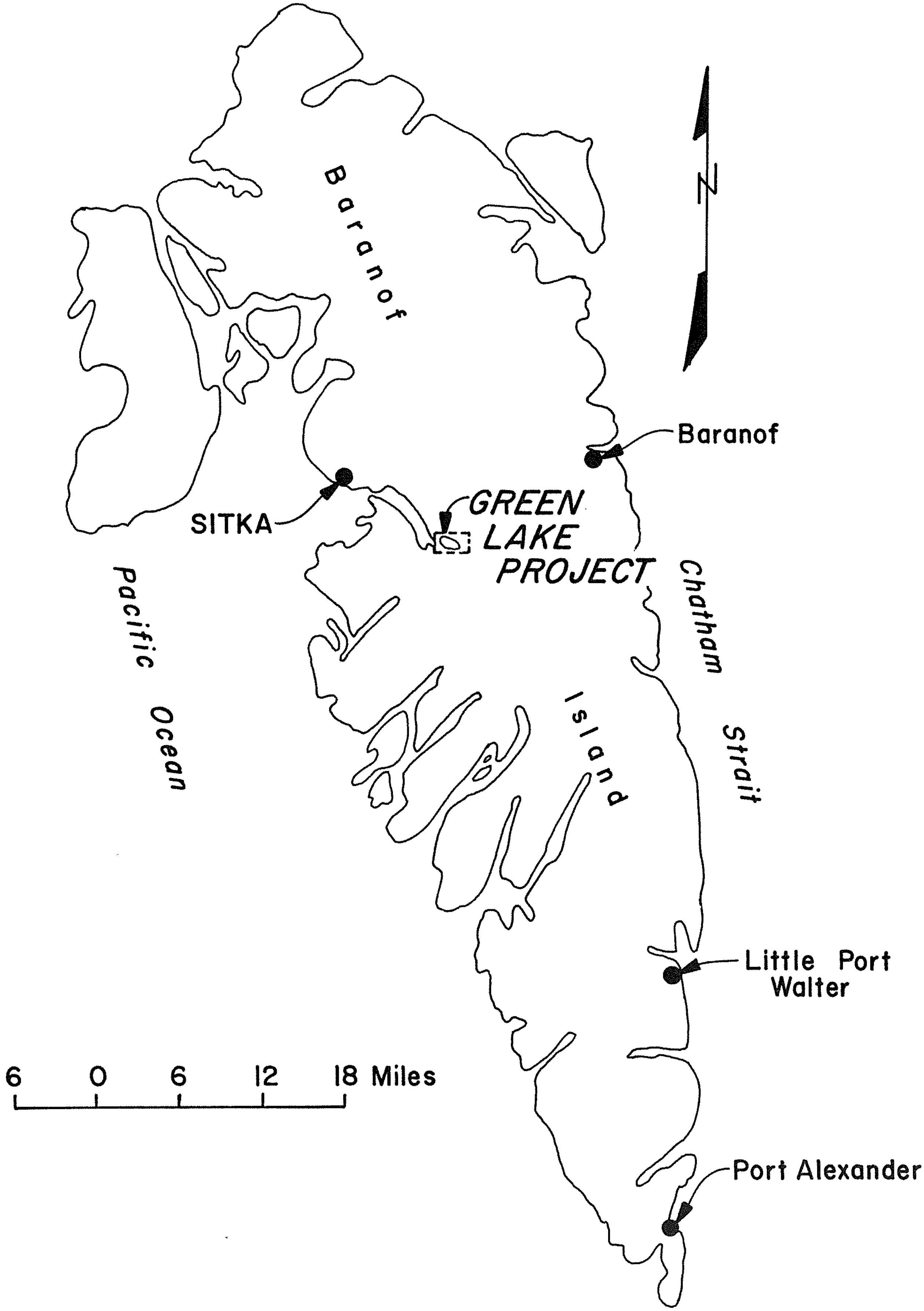
NOTES:

1. Based on topography prepared by H.G. Chickering, Jr., January 1975. Vertical and horizontal control based on U.S.G.S. Quadrangle control.
2. Elevations based on Mean Sea Level (MSL) datum.

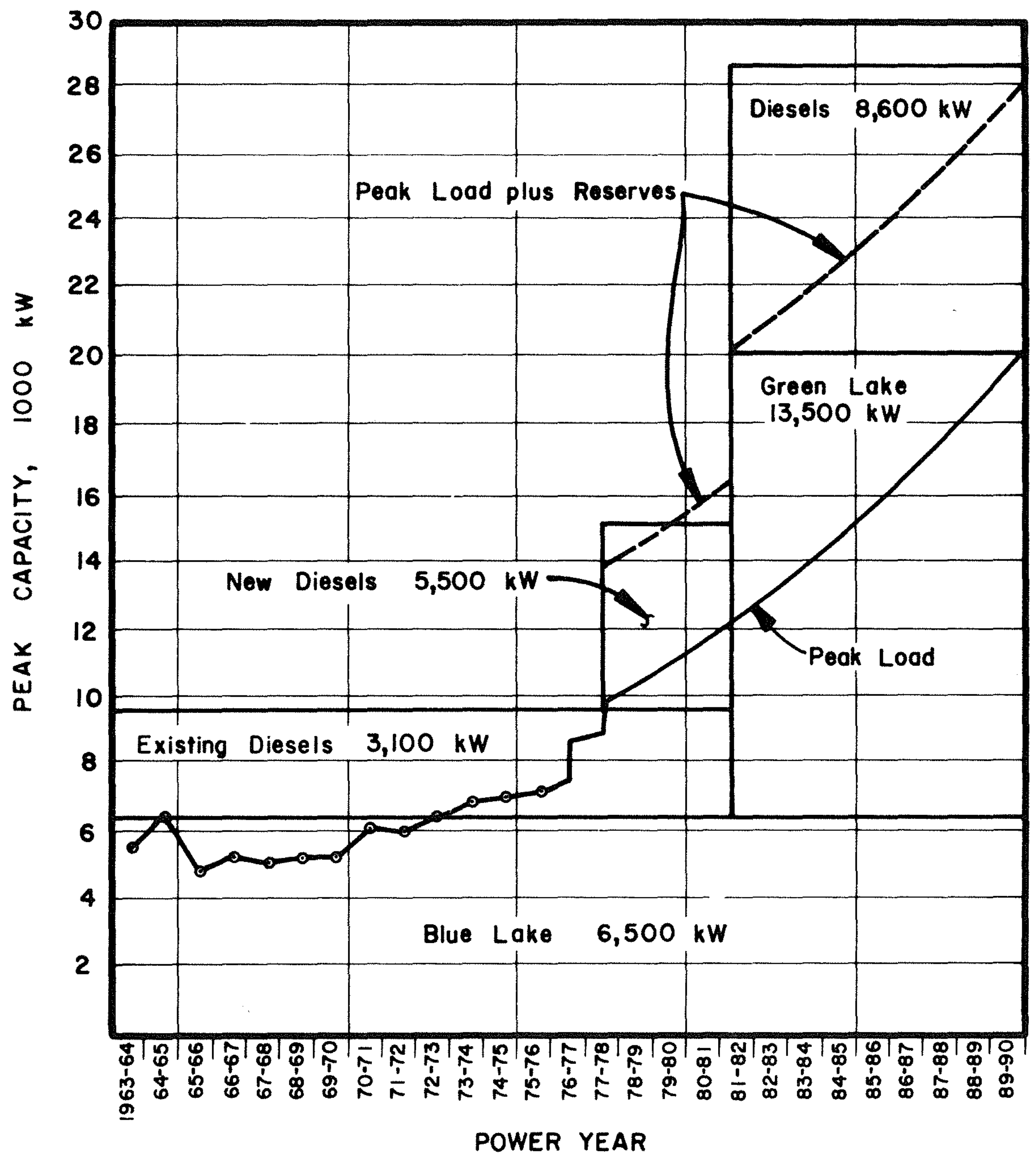
September, 1977

Figure W-2

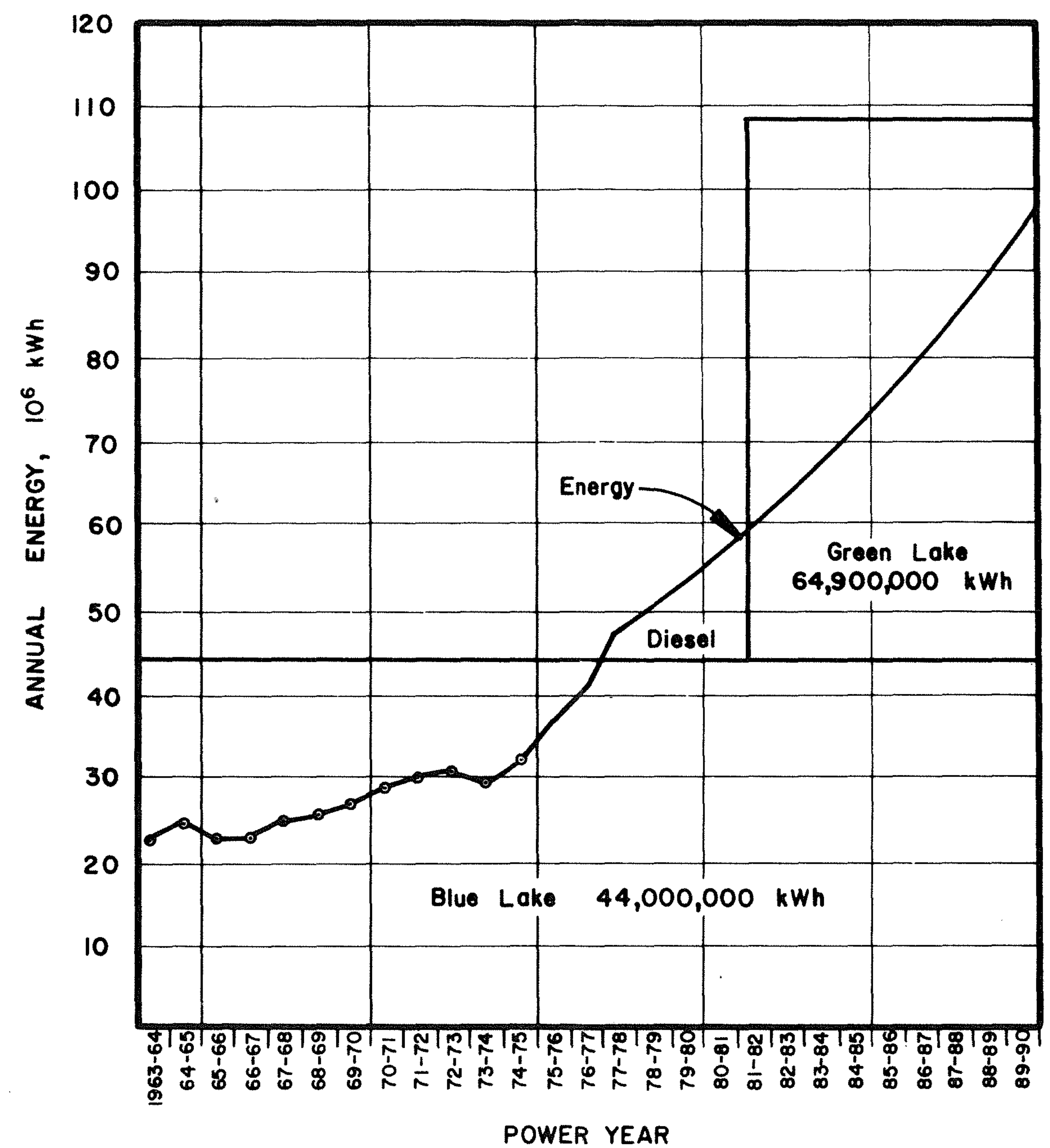
GREEN LAKE PROJECT
BARANOF ISLAND WEATHER STATIONS



GREEN LAKE PROJECT
LOADS AND RESOURCES



PEAK LOADS AT LOAD CENTER



ENERGY REQUIREMENTS AT LOAD CENTER

NOTES:

1. Hydroelectric plant energy is average annual delivered at load center.
2. Plant capacities are dependable delivered.
3. Power years extend from July 1 through June 30.
4. ⊖ indicates actual value.
5. Growth rate 6% for projected peak loads and energy requirements.

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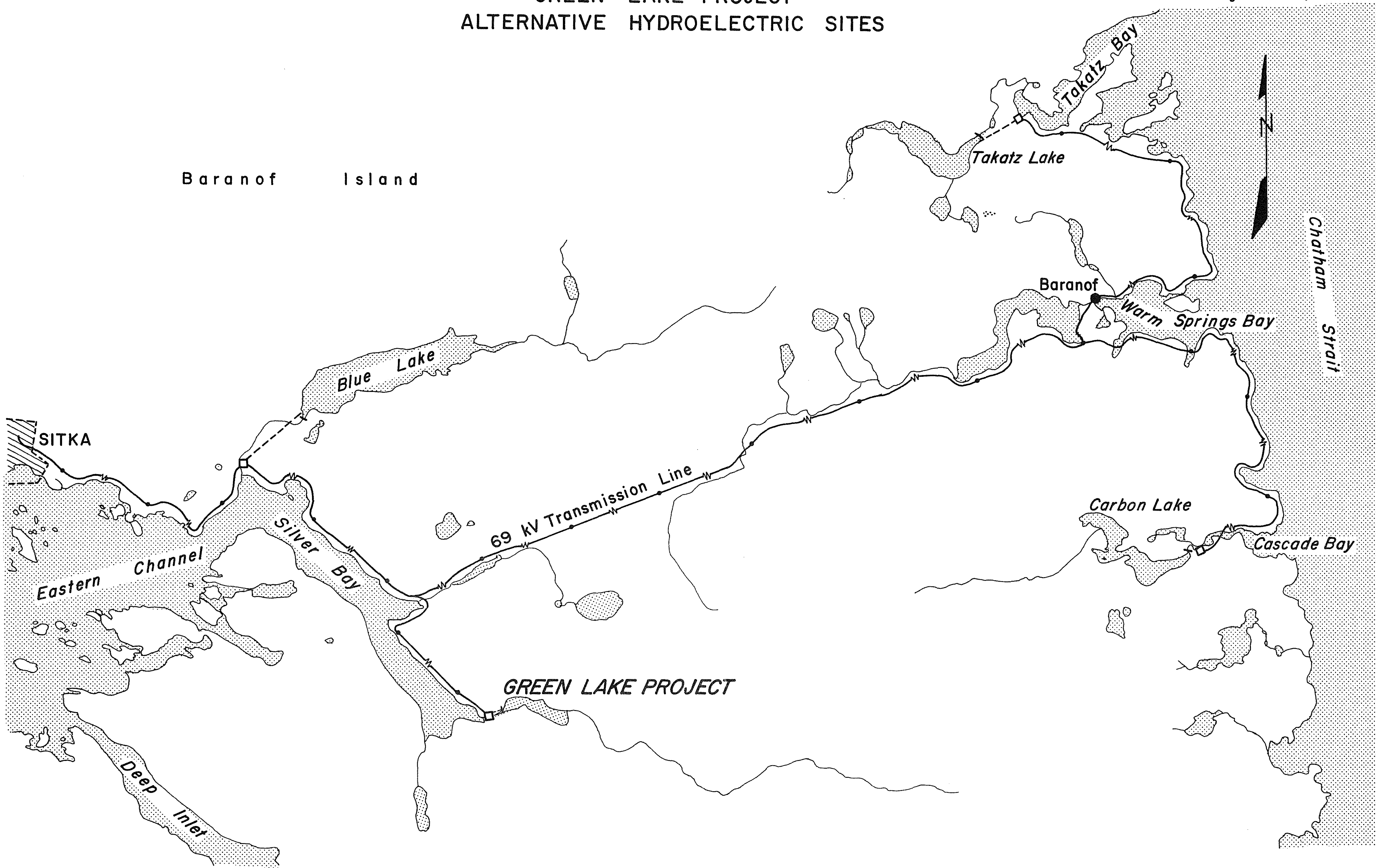
GREEN LAKE PROJECT
ALTERNATIVE HYDROELECTRIC SITES

Figure W-4



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Appendices

Appendix W - 1

Exhibit F

EXHIBIT F

SUMMARY OF THE NATURE AND EXTENT OF THE APPLICANT'S TITLE TO OR RIGHTS TO OCCUPY OR USE THE PRIVATE LANDS NECESSARY TO DEVELOP, OPERATE AND MAINTAIN THE PROJECT

The Applicant is acquiring title to approximately 5,700 acres of Tongass National Forest land upon which to develop the Project. The acquisition is authorized under Section 6(a) of the Alaska Statehood Act (PL 85-508), which allows for selection of national forest lands for economic development purposes. A full description of the lands being selected and the extent to which the Project will occupy those lands, is provided in Table F-1.

Upon completion of the selection and transfer of title to the Applicant, the Project will be located wholly on private lands owned by the Applicant. Full details of the selection will be submitted to the Commission in accordance with Commission regulations.

GREEN LAKE PROJECT

DESCRIPTION OF SELECTED AND PROJECT LANDS

Unsurveyed Lands
T.56S., R.64E, Copper River Meridian (CRM) Protracted.

Section	Aliquot Parts	Selected Acres	Project Acres	Exhibit
2	W-1/2 E-1/2, W-1/2	390	24	K-1
3	E-1/2, E-1/2 NW-1/2	190(1)	36(2)	K-1
11	E-1/2, NW-1/4	180	26	K-1
12	S-1/2 NW-1/4, SW-1/4 NW-1/4 SE-1/4, S-1/2 SE-1/4	325	13	K-1
13	E-1/2, N-1/2 NW-1/4	186	38	K-1, K-2
24	NE-1/4	40	12	K-2

T.56S., R.65E. CRM (Protracted).

Section	Aliquot Parts	Selected Acres	Project Acres	Exhibit
18	N-1/2, SW-1/4, NW-1/4 SE-1/4	503	17	K-2
19	SW-1/2 NE-1/4, W-1/2, SE-1/4	390	23	K-2
20	S-1/2 S-1/2	160	0	K-3
21	S-1/2 SW-1/4	80	4	K-3
26	NW-1/4 SW-1/4, S-1/2 SW-1/4, SW-1/4 SE-1/4	160	6	K-4
27	NW-1/4 NW-1/4, S-1/2 NW-1/4, S-1/2	440	233	K-3, K-4
28	All	560	325	K-3
29	All	609	142	K-3
30	N-1/2 NE-1/4 N-1/2 S-1/2 NE-1/4	40	16	K-2
33	NE-1/4 NE-1/4	40	2	K-3
34	NE-1/4, N-1/2 NW-1/4, SE-1/4 NW-1/4, NE-1/4 SE-1/4	320	151	K-3, K-4
35	N-1/2, N-1/2 SW-1/4, SE-1/4 SW-1/4, SE-1/4	600	366	K-4
36	W-1/2 NW-1/4, SW-1/4, W-1/2 SE-1/4	320	50	K-4

GREEN LAKE PROJECT

DESCRIPTION OF SELECTED AND PROJECT LANDS

Section	Aliquot Parts	Selected Acres	Project Acres	Exhibit
T.57S., R.66E., CRM (Protracted).				
3	NW-1/4 NW-1/4, W-1/2 NE-1/4 NW-1/4	60	0	K-4
4	N-1/2 NE-1/4, E-1/2 NE-1/4 NW-1/4	100	1	K-4

NOTES:

(1) Excluding U.S. Surveys 3551 and 3665.

(2) Including right-of-way through U.S. Surveys 3551 and 3665.

(3) All lands are unpatented, including U.S. Surveys, U.S. Mineral Surveys, islands, pinnacles and rocks, except as excluded above.

(4) Selected lands to contain 5,693 acres more or less.

(5) Elevations based on Mean Sea Level (MSL) datum.

Appendix W - 2

Exhibit H

EXHIBIT H

STATEMENT OF THE PROPOSED OPERATION OF THE PROJECT DURING PERIODS OF LOW, NORMAL AND FLOOD STREAMFLOWS

1. GENERAL

The proposed Green Lake Project is located near the outlet of the Green Lake-Vodopad River drainage, approximately 10 air miles southeast of Sitka, Alaska. The basin is elongated in shape, approximately 9.5 miles long by 4.5 miles wide and drains an area of 28.2 square miles. The mean basin elevation is about 2,150 feet (MSL) with extremes ranging from 230 feet (MSL) to over 4,000 feet (MSL) and slopes are typically fairly steep. Permanent snow or glacier cover only extends over an insignificant portion of the watershed.

The Vodopad River is the main watercourse in the basin and extends its full length. The gradient of the river is about 36% in the upper 1.9 miles and flattens to 3% in the lower 4.7 miles to Green Lake. From the lake, the river discharges into Silver Bay through a series of falls and rapids in a narrow canyon. The average annual streamflow was determined to be 310 cfs.

The basin shape, relatively steep and narrow, makes it especially responsive to runoff events. High runoff periods normally occur during the rainy fall months while low flow periods occur during winter and early spring months. Only a minor portion of the total runoff comes from glacier contribution.

A concrete arch dam in the narrow canyon at the mouth of Green Lake with the spillway crest at El 390 (MSL) will increase the surface area of the lake from its present size of 173 acres to the proposed 1,000 acres. This will provide an active storage capacity of 74,000 acre-feet which will allow about 95% regulation of the watershed runoff.

2. STREAMFLOW

Ten years of streamflow records from 1915 to 1925 are available for the Vodopad River. The average runoff from the historic records is 215,000 acre-feet per year and recorded daily flows range from a minimum of 10 cfs to a maximum of 3,300 cfs. Since the existing Vodopad River flow data form an insufficient period of record to conduct meaningful long-term operation studies, it was necessary to extend the available data by statistical means. The available data were extended to provide 42 years of streamflow by correlating flows at Green Lake Basin with those at nearby Blue Lake Basin as well as with long-term precipitation data at Sitka. A summary of the historical as well as synthesized flows is shown in Table H-1.

3. PROJECT OPERATION

The Project will be operated as a conventional hydroelectric plant. It will be operated in conjunction with the Blue Lake Project with Blue Lake being operated as a base load unit and Green Lake supplying the remainder of system requirements. The reservoir operation will be such that water will only be drawn from storage to deliver firm energy (see Table H-2) and secondary energy will be generated only at times when the reservoir is full and there is excess flow available. During years of high runoff little water will be drawn from storage and the reservoir will be at higher levels.

During low runoff years, the reservoir will be drawn down as required to deliver firm energy so that maximum reservoir drawdowns will occur during these adverse hydrological periods. The resulting pattern of reservoir fluctuation is illustrated graphically in Exhibit H-1 which shows envelopes of extremes of reservoir levels and the average reservoir levels, by month, for the flow data period studied.

4. FLOOD CONTROL

The reservoir will not be operated for flood control purposes. Accordingly, none of the active reservoir storage volume has been reserved for flood storage and the Project has been designed to safely pass all floods, up to and including the Probable Maximum Flood (PMF).

A flood with one-half the peak inflow and volume of the PMF, the Spillway Design Flood (SDF), will be contained within the ungated overflow spillway located in the dam crest. Larger floods will overtop the dam crest.

The PMF was developed using a synthesized unitgraph derived by Clark's method and applying the unitgraph to the Probable Maximum Precipitation (PMP) in combination with snowmelt for the area. Since the regional drainage characteristics have not been developed for the Green Lake Basin, an area near the Siskiyou Mountains in California, with basin characteristics similar to the Green Lake Basin, was used in the unitgraph derivation. Several methods were used to arrive at a time of concentration which was ultimately fixed at 2.5 hours. The unitgraph derived has a peak inflow of 3,060 cfs and a duration of 30 minutes.

The PMP was developed from information contained in Technical Paper No. 47.(1) The PMP included a compensating adjustment

(1) U.S. Department of Commerce, Technical Paper No. 47, "Probable Maximum Precipitation and Rainfall - Frequency Data for Alaska, for Areas to 400 Square Miles, Durations to 24-Hours, and Return Periods from 1 - 100 Years" 1963.

for drainage area size and resulted in a total rainfall of 29.2 inches over the 24-hour PMP storm period. Snowmelt contribution was derived from criteria developed by the Corps of Engineers[2] (Manual No. EM-1110-2-1406) and was calculated to be 5 inches during the 24-hour PMP storm period.

Runoff losses were assumed initially to be approximately equal to precipitation plus snowmelt contribution until the cumulative loss totaled 10% of the rainfall portion; thereafter a constant loss rate of 0.1 inches per hour was used for the remainder of the storm period. By this method the net excess precipitation was determined to be 28.73 inches.

The PMF has a peak inflow of 42,300 cfs and a volume of 43,000 acre-feet. Because of the infrequency of occurrence of the PMF, it was determined that a portion of this flood could be allowed to pass over the non-overflow portion of the dam crest and that the dam crest spillway section would be designed to pass a smaller more frequently occurring flood. With the reservoir at El 390 (MSL), the PMF flood inflow resulted in a peak routed discharge of 32,600 cfs and maximum reservoir surface of El 404.9 (MSL). This resulted in the non-overflow section of the dam being overtopped for about 15 hours. Because of the type of dam structure being used and the quality of the foundation rock, it was determined that nominal overtopping under these conditions could be tolerated without danger to the structure.

The Spillway Design Flood, one-half of the PMF, has a peak inflow of 21,150 cfs and a volume of 21,500 acre-feet. The flood would have an estimated return frequency of about once in

(2) U.S. Army Corps of Engineers, Division of Engineering and Design, Manual No. 1110-2-1406, "Runoff from Snowmelt", January 5, 1960.

5,000 years and when routed, resulted in a peak discharge of 11,000 cfs at reservoir El 399.3 (MSL). The hydrographs for the PMF and Spillway Design Flood are shown in Exhibit H-2.

5. IRRIGATION, MUNICIPAL AND DOMESTIC WATER SUPPLY

No use of the project waters is anticipated for irrigation or water supply.

6. NAVIGATION

The Project will have no effect on commercial navigation since there is none on the Vodopad River or Green Lake. The Vodopad River is not classified as navigable by the U.S. Army Corps of Engineers. The magnitude of the discharge velocity, which will be a maximum of approximately 7 fps during project operation, will not be of an order great enough to present a hazard to navigation in Silver Bay. Resulting turbulence is expected to be minimal.

7. WATER QUALITY

a. Introduction

This section of the Exhibit will discuss the probable effects of the Green Lake Project operation on the water quality of Green Lake and Silver Bay. Construction related impacts on water quality are specifically discussed in Exhibit W, Sections 3 and 4.

While specific effects on water quality as a result of the impoundment are difficult to predict, some conclusions concerning potential and probable effects can be drawn by using the Blue Lake Project (FPC Project No. 2230) as a model.

b. Blue Lake Project

The Blue Lake Project, a conventional hydroelectric development similar in scope to the Green Lake Project and located about eight miles north of Green Lake, was completed and operational in 1961. A chemical similarity between the two lakes was shown in a 1974 limnological study by the Alaska Department of Fish and Game.[3] Table H-3 illustrates the physical similarity between Blue Lake and the proposed Green Lake Reservoir. A geological and hydrological similarity may be inferred from the relative proximity of the two lakes and similar mean basin elevations. For these reasons Blue Lake is felt to provide an excellent model of the effects on water quality by the Green Lake Reservoir.

c. Effects of Impoundment

The following effects are considered probable either by reason of simple physical effects of the impoundment or by use of the Blue Lake model.

The degree of thermal stratification in the Green Lake Reservoir can be expected to increase with an attendant drop in atmospheric reaeration as a result of increased depth and reduced velocities in the reservoir. The limnological study indicates a marked thermal stratification in Blue Lake was apparent by late August after being isothermal in May.

A shallow bar (1 to 3 feet below the present surface of Green Lake) separates the lake into east and west basins. Circulation within the lake should greatly improve as a result of the "elimination" of the two-basin effect.

(3) Water Resources in Alaska, "Limnological Investigations of Six Lakes in Southeast Alaska", WRI 76-122, prepared by the U.S. Department of the Interior, Geological Survey in Cooperation with the Alaska Department of Fish and Game.

Although the limnological study of Green Lake indicates low turbidity, natural levels increase markedly under certain conditions. Specific sightings by Artwin Schmidt (Sept. 14-15, 1975) and R. W. Beck personnel (Oct., 1976) have shown pronounced turbidity in Silver Bay and Green Lake after periods of heavy rains. This turbidity is felt to be caused by silt from stream scouring in the Vodopad River Valley during periods of high runoff. This turbidity during these periods is felt to be short-term, up to several days, due to the low retention time in Green Lake and flushing action of the tidal flow in Silver Bay.

A beneficial effect on water quality as a result of impoundment will be a reduction of this turbidity due to the inundation of much of the silt producing areas along the Vodopad River Valley. Sediments flowing into the Green Lake Reservoir will most likely settle there due to the lower velocities and longer detention time in the reservoir. However, the volume of silt flowing into the proposed reservoir is expected to be small and will not have any adverse effect on project operation.

"The relative productivity of Green Lake is expected to increase temporarily as decomposing organic material creates additional nutrients to serve as a food source for the resident brook trout population. Blue Lake showed an increased productivity for a period of about 10 years before stabilizing at a comparatively low nutrient level. A similar evolution in productive capacity can be anticipated for the proposed Green Lake Reservoir."[4]

(4) Investigation of the Biotic Communities in the Vicinity of Green Lake, Baranof Island, Alaska, Prepared for R. W. Beck and Associates, Inc., by Dr. David T. Hoopes, July 15, 1977.

d. Silver Bay

Turbidity during construction is expected to be the major project-related effect on the water quality in Silver Bay. Turbidity will exceed State limits for short periods of time during construction. The Applicant is aware of the effects of excessive turbidity on sight-feeding aquatic life and birds and measures will be taken to lessen the impact of turbidity (see Exhibit W, Sections 3 and 4). However, no permanent damage to either population is expected.

Project operation is expected to have little or no effect on the water quality or thermal regime of Silver Bay.

e. Conclusion

No significant adverse effect on the water quality of either Green Lake or Silver Bay is expected to result from the operation of the Green Lake Project. The continued operation of the Blue Lake Project with no deterioration of water quality is considered to provide adequate evidence of that conclusion and no further water quality monitoring is considered necessary or justified.

8. RECREATION

The effects of project operation on recreation in the area are described in Exhibits R and W.

9. FISH AND WILDLIFE

The effects of project construction and operation on the fish and wildlife resources in the area are described in Exhibit W.

10. CONSULTATION WITH FEDERAL, STATE AND LOCAL AGENCIES HAVING RESPONSIBILITY FOR WATER QUALITY CONTROL

The following consultations with Federal, State and local agencies were conducted with regard to water for the Project:

(1) <u>U.S. Army Corps of Engineers (COE), Alaska District</u>

Date/Time: March 8, 1977/10:00 a.m.
Type: Meeting
Participants: R. W. Beck and Associates, Inc. (RWB) representing the City and Borough of Sitka.
Steen and Matlock, Inc., Access Road Consultants
Subjects discussed: Section 10 of River and Harbor Act of 1899
Section 404 of Federal Water Pollution Control Act (FWPCA)
Section 401 of FWPCA

Date: April 14, 1977
Type: Meeting
Participants: RWB representing City and Borough of Sitka
Steen & Matlock, Inc.
Subjects discussed: Section 10 of River and Harbor Acts
Section 404 of FWPCA
Section 401 of FWPCA

(2) <u>Environmental Protection Agency, Region X, Alaska Operations Office (EPA)</u>

Date: April 14, 1977
Type: Meeting

Participants: RWB representing the City and Borough of Sitka
Steen & Matlock, Inc.

Subjects discussed: National Pollution Discharge Elimination System (NPDES)

Date: April 15, 1977
Type: Telephone Conference
Participants: RWB representing the City and Borough of Sitka
Subjects discussed: Effects of construction on water quality in the project area.

(3) Alaska Division of Lands and Water Management (ADL)

Date: March 9, 1977
Type: Meeting
Participants: RWB representing the City and Borough of Sitka,
Steen & Matlock, Inc.
Subjects discussed: Water Rights Application
State Tidelands Permit
Access to Navigable or Public Waters
Section 401 of FWPCA

(4) Alaska Department of Environmental Conservation

Date: April 14, 1977
Type: Telephone Conference
Participants: RWB representing the City and Borough of Sitka
Subjects discussed: Current water quality studies and the effects of construction on the project area waters.

(5) Alaska Department of Fish and Game

Date: December 16, 1976
Type: Telephone Conference
Participants: RWB representing the City and Borough of Sitka
Subjects discussed: Limnological data available for Green Lake

Date: March 18, 1977
Type: Telephone Conference
Participants: RWB representing City and Borough of Sitka
Subject discussed: Title 16 Permit

11. UTILIZATION OF THE RESOURCE

The Project as described herein, will fully develop and utilize the water resource in the best public interest for power, recreation and fish and wildlife purposes. Exhibit I describes the power development; Exhibits R and S describe the recreational and fish and wildlife plans respectively, associated with this project development. The fullest practicable utilization of the streamflow and head available will be accomplished by this Project.

GREEN LAKE PROJECT

GREEN LAKE MONTHLY INFLOWS
(cfs)

YEAR	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	AVERAGE
1915-16*	452	510	573	487	188	117	23	73	41	116	283	568	286
1916-17*	445	499	564	471	210	97	82	120	50	74	310	475	283
1917-18*	491	526	620	652	636	78	127	40	18	75	296	582	345
1918-19*	600	489	492	420	378	190	231	38	15	126	255	358	299
1919-20*	488	452	500	392	181	128	217	83	27	41	172	479	263
1920-21*	445	437	330	282	254	74	64	112	58	69	285	542	246
1921-22*	387	309	416	571	160	293	91	36	27	83	352	466	266
1922-23*	462	500	551	246	400	82	31	110	117	219	341	510	297
1923-24*	390	250	648	292	484	182	98	119	90	159	479	688	323
1924-25*	674	539	698	437	285	162	34	25	50	86	474	520	332
1925-26	560	395	340	434	299	184	155	78	49	124	296	492	284
1926-27	484	441	547	400	276	169	143	72	46	114	273	454	285
1927-28	446	407	504	460	317	195	165	83	52	131	314	522	300
1928-29	512	468	580	458	316	194	164	82	52	131	313	520	316
1929-30	510	466	577	449	529	118	106	74	47	110	358	590	328
1930-31	590	480	553	484	570	127	115	80	51	118	386	636	349
1931-32	637	518	597	470	324	199	168	85	54	134	321	533	337
1932-33	524	478	592	398	215	90	53	100	47	83	286	517	282
1933-34	429	429	514	456	314	193	163	82	52	130	311	517	299
1934-35	508	464	575	523	616	138	124	86	55	128	417	687	360
1935-36	688	560	645	612	721	161	145	101	64	150	488	804	428
1936-37	805	655	754	614	723	162	145	101	65	150	490	807	456
1937-38	808	657	757	468	322	198	167	84	53	134	320	531	375
1938-39	521	476	590	502	592	132	119	83	53	123	401	660	354
1939-40	661	538	619	446	307	189	160	80	51	127	305	506	332
1940-41	497	453	562	319	172	72	42	80	37	67	229	414	245
1941-42	343	343	411	458	316	194	164	82	52	131	313	520	277
1942-43	510	466	577	432	298	183	155	78	49	123	295	490	305
1943-44	481	439	545	414	285	175	148	75	47	118	283	470	290
1944-45	461	421	522	449	529	118	106	74	47	110	358	590	315
1945-46	590	480	553	400	276	169	143	72	46	114	273	454	296
1946-47	446	407	504	517	610	136	123	85	54	127	413	680	342
1947-48	681	554	638	480	566	126	114	79	51	118	383	631	368
1948-49	632	514	592	497	586	131	118	82	52	122	397	653	365
1949-50	654	532	613	412	223	93	55	103	48	87	296	536	304
1950-51	444	444	532	277	150	63	37	69	32	58	199	360	222
1951-52	299	299	358	406	220	92	54	102	48	85	292	528	232
1952-53	438	438	524	478	329	202	171	86	54	137	327	542	311
1953-54	533	486	603	404	278	171	145	73	46	115	276	458	299
1954-55	450	411	509	442	305	187	158	80	50	126	302	501	293
1955-56	492	449	557	360	195	82	48	90	42	76	259	468	260
1956-57	388	388	465	404	278	171	145	73	46	115	276	458	257
AVERAGE	520	464	552	442	363	148	119	81	50	113	326	541	310

* Recorded flows. All others are synthesized

GREEN LAKE PROJECT

FIRM ENERGY DELIVERED BY MONTH

Month	Firm Energy Delivered, kWh
July	2,982,000
August	3,065,000
September	3,162,000
October	3,566,000
November	3,669,000
December	4,039,000
January	4,090,000
February	3,283,000
March	3,783,000
April	3,365,000
May	3,305,000
June	2,926,000

NOTE: Firm energy based on power studies using historic and synthetic streamflow (Table H-1) and having a 1 in 42-year frequency.

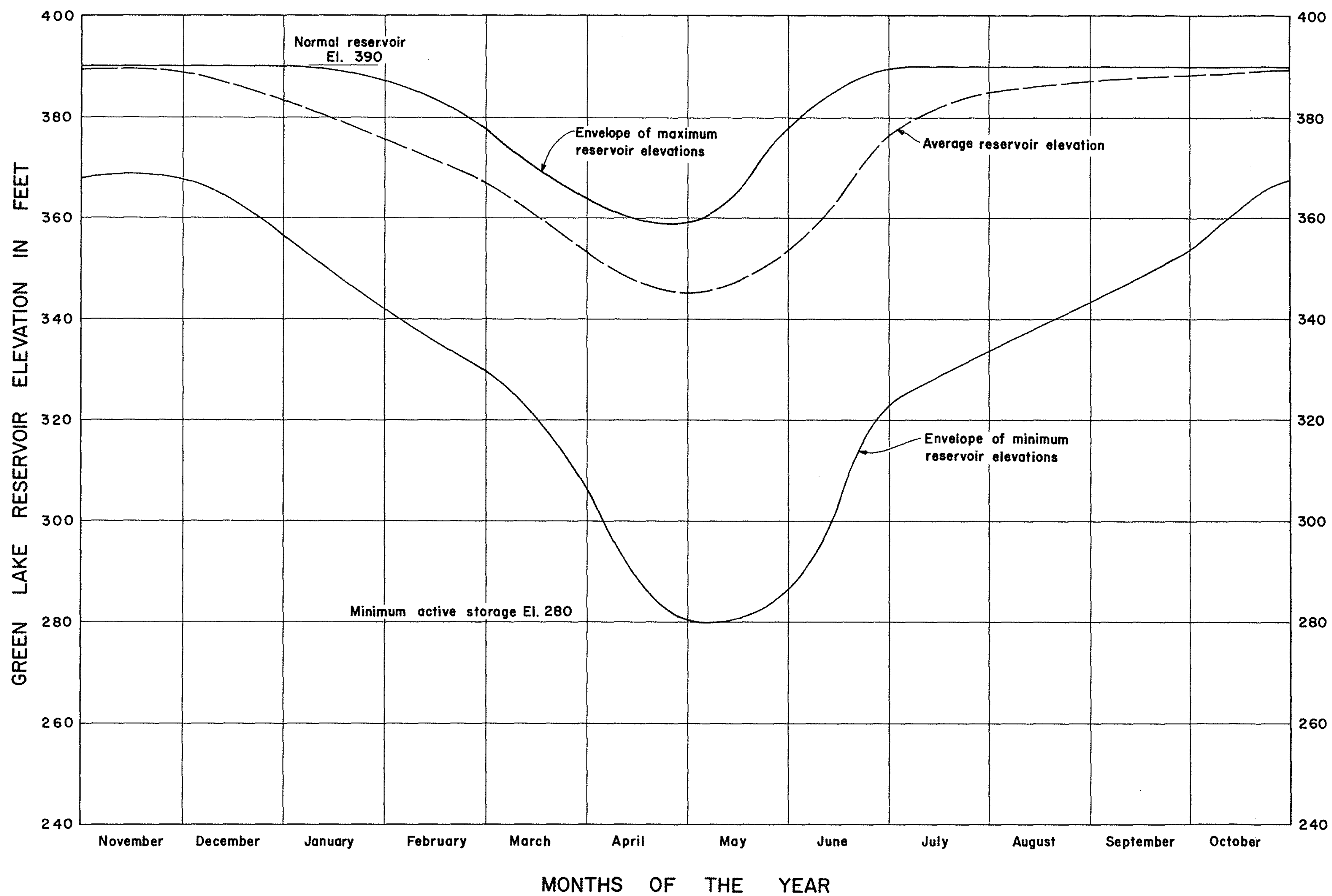
TABLE H-3

GREEN LAKE PROJECT
RESERVOIR PHYSICAL CHARACTERISTICS

Feature	Blue Lake Reservoir	Green Lake Reservoir
Maximum depth	463 feet	246 feet
Average depth	171 feet	200 feet
Drainage area	37 square miles	28.2 square miles
Surface area	1,334 acres	1,000 acres
Volume	227,800 acre-feet	97,000 acre-feet
Altitude	350 feet (MSL)	390 feet (MSL)

NOTE: All data based on normal reservoir elevations of 350 feet (MSL) for Blue Lake and 390 feet (MSL) for Green Lake.

September, 1977



NOTES:

1. Curves show results of reservoir operation studies based on historical load data for Sitka and recorded and synthesized streamflow data for the Vodopad River. Study period from 1916 – 1957.
2. Recorded streamflow data from U.S.G.S. Water Supply Paper Volume 1372, Gage 37 "Green Lake Outlet near Sitka" water years 1916-1925.
3. Synthesized streamflows developed from (a) precipitation data at Sitka from Climatic Summary of the United States, Alaska; Bulletin W, and Bulletin W Supplements for 1931-1952 and 1951-1960, U.S. Weather Bureau, and (b) streamflow data on Sawmill Creek from U.S.G.S. Water Supply Papers Volumes 1372 and 1740, Gage 36 and 880 "Sawmill Creek near Sitka" water years 1920-1922, 1928-1942 and 1946-1957.
4. Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY (ADMINISTRATOR)

CONSULTING ENGINEER:
R.W. BECK & ASSOCIATES, INC.
SEATTLE, WASHINGTON

APPROVED BY

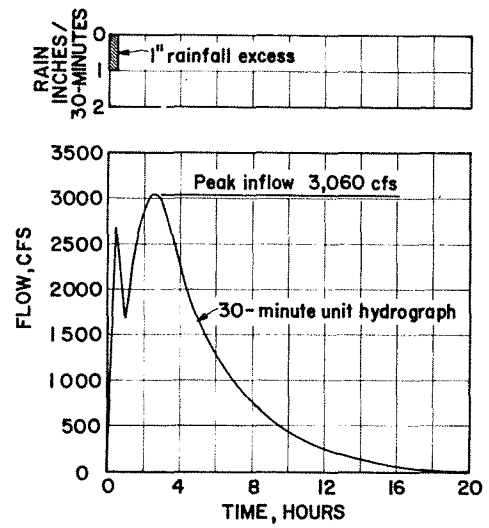
DATE September 6, 1977

DRAWING NO. 462-P-1

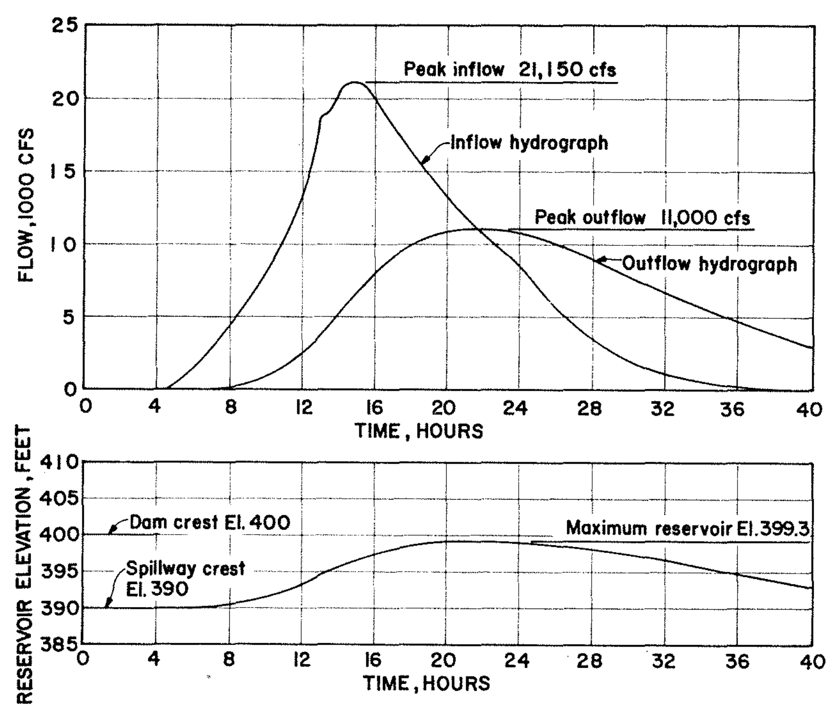
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA

EXHIBIT H-1

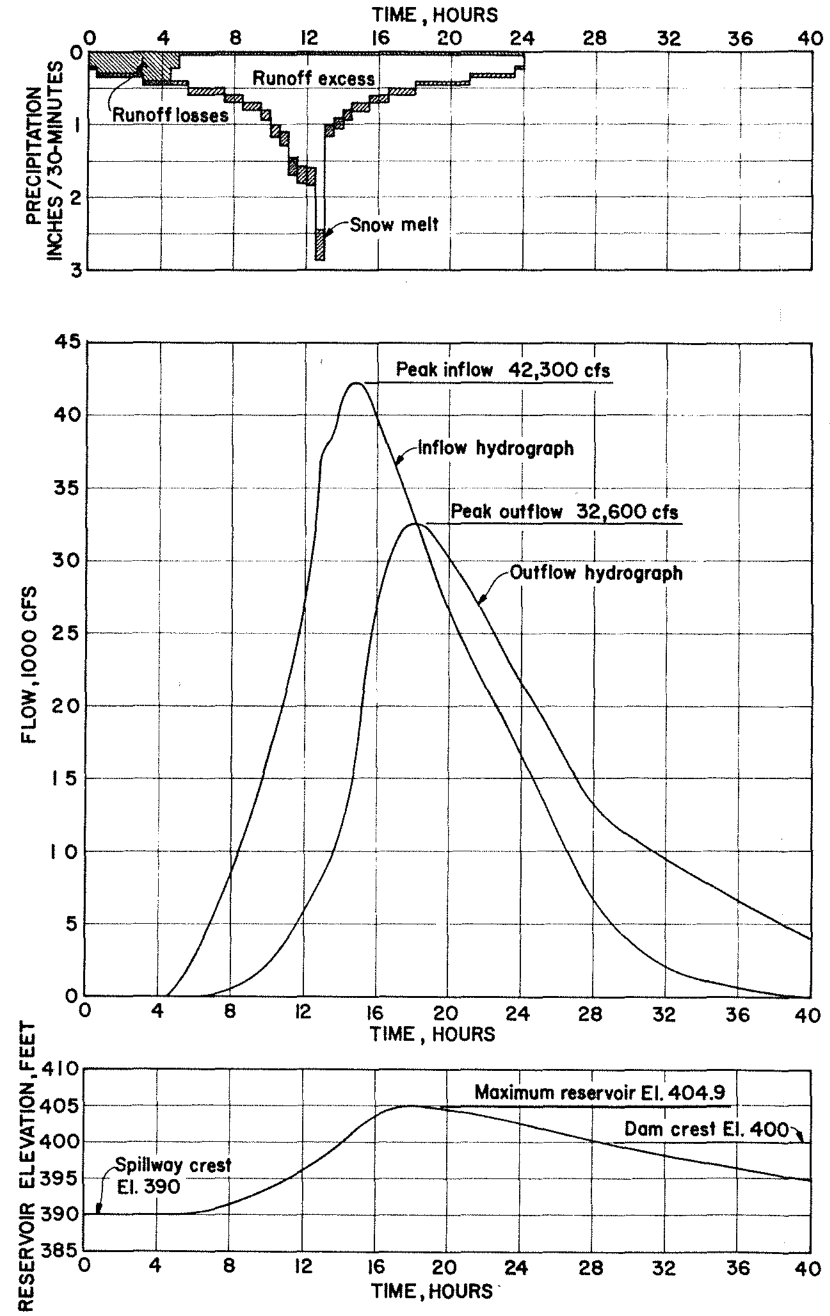
GREEN LAKE RESERVOIR
OPERATION STUDY RESULTS



ONE-HALF HOUR UNIT HYDROGRAPH



SPILLWAY DESIGN FLOOD



PROBABLE MAXIMUM FLOOD

NOTES:

1. Probable maximum flood was derived using probable maximum precipitation from U.S. Weather Bureau Technical Paper 47 and the Corps of Engineers snowmelt formula from Manual No. EM 1110-2-1406.
2. Spillway Design Flood inflow is one half probable maximum flood.
3. Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977
BY [signature]
(ADMINISTRATOR)

CONSULTING ENGINEER:
R.W. BECK & ASSOCIATES, INC.
SEATTLE, WASHINGTON
APPROVED BY [signature]
DATE September 6, 1977
DRAWING NO. 462-P-2

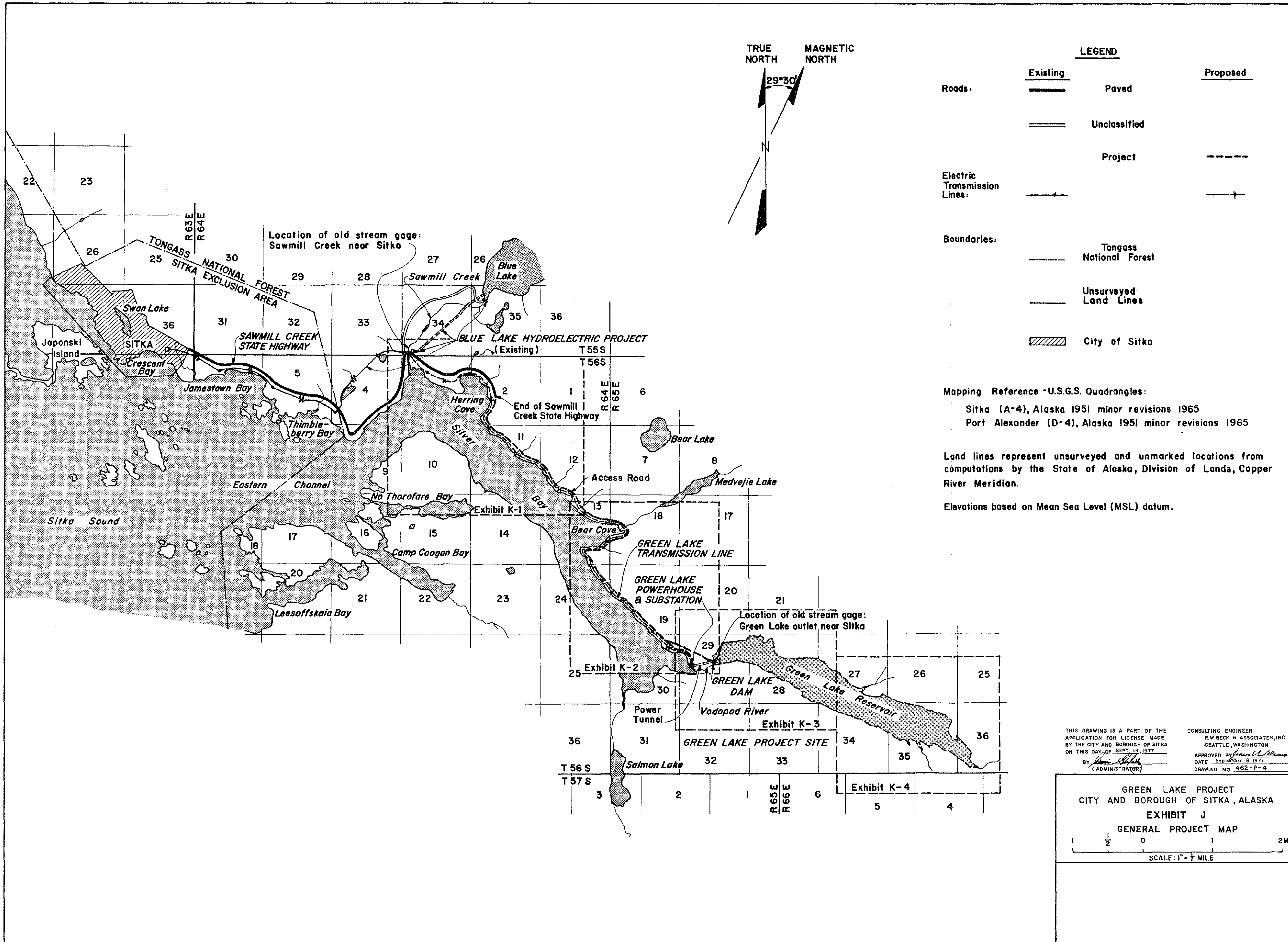
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA

EXHIBIT H-2

FLOOD HYDROGRAPHS

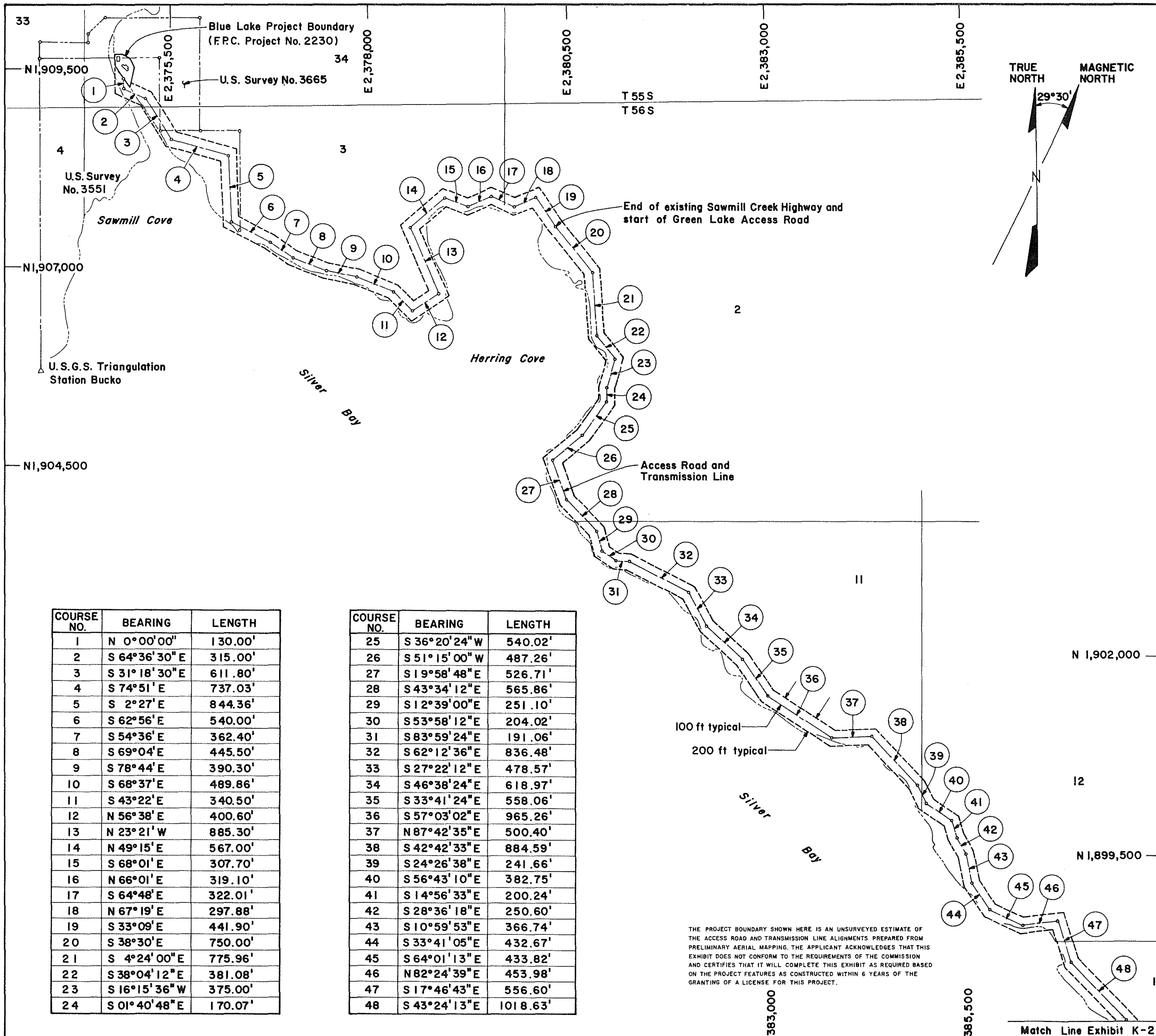
Appendix W - 3

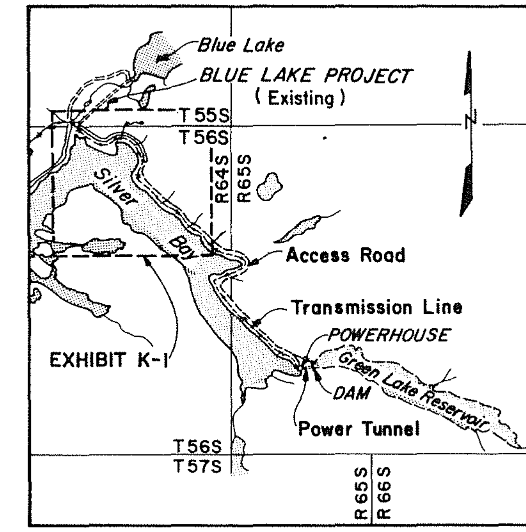
Exhibit J


TRUE NORTH
MAGNETIC NORTH
29°30'
N
LEGEND
Existing
Proposed
Roads:
Paved
Unclassified
Project
Electric Transmission Lines:
Boundaries:
Tongass National Forest
Unsurveyed Land Lines
City of Sitka
Mapping Reference - U.S.G.S. Quadrangles:
Sitka (A-4), Alaska 1951 minor revisions 1965
Port Alexander (D-4), Alaska 1951 minor revisions 1965
Land lines represent unsurveyed and unmarked locations from computations by the State of Alaska, Division of Lands, Copper River Meridian.
Elevations based on Mean Sea Level (MSL) datum.
TONGASS NATIONAL FOREST
SITKA EXCLUSION AREA
Location of old stream gage: Sawmill Creek near Sitka
Sawmill Creek
Blue Lake
BLUE LAKE HYDROELECTRIC PROJECT (Existing)
SAWMILL CREEK STATE HIGHWAY
Swan Lake
Japonski Island
SITKA
Crescent Bay
Jamestown Bay
Thimbleberry Bay
Herring Cove
End of Sawmill Creek State Highway
Silver Bay
Bear Lake
Medvejie Lake
Access Road
Eastern Channel
No Thorofare Bay
Exhibit K-1
Sitka Sound
Bear Cove
GREEN LAKE TRANSMISSION LINE
Camp Coogan Bay
GREEN LAKE POWERHOUSE & SUBSTATION
Leesoffskaia Bay
Location of old stream gage: Green Lake outlet near Sitka
Exhibit K-2
GREEN LAKE DAM
Green Lake Reservoir
Power Tunnel
Vodopad River
Exhibit K-3
GREEN LAKE PROJECT SITE
Salmon Lake
Exhibit K-4
R63E R64E
R64E R65E
R65E R66E
T55S T56S
T56S T57S
THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977
BY (ADMINISTRATOR)
CONSULTING ENGINEER: R.W. BECK & ASSOCIATES, INC. SEATTLE, WASHINGTON
APPROVED BY
DATE September 6, 1977
DRAWING NO. 462-P-4
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT J
GENERAL PROJECT MAP
1 ½ 0 1 2 Miles
SCALE: 1" = ½ MILE

Appendix W - 4

Exhibit K





KEY MAP

1 0 1 Mile
Scale

COURSE NO.	BEARING	LENGTH
1	N 0°00'00"	130.00'
2	S 64°36'30" E	315.00'
3	S 31°18'30" E	611.80'
4	S 74°51' E	737.03'
5	S 2°27' E	844.36'
6	S 62°56' E	540.00'
7	S 54°36' E	362.40'
8	S 69°04' E	445.50'
9	S 78°44' E	390.30'
10	S 68°37' E	489.86'
11	S 43°22' E	340.50'
12	N 56°38' E	400.60'
13	N 23°21' W	885.30'
14	N 49°15' E	567.00'
15	S 68°01' E	307.70'
16	N 66°01' E	319.10'
17	S 64°48' E	322.01'
18	N 67°19' E	297.88'
19	S 33°09' E	441.90'
20	S 38°30' E	750.00'
21	S 4°24'00" E	775.96'
22	S 38°04'12" E	381.08'
23	S 16°15'36" W	375.00'
24	S 01°40'48" E	170.07'

COURSE NO.	BEARING	LENGTH
25	S 36°20'24" W	540.02'
26	S 51°15'00" W	487.26'
27	S 19°58'48" E	526.71'
28	S 43°34'12" E	565.86'
29	S 12°39'00" E	251.10'
30	S 53°58'12" E	204.02'
31	S 83°59'24" E	191.06'
32	S 62°12'36" E	836.48'
33	S 27°22'12" E	478.57'
34	S 46°38'24" E	618.97'
35	S 33°41'24" E	558.06'
36	S 57°03'02" E	965.26'
37	N 87°42'35" E	500.40'
38	S 42°42'33" E	884.59'
39	S 24°26'38" E	241.66'
40	S 56°43'10" E	382.75'
41	S 14°56'33" E	200.24'
42	S 28°36'18" E	250.60'
43	S 10°59'53" E	366.74'
44	S 33°41'05" E	432.67'
45	S 64°01'13" E	433.82'
46	N 82°24'39" E	453.98'
47	S 17°46'43" E	556.60'
48	S 43°24'13" E	1018.63'

THE PROJECT BOUNDARY SHOWN HERE IS AN UNSURVEYED ESTIMATE OF THE ACCESS ROAD AND TRANSMISSION LINE ALIGNMENTS PREPARED FROM PRELIMINARY AERIAL MAPPING. THE APPLICANT ACKNOWLEDGES THAT THIS EXHIBIT DOES NOT CONFORM TO THE REQUIREMENTS OF THE COMMISSION AND CERTIFIES THAT IT WILL COMPLETE THIS EXHIBIT AS REQUIRED BASED ON THE PROJECT FEATURES AS CONSTRUCTED WITHIN 6 YEARS OF THE GRANTING OF A LICENSE FOR THIS PROJECT.

LEGEND

- (5) Course number
- Access road base line
- Project boundary
- U.S. survey boundaries
- Unsurveyed land lines
- 12 Section number
- Shoreline

NOTES:

1. Land lines represent unsurveyed and unmarked locations from computations by the State of Alaska, Division of Lands, Copper River Meridian taken from U.S.G.S. 1:63,360 topographic series.
2. Grid based on Alaska coordinate system, zone I.
3. Shoreline from topography prepared by H.G. Chickering, Jr., January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
4. Elevations based on Mean Sea Level (MSL) datum.

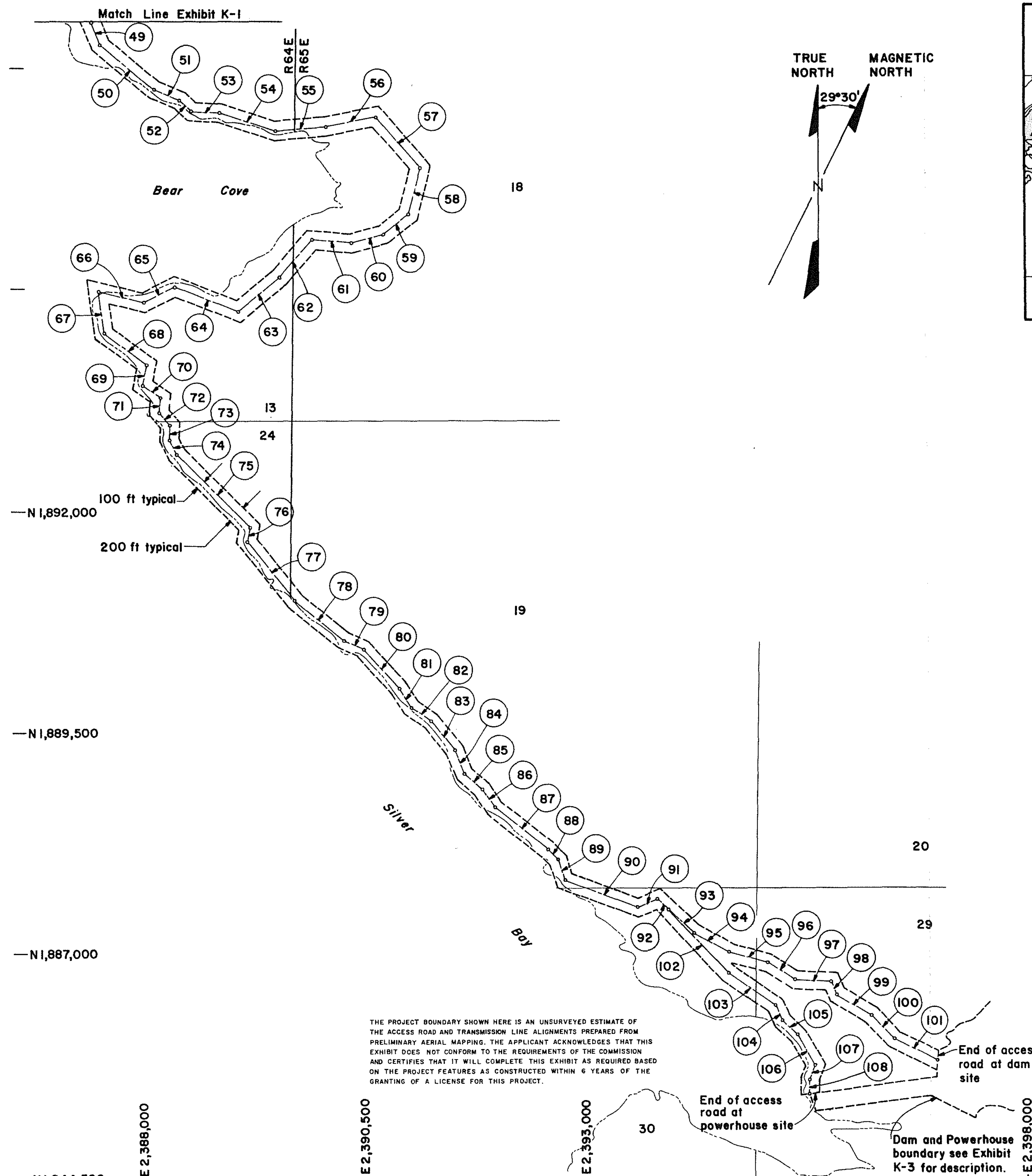
THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977
BY [signature]
(ADMINISTRATOR)

CONSULTING ENGINEER:
R. W. BECK & ASSOCIATES, INC.
SEATTLE, WASHINGTON
APPROVED BY [signature]
DATE September 6, 1977
DRAWING NO. 462-P-5

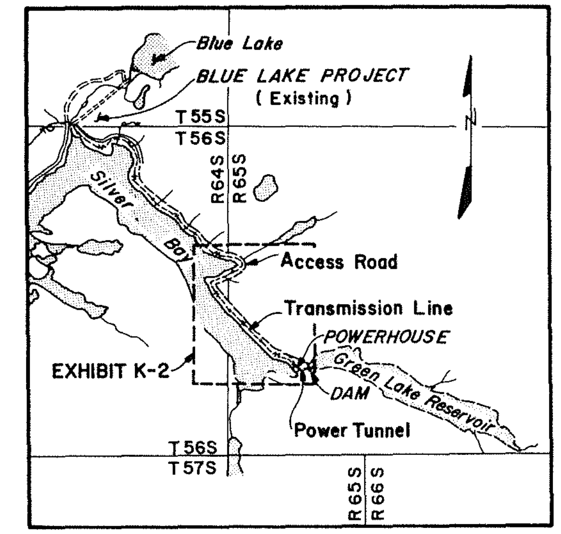
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT K-I
PROJECT BOUNDARY

500' 0 500' 1000' 1500' 2000' 2500'
SCALE: 1" = 500'

COURSE NO.	BEARING	LENGTH
49	S 22°55'58" E	282.31'
50	S 51°27'34" E	754.32'
51	S 66°34'19" E	326.96'
52	S 42°42'06" E	176.92'
53	S 88°09'11" E	310.16'
54	S 72°23'17" E	660.98'
55	N 86°07'15" E	591.35'
56	N 77°28'14" E	553.17'
57	S 41°49'15" E	764.85'
58	S 12°59'38" W	533.67'
59	S 51°20'22" W	384.19'
60	S 74°28'30" W	373.63'
61	N 84°55'17" W	451.77'
62	S 40°29'06" W	539.07'
63	S 50°18'48" W	610.74'
64	N 68°45'03" W	772.53'
65	S 61°23'18" W	375.90'
66	N 76°13'07" W	545.71'
67	S 9°27'45" E	486.62'
68	S 53°54'07" E	594.05'
69	S 11°46'05" W	245.15'
70	S 57°05'42" E	202.48'
71	S 6°20'24" W	181.11'
72	S 42°42'34" E	176.92'
73	S 3°10'47" W	180.28'
74	S 25°27'48" E	232.59'
75	S 45°21'54" E	1160.00'
76	S 10°37'11" W	162.79'
77	S 39°14'44" E	916.79'
78	S 51°50'34" E	712.18'
79	S 66°48'05" E	228.47'
80	S 42°16'25" E	594.64'
81	S 32°28'16" E	260.77'
82	S 57°31'44" E	260.77'
83	S 39°59'13" E	404.60'
84	S 21°26'52" E	300.83'
85	S 49°38'08" E	262.49'
86	S 34°59'31" E	244.13'
87	S 51°40'00" E	748.18'
88	S 50°12'34" E	351.46'
89	S 17°02'08" E	256.22'
90	S 69°29'51" E	870.20'
91	N 68°11'01" E	242.33'
92	S 47°34'04" E	180.79'
93	S 47°34'04" E	374.84'
94	S 59°56'47" E	439.09'
95	S 75°31'31" E	459.62'
96	S 56°59'28" E	357.81'
97	S 86°31'32" E	410.77'
98	S 23°12'49" E	152.32'
99	S 59°20'46" E	499.93'
100	S 42°48'45" E	367.97'
101	S 64°38'51" E	550.00'
102	S 42°50'36" E	965.59'
103	S 55°56'02" E	633.76'
104	S 23°57'45" E	196.98'
105	S 46°50'51" E	219.32'
106	S 30°50'15" E	350.16'
107	S 21°30'05" W	177.34'
108	S 3°21'59" W	170.29'



THE PROJECT BOUNDARY SHOWN HERE IS AN UNSURVEYED ESTIMATE OF THE ACCESS ROAD AND TRANSMISSION LINE ALIGNMENTS PREPARED FROM PRELIMINARY AERIAL MAPPING. THE APPLICANT ACKNOWLEDGES THAT THIS EXHIBIT DOES NOT CONFORM TO THE REQUIREMENTS OF THE COMMISSION AND CERTIFIES THAT IT WILL COMPLETE THIS EXHIBIT AS REQUIRED BASED ON THE PROJECT FEATURES AS CONSTRUCTED WITHIN 6 YEARS OF THE GRANTING OF A LICENSE FOR THIS PROJECT.



KEY MAP

1 0 1 Mile
Scale

LEGEND

(35) Course number

Access road base line

Project boundary

Unsurveyed land lines

19 Section number

Shoreline

NOTES:

1. Land lines represent unsurveyed and unmarked locations from computations by the State of Alaska, Division of Lands, Copper River Meridian taken from U.S.G.S. 1:63,360 topographic series.
2. Grid based on Alaska, coordinate system, zone 1.
3. Shoreline from topography prepared by H. G. Chickering, Jr., January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
4. Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY (ADMINISTRATOR)

CONSULTING ENGINEER: R.W. BECK & ASSOCIATES, INC. SEATTLE, WASHINGTON

APPROVED BY

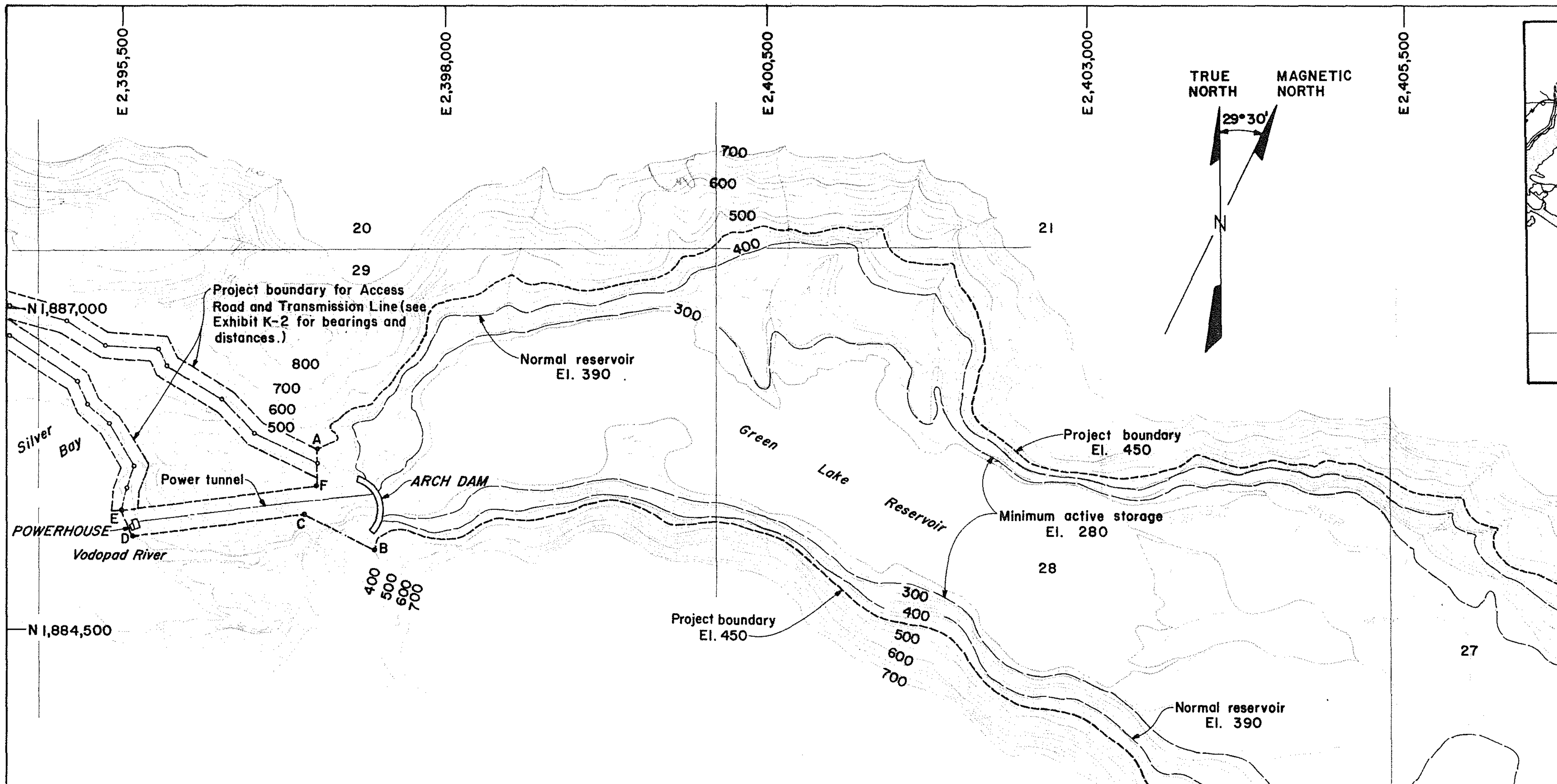
DATE September 6, 1977

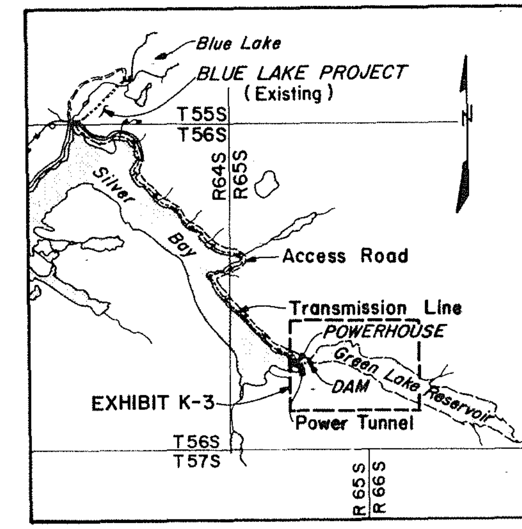
DRAWING NO. 462-P-6

GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT K-2
PROJECT BOUNDARY

500' 0 500' 1000' 1500' 2000' 2500'
SCALE: 1" = 500'

2818 - 6





KEY MAP

0 Mile

Scale

LEGEND

(5) Course number

Access road base line

Project boundary

Unsurveyed land lines

• B Meander point

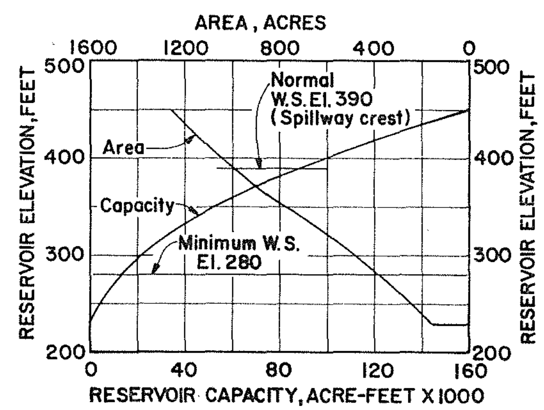
36 Section number

NOTES:

1. Land lines represent unsurveyed and unmarked locations from computations by the State of Alaska, Division of Lands, Copper River Meridian and taken from U.S.G.S. 1:63,360 topographic series.
2. Grid based on Alaska coordinate system, zone 1.
3. Topography prepared by H.G. Chickering, Jr., January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
4. Elevations based on Mean Sea Level (MSL) datum.

DESCRIPTION OF RESERVOIR, DAM, AND POWERHOUSE PROJECT BOUNDARY

A tract of land bounded by a line beginning at point A located at the intersection of the dam access road north boundary and the contour elevation 450 in the vicinity of the dam; thence along the contour elevation 450 enclosing the reservoir area and ending at a point south of the left abutment of the dam, point B; thence north 63° 07' west a distance of 610 feet to point C; thence south 83° 00' west 1,350 feet to mean high water line, point D; thence northwest along the mean high water line of Silver Bay approximately 220 feet to point E located on the end of the access road to the powerhouse boundary; thence north 83° 00' west 1,540 feet to point F; thence north 2° 10' east 290 feet to the point of true beginning, being point A.



AREA-CAPACITY CURVE

THE PROJECT BOUNDARY SHOWN HERE IS AN UNSURVEYED ESTIMATE OF THE POWERHOUSE AND DAM LOCATIONS AND THE ALIGNMENTS OF THE POWER TUNNEL, ACCESS ROAD, AND TRANSMISSION LINE PREPARED FROM PRELIMINARY AERIAL MAPPING. THE APPLICANT ACKNOWLEDGES THAT THIS EXHIBIT DOES NOT CONFORM TO THE REQUIREMENTS OF THE COMMISSION AND CERTIFIES THAT IT WILL COMPLETE THIS EXHIBIT AS REQUIRED BASED ON THE PROJECT FEATURES AS CONSTRUCTED WITHIN 6 YEARS OF THE GRANTING OF A LICENSE FOR THIS PROJECT.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY (ADMINISTRATOR)

CONSULTING ENGINEER: R. W. BECK & ASSOCIATES, INC SEATTLE, WASHINGTON

APPROVED BY

DATE September 6, 1977

DRAWING NO. 462-P-7

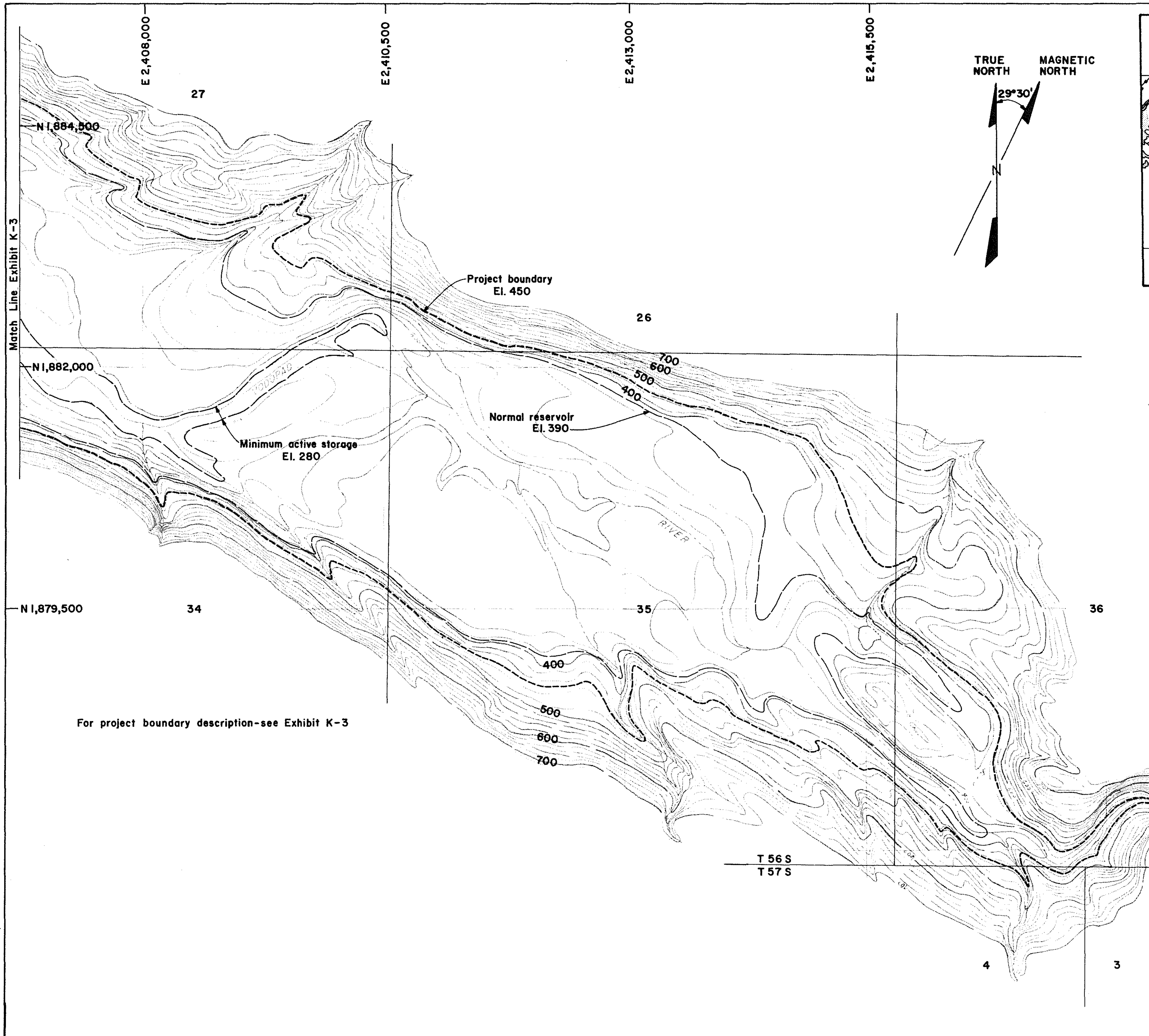
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA

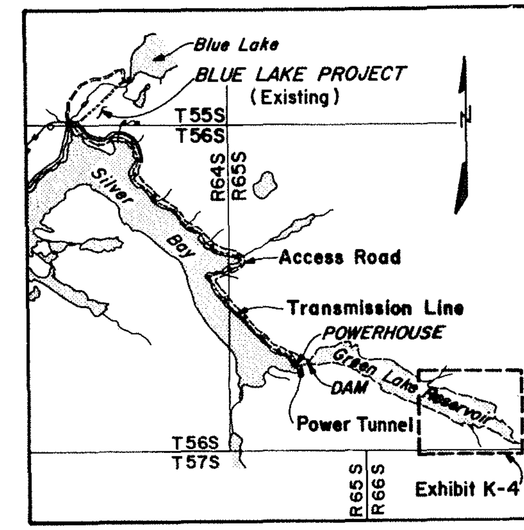
EXHIBIT K-3

PROJECT BOUNDARY

400' 0 400' 800' 1200' 1600' 2000'

SCALE: 1" = 400'





KEY MAP

1 0 1 Mile
Scale

LEGEND

- - - - - Project boundary

——— Unsurveyed land lines

35 Section number

NOTES:

1. Land lines represent unsurveyed and unmarked locations from computations by the State of Alaska, Division of Lands, Copper River Meridian taken from U.S.G.S. 1:63,360 topographic series.
2. Grid based on Alaska coordinate system, zone I.
3. Topography prepared by H. G. Chickering, Jr., January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
4. Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY ______ (ADMINISTRATOR)

CONSULTING ENGINEER:
R.W. BECK & ASSOCIATES, INC
SEATTLE, WASHINGTON

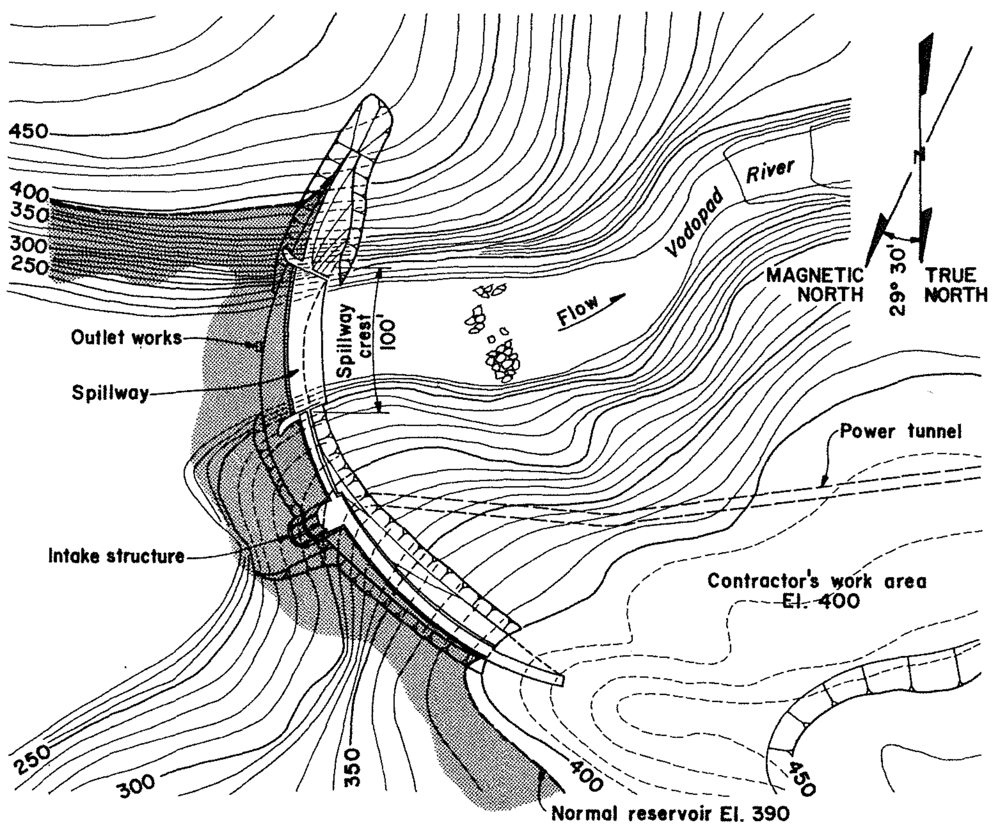
APPROVED BY ______
DATE September 6, 1977
DRAWING NO. 462-P-8

GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT K-4
PROJECT BOUNDARY

400' 0 400' 800' 1200' 1600' 2000'
SCALE: 1" = 400'

Appendix W - 5

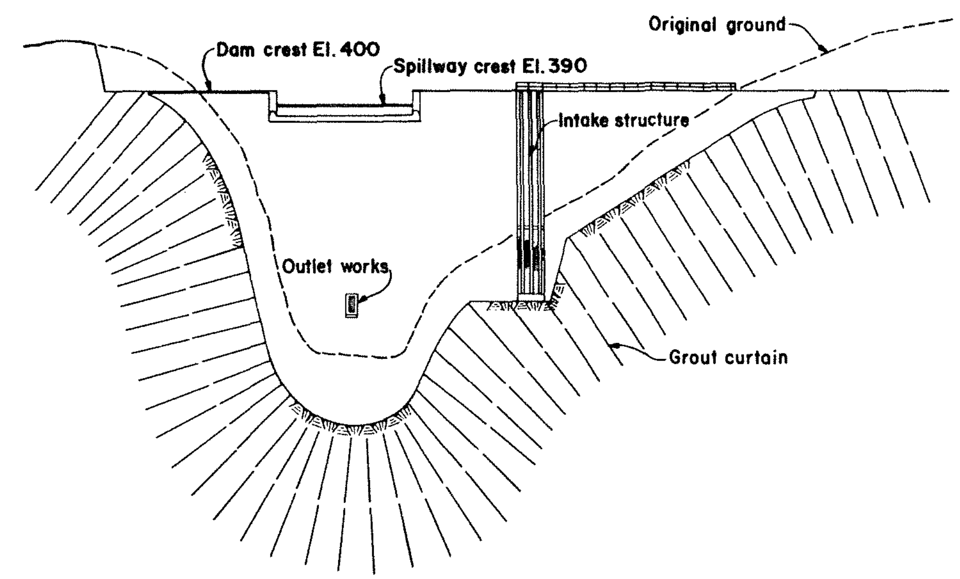
Exhibit L



DAMSITE - PLAN

50' 0 50' 100' 150' 200' 250'

Scale: 1" = 50'



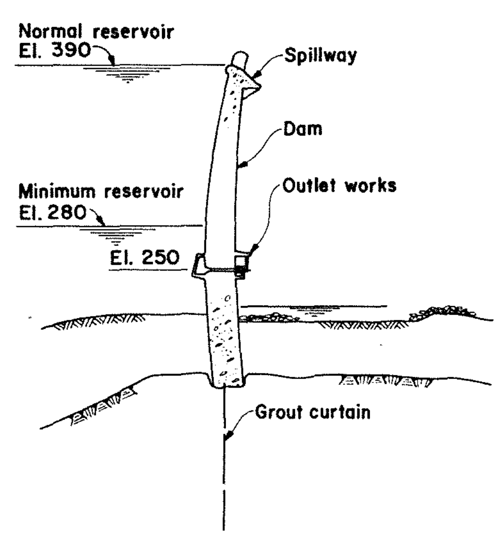
DAM - ELEVATION

50' 0 50' 100' 150' 200' 250'

Scale: 1" = 50'

NOTES:

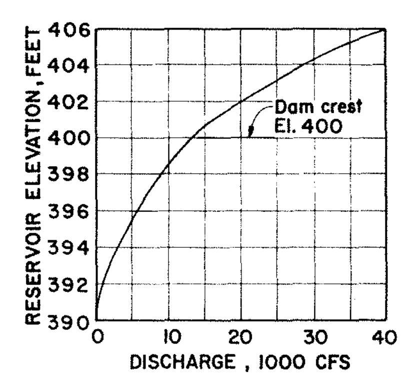
1. Topography prepared by H.G. Chickering, Jr. January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
2. Elevations based on Mean Sea Level (MSL) datum.



DAM - MAXIMUM SECTION

50' 0 50' 100' 150' 200' 250'

Scale: 1" = 50'



SPILLWAY RATING CURVE

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY ______ (ADMINISTRATOR)

CONSULTING ENGINEER:
R. W. BECK & ASSOCIATES, INC.
SEATTLE, WASHINGTON

APPROVED BY ______
DATE September 6, 1977
DRAWING NO. 462-P-9

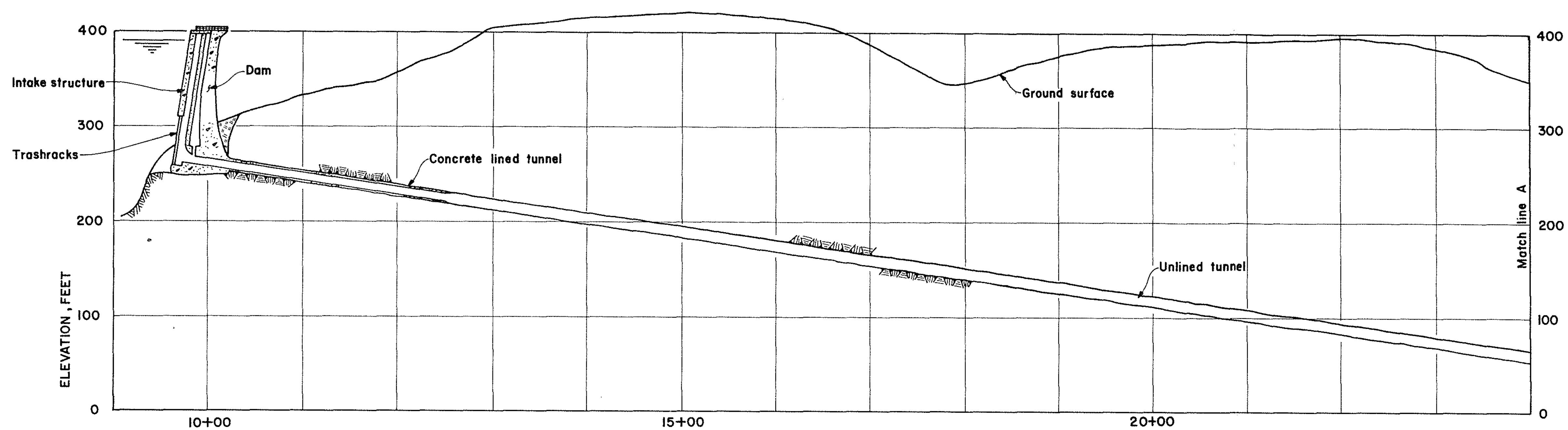
GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA

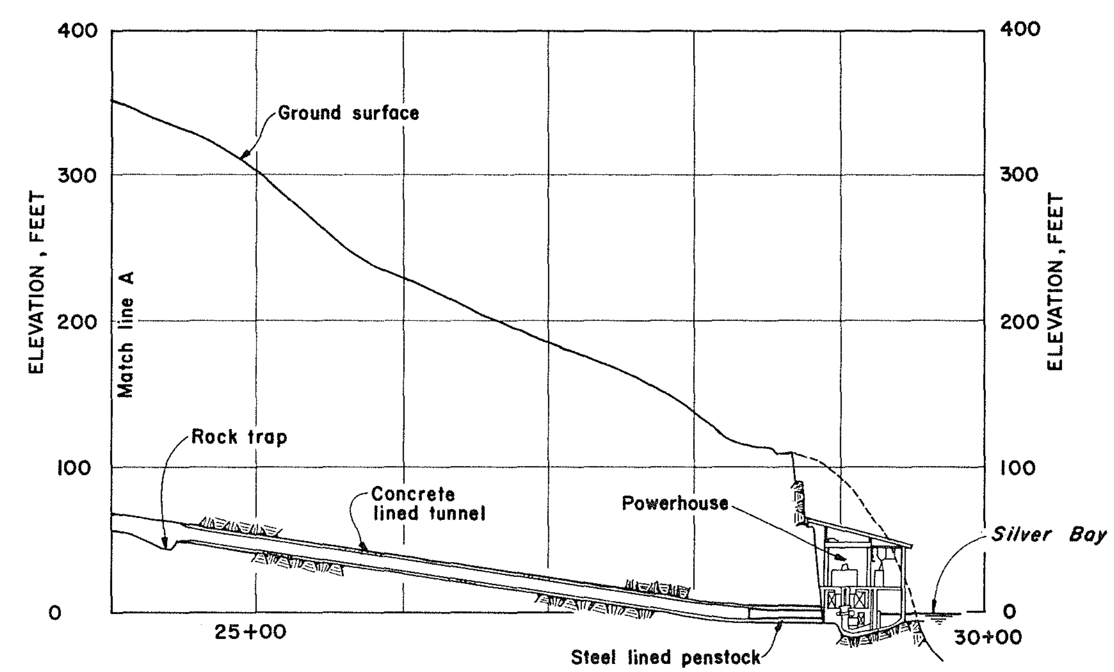
EXHIBIT L-1

DAM PLAN, ELEVATION AND SECTION

0 1" 2" 3" 4" 5" 6"

Scale as noted

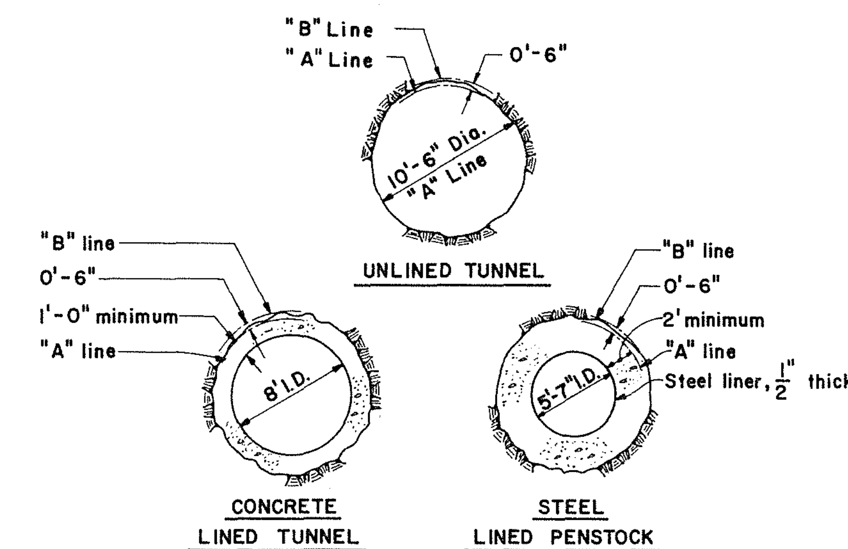




POWER TUNNEL PROFILE

50' 0 50' 100' 150' 200' 250'

Scale: 1" = 50'



POWER TUNNEL SECTIONS

5' 0 5' 10' 15' 20' 25'

Scale: 1" = 5'

NOTE:

Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977

BY (ADMINISTRATOR)

CONSULTING ENGINEER:
R.W. BECK & ASSOCIATES, INC
SEATTLE, WASHINGTON

APPROVED BY

DATE September 6, 1977

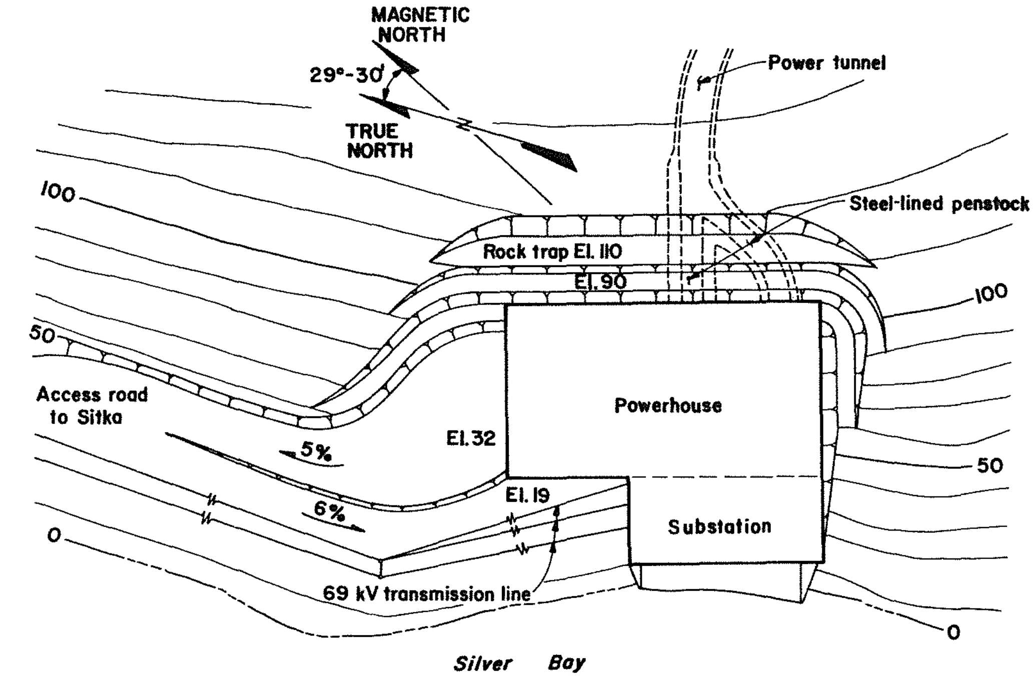
DRAWING NO. 462-P-10

GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT L-2

POWER TUNNEL PROFILE AND SECTIONS

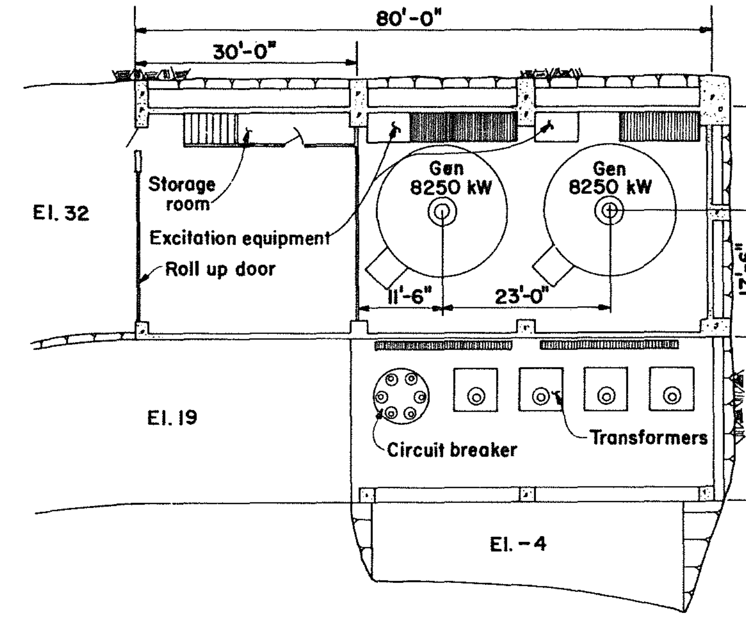
0 1" 2" 3" 4" 5" 6"

Scale as noted



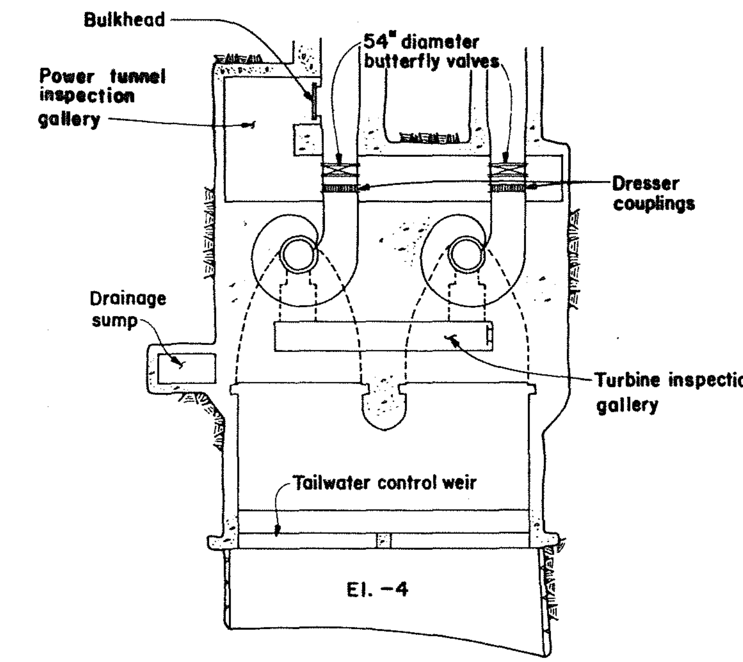
POWERHOUSE AREA PLAN

20' 0 20' 40' 60' 80' 100'
Scale: 1" = 20'



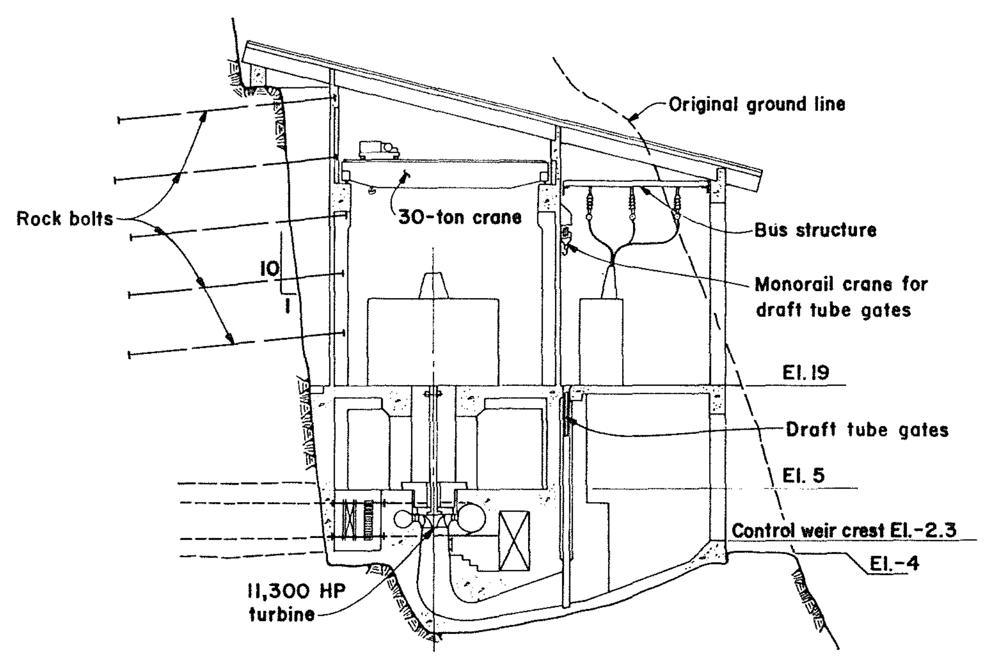
SECTIONAL PLAN - El. 35

10' 0 10' 20' 30' 40' 50'
Scale: 1" = 10'



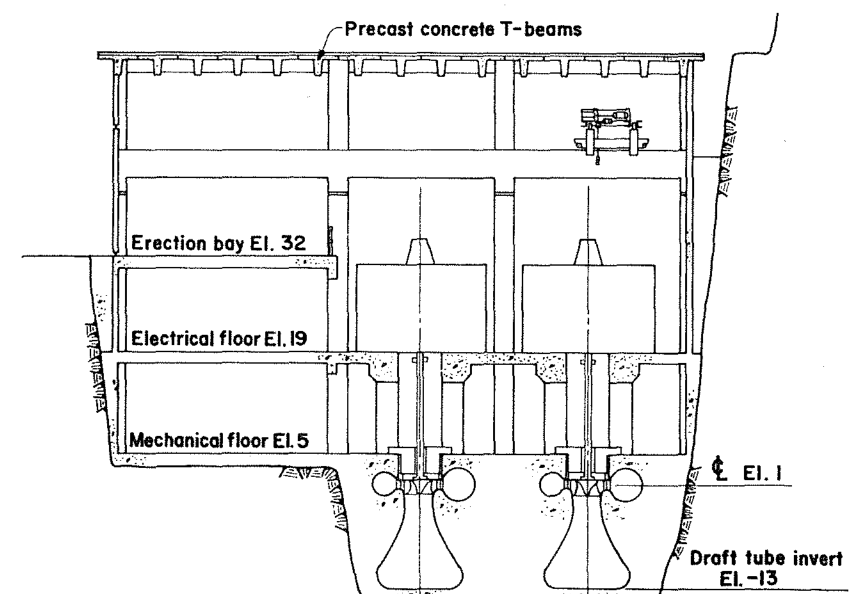
SECTIONAL PLAN - El. 1

10' 0 10' 20' 30' 40' 50'
Scale: 1" = 10'



TRANSVERSE SECTION THROUGH CENTERLINE OF UNIT

10' 0 10' 20' 30' 40' 50'
Scale: 1" = 10'



LONGITUDINAL SECTION THROUGH CENTERLINE OF UNITS

10' 0 10' 20' 30' 40' 50'
Scale: 1" = 10'

NOTES:

1. Topography prepared by H. G. Chickering, Jr. January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.
2. Elevations based on Mean Sea Level (MSL) datum.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT. 14, 1977
BY (ADMINISTRATOR)

CONSULTING ENGINEER:
R. W. BECK & ASSOCIATES, INC.
SEATTLE, WASHINGTON
APPROVED BY
DATE September 6, 1977
DRAWING NO. 462-P-11

GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT L-3
POWERHOUSE AND SUBSTATION PLANS AND SECTIONS
0 1" 2" 3" 4" 5" 6"
Scale as noted

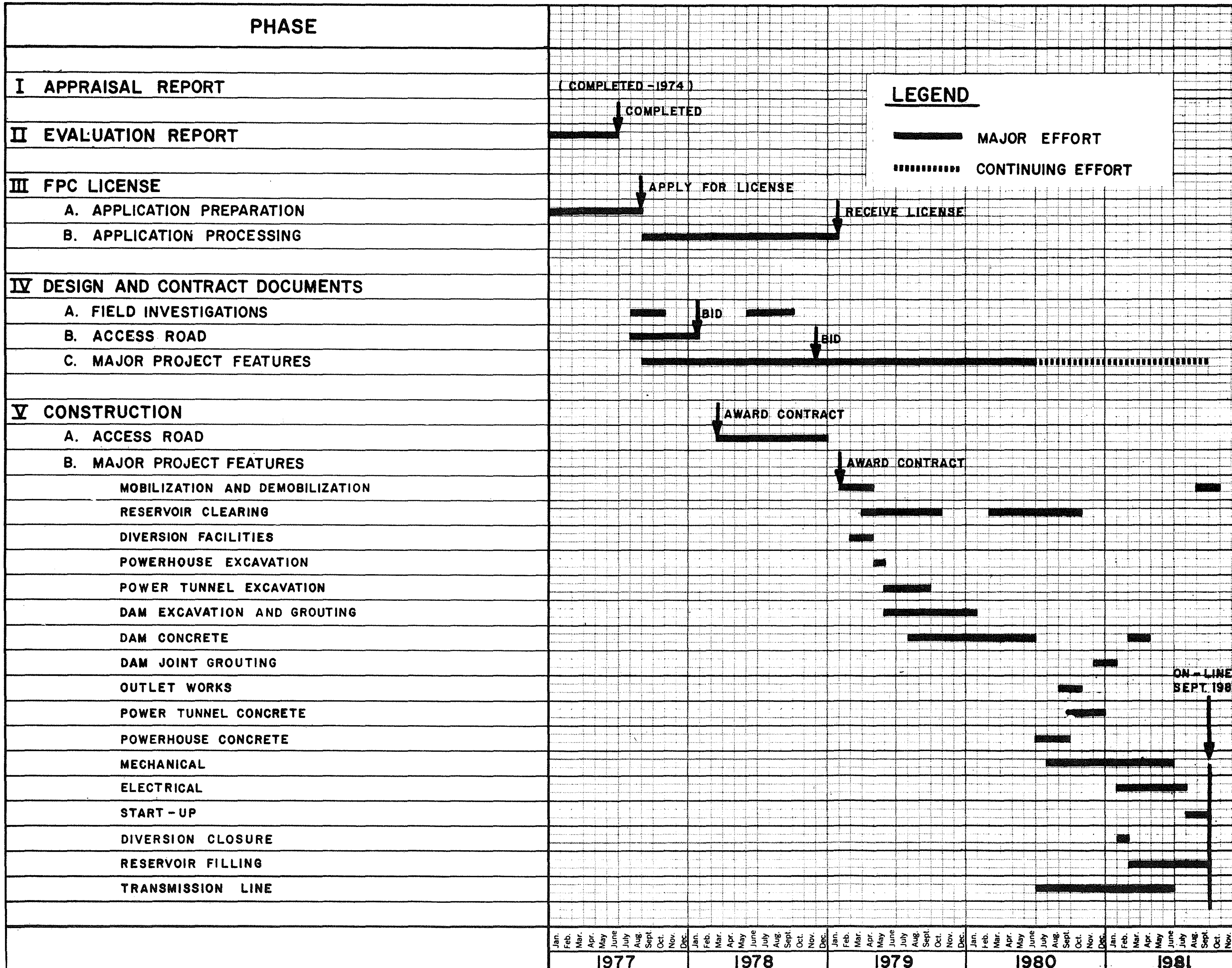
Appendix W - 6

Exhibit O

EXHIBIT O

STATEMENT OF THE ESTIMATED TIME REQUIRED TO COMPLETE PROJECT WORKS

EXHIBIT O


PHASE
I APPRAISAL REPORT
II EVALUATION REPORT
III FPC LICENSE
A. APPLICATION PREPARATION
B. APPLICATION PROCESSING
IV DESIGN AND CONTRACT DOCUMENTS
A. FIELD INVESTIGATIONS
B. ACCESS ROAD
C. MAJOR PROJECT FEATURES
V CONSTRUCTION
A. ACCESS ROAD
B. MAJOR PROJECT FEATURES
MOBILIZATION AND DEMOBILIZATION
RESERVOIR CLEARING
DIVERSION FACILITIES
POWERHOUSE EXCAVATION
POWER TUNNEL EXCAVATION
DAM EXCAVATION AND GROUTING
DAM CONCRETE
DAM JOINT GROUTING
OUTLET WORKS
POWER TUNNEL CONCRETE
POWERHOUSE CONCRETE
MECHANICAL
ELECTRICAL
START-UP
DIVERSION CLOSURE
RESERVOIR FILLING
TRANSMISSION LINE
(COMPLETED - 1974)
COMPLETED
APPLY FOR LICENSE
RECEIVE LICENSE
BID
BID
AWARD CONTRACT
AWARD CONTRACT
ON-LINE SEPT. 1981
LEGEND
MAJOR EFFORT
CONTINUING EFFORT
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1977
1978
1979
1980
1981

Appendix W - 7

Exhibit R

EXHIBIT R

RECREATION PLAN

1. GENERAL

The Green Lake Project site is located on Baranof Island southeast of Sitka near the head of Silver Bay. The Project will consist of a dam and reservoir on Green Lake, with the powerhouse, access road and transmission line located along the shoreline of Silver Bay. The topography of both Green Lake and Silver Bay is typical of Southeast Alaska with precipitous side slopes rising from the waterline. The vegetation of the area extends from shoreline to timberline (2,250 ft.) and consists of heavy stands of Sitka Spruce and Western Hemlock with undergrowth shrubs and young conifers. The open, less precipitous slopes support scrub conifers, muskeg and moss-type vegetation. Wildlife of the area is again typical of the region with the larger mammals being Alaska Brown Bear, Sitka Deer, and Mountain Goats at the higher elevations.

The project area, while in a rugged and scenic setting, is not unique in comparison to other local areas and in fact is somewhat limited in its recreational potential because of the ruggedness of these features. The reservoir will provide a good trout fishing area but Green Lake Valley will be of little value from a hiking and camping standpoint due to the steep terrain. The portion of the project area along the access road alignment has similar terrain restraints on its recreational potential. Since public vehicular access must be prohibited on the access road it will serve, from a recreational standpoint, only as a hiking trail.

The Applicant fully realizes the limitations of the project area from a recreational standpoint and will demonstrate in this exhibit that there are other areas in the Sitka vicinity which will more satisfactorily fulfill the recreational needs. The following discussion explains the regional recreational needs and the Applicant's plans to meet those needs.

2. SOUTHEAST ALASKA RECREATION

The State of Alaska, in its current outdoor recreation plan, has defined the supplies and demands for recreation facilities for the major geographical regions of the State.

To define the type of demand placed upon outdoor recreation, the State conducted a variety of resident and non-resident recreation surveys from 1966 through 1969. The analysis of this data established the levels of participation in outdoor recreation activities on a State and regional basis. The results indicate that trail related activities lead in participation on both a State and regional level. These were followed by activities such as sightseeing, driving for pleasure, picnicking, fishing, boating, camping, swimming, and hunting. The Alaska Outdoor Recreation Plan further indicates that the greatest majority of resident participation is "activities carried out near the participant's home when he has only a few hours available for outdoor recreation."

For the Southeast Alaska Region, the State plan has identified 2,811,225 acres of available land already dedicated to recreation and recreation facilities as of July 1973. But, some 2,810,640 acres, (approximately 99.97%) of this land are under State and Federal jurisdiction and are categorized as "extended trip acreage", where the term "extended trip" relates to facilities which are further than one hour travel time from most users.

In carrying out its study the State has used the supply and demand information to define the recreation needs of the various regions. In defining the needs for the future recreation facilities for Southeastern Alaska, the State plan established that facilities and acreage available in 1975 will supply thirty-one percent (31%) of the total outdoor recreation needs. For the southeast region the largest deficit in available wilderness-type facilities has been identified as the need for trail systems. The plan shows that the 1975 trail facilities available will supply only 14% of the 1975 need, leaving an 86% deficit. This is followed by deficits of 78% for picnic units, 60% for outdoor game areas and 35% for camp units.

3. CITY AND BOROUGH RECREATION

To further refine the State's outdoor recreation plan on a local level, the City and Borough of Sitka (Applicant) prepared a comprehensive recreation plan designed to identify the specific needs of and the resources available to the residents of the Sitka area. The plan is currently in a draft stage, but is the best information available to define local needs.

Sitka, as a highly mobile water-oriented community, could not afford to restrict its study to the Sitka Exclusion Area but was obliged to review existing and potential resources within the much larger physical area considered accessible to the majority of the community. Like most Southeast Alaska communities, Sitka is completely surrounded by the Tongass National Forest. As a result, most of the existing and potential recreational facilities are located on lands owned by the United States and administered by the U.S. Forest Service (USFS). Therefore the City and Borough of Sitka has relied heavily on the usage and expansion of existing USFS facilities in the Study Area.

Drawing Exhibit R identifies the existing and proposed regional trail system, cabins and alpine shelters, major anchorages, green belt/protected areas and proposed/potential general recreation sites contained within the Sitka Study Area. The recreational facilities shown in that exhibit were chosen to provide the community with a full range of activities in the out-of-doors.

A regional trail system, identified by the State as the one recreational facility needing the most development, appears very feasible in the Sitka area, due to the amount and wide variety of existing logging roads. A variety of existing and proposed trails are shown in Drawing Exhibit R that would provide a trail system ranging in type from low or cross-country to alpine. This system would provide access to and interconnect many of the unique and popular recreation areas, such as the Mount Edgecumbe/Fumerole Camp Area on Kruzof Island and the glacier area east of Sitka on Baranof Island.

4. SILVER BAY RECREATION

The Salmon Lake/Lake Redoubt recreation area is located at the head of Silver Bay, just west of the Green Lake Project. The existing trail leads from Silver Bay, along Salmon Creek past Salmon Lake and ends at the USFS hiker's cabin at the head of Lake Redoubt.

The Salmon Creek/Salmon Lake segment is popular for its hiking and fishing resources. Salmon Creek is an anadromous stream, supporting annual salmon migrations, and Salmon Lake is a popular freshwater fishing lake.

Redoubt Lake lies in a steep-walled, scenic glacial basin. The lake is a miromictic lake with a distinctive tidewater outfall between Redoubt Bay and Redoubt Lake. It is an excellent sport fishery and is being proposed as a wilderness study area. The Applicant has proposed that the existing cabin at the tidewater outfall be rebuilt and the trail system extended from the existing cabin near the head of the lake. This proposal would, however, rely on U.S. Forest Service implementation.

5. PROJECT RECREATION

In view of the existing and proposed recreational facilities available in the greater Sitka area, the Green Lake Project is not considered to be a major recreational resource. There are no unique scenic, archaeologic, or geologic features within the project area and the topography of the site severely limits the range of recreational uses which can feasibly be developed.

Discussions with the U.S. Forest Service, U.S. Bureau of Outdoor Recreation, Alaska Division of Parks and the National Park Service have established that there have been no recreational use studies conducted in the project area. Thus, there are no official agency estimates of present or projected recreational use. Based on its own knowledge, the Applicant estimates that the project area presently receives approximately 15 visitors annually with the predominent use of the area being trout fishing. It is expected that this use pattern will continue in the future and the Applicant believes that the future recreational usage will be closely associated with level of fish population in Green Lake. The proposed reservoir will increase the nutrient levels in the lake, due to the decomposition of flooded organic materials, which will provide an increased food source for the existing brook trout population. The increase in nutrient level is expected to peak within 1 to 3 years after the inundation of the reservoir and return to present nutrient levels in about 15 years. The vitality of the resident fish population and hence recreational fishing use, is expected to follow a similar cycle. The Applicant estimates that during the 1 to 3-year period, recreational use will double to approximately 30 visitors annually. From that time visitor use is expected to decrease, as fish population decreases, until use returns to approximately the same levels occurring presently. The above is predicated on the maintenance of the fish population upon filling of the reservoir. It is recognized, however, that raising the lake level may also result in the loss of the trout spawning grounds at the head of the existing lake. The proposed institution of an appropriate trout stocking program through the Alaska Department of Fish and Game would mitigate the loss of the spawning grounds and provide a good freshwater trout lake. More complete plans for this program will be submitted to the Commission upon culmination of formal agreement between the Applicant and the Alaska Department of Fish and Game.

While the above estimates indicate the expected low recreational usage of the project area, it is felt that some enhancement of access to Green Lake would be provided. Public vehicular access via the single lane access road will be prohibited for safety reasons and the costs involved in bringing the access road up to public use standards would seriously compromise the financial integrity of the Project. Additionally, public vehicular traffic in such proximity to the several existing eagle nests identified along Silver Bay could disrupt nesting activities to the point where abandonment of the nests would occur and realignment of the road would not be economically feasible.

To facilitate access to the Green Lake Reservoir from Silver Bay, a mooring buoy will be installed near the powerhouse to provide anchorage for up to two (2) moderate sized pleasure craft. Due to the low expected visitor usage of the project area, the Applicant believes that a dock structure is unwarranted. Access to shore will be via a small dingy commonly carried aboard such craft locally. Usually, the dingy is drawn up on shore and tied to a nearby tree or rock. The existing hiking trail, shown in Detail Z of Drawing Exhibit R, and the portion of the access road from the powerhouse to the dam will provide alternative hiking accesses to Green Lake Reservoir from the tidewater. The hiking trail will require rehabilitation and upgrading. In addition the project access road will provide hiking access from Herring Cove to the project site.

Should usage resulting from the enhanced access increase beyond that expected, the Applicant will consider providing skiffs at the lake or other appropriate measures at that time.

It is expected that the on-site (project-related) recreational development cost for the Project will be $12,000, itemized as follows:

Mooring buoy	-	$ 2,000
Trail rehabilitation	-	$10,000

The cost of the access road even though it can be used for hiking has not been allocated to recreation.

Due to the above constraints on the already limited recreational potential of the Project and the existence of the nearby Salmon Lake/Lake Redoubt recreational area, Green Lake will be retained in much the same recreational capacity as it has served prior to the project development, that is, as a trout fishing lake.

6. CONSULTATIONS WITH FEDERAL, STATE AND LOCAL AGENCIES HAVING RESPONSIBILITY FOR RECREATION

The following consultation with Federal, State and local agencies were conducted with regard to recreation for the Project.

a. <u>Bureau of Outdoor Recreation</u>

Date:	August 18, 1977
Type:	Meeting
Participants:	R. W. Beck and Associates (RWB) representing the City and Borough of Sitka
Subjects:	Review of Draft Exhibit R for BOR comments.

b. U.S. Forest Service

Date: June 7, 1977
Type: Telephone Conversation
Participants: RWB representing the City and Borough of Sitka
Subjects: Forest Service Recreational Plans for the Green Lake Area.

c. Bureau of Outdoor Recreation

Date: May 2, 1977
Type: Telephone Conversation
Participants: RWB representing the City and Borough of Sitka
Subjects: Criteria and Guidelines for Planning for Recreational Facilities in Southeast Alaska.

d. Alaska Division of Parks

Date: May 2, 1977
Type: Telephone Conversation
Participants: RWB representing the City and Borough of Sitka
Subjects: State Recreation Plans for the Green Lake Area and State Guidelines or Criteria for Recreation Planning.

Date: March 9, 1977
Type: Meeting
Participants: RWB representing the City and Borough of Sitka
Subject: Project Recreation Planning

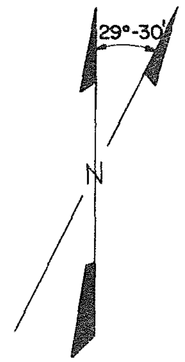
e. City and Borough of Sitka

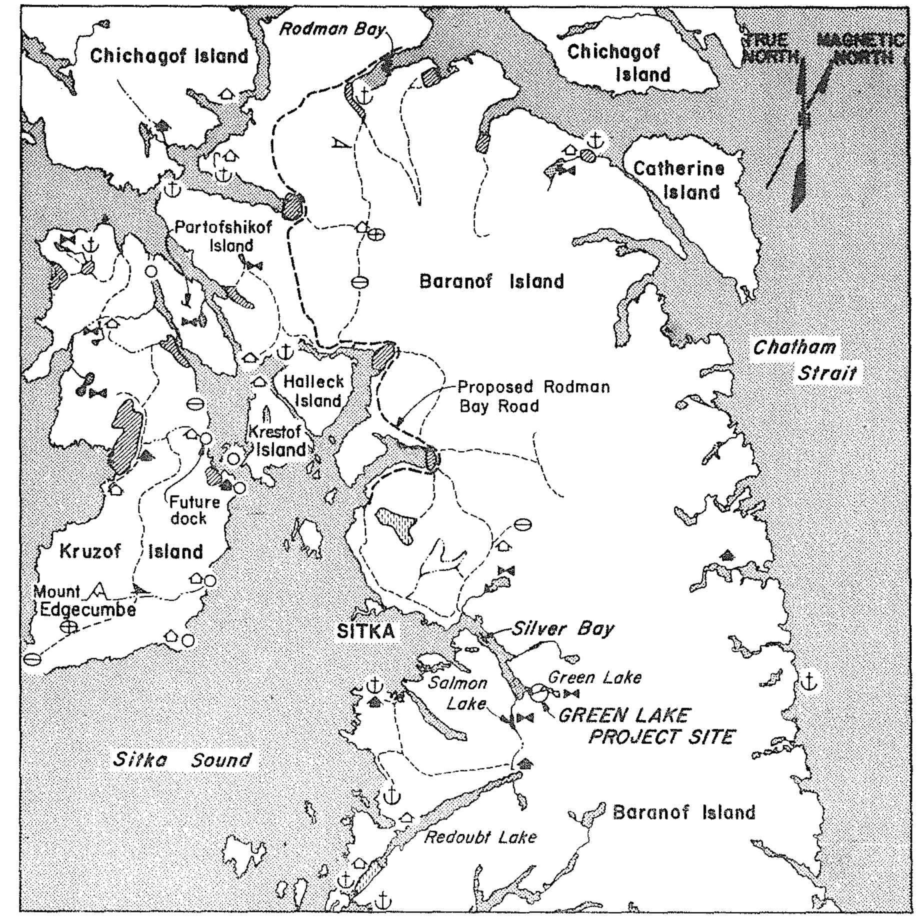
Date: Various Dates

Type: Meetings and Telephone Conversations

Participants: RWB

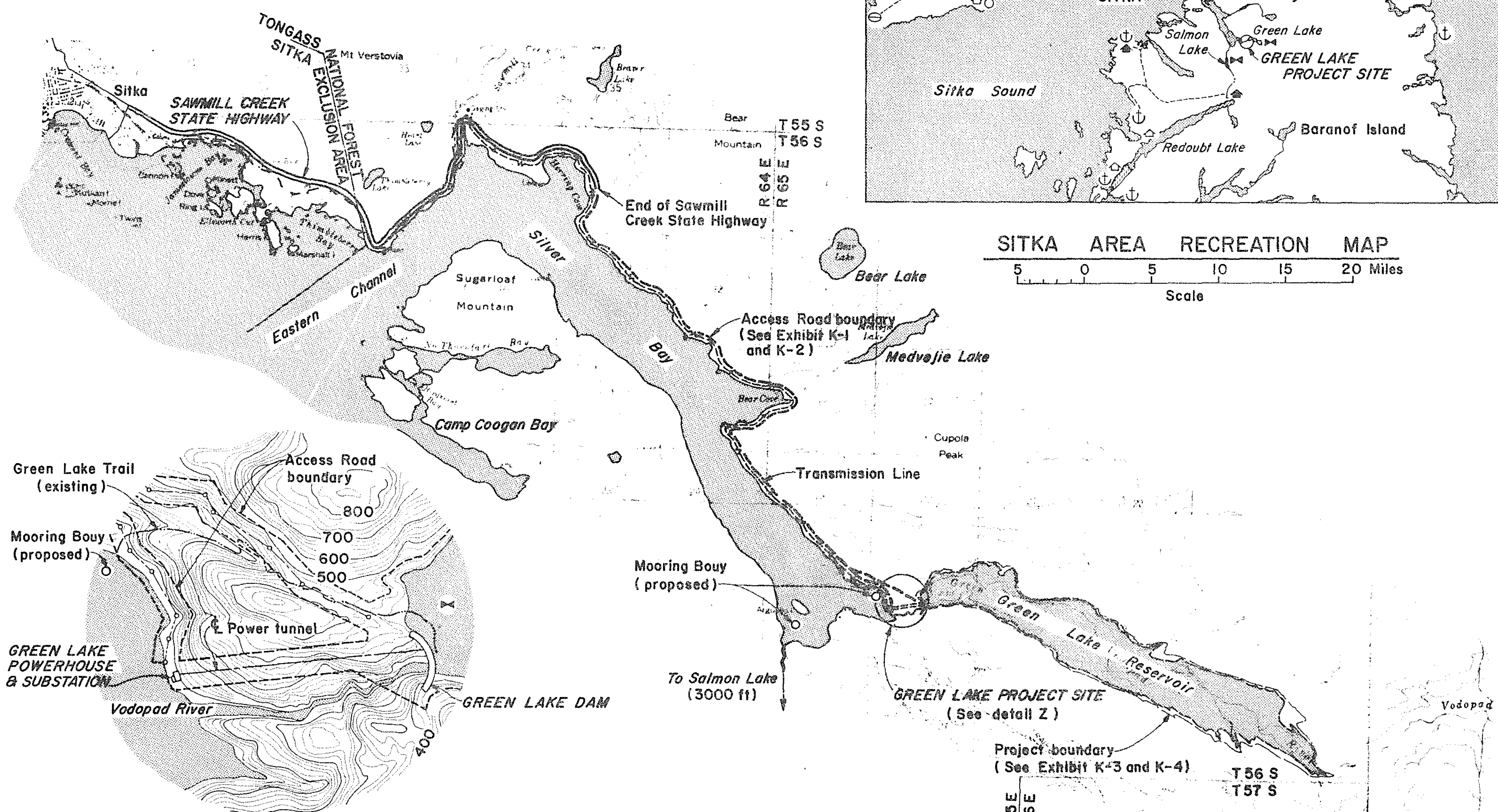
Subject: City and Borough Recreation Planning for the Green Lake Area.





SITKA AREA RECREATION MAP

5 0 5 10 15 20 Miles
Scale



DETAIL Z
GREEN LAKE PROJECT SITE

400' 0 400' 800' 1200' 1600' 2000'
Scale

GREEN LAKE PROJECT RECREATION MAP

1 0 1 2 Miles
Scale

LEGEND

	Existing	Proposed	Potential
Boat anchorage	⚓		
Bouy	●	○	
Trail			
Cabin			
Shelter			
Fresh water fishing			
Park			
Green belt			
Recreation		⊕	⊖

NOTE:

Elevations based on Mean Sea Level (MSL) datum.

MAPPING REFERENCES

Sitka Area Recreation Map

U.S.G.S. Quadrangles, 1:250,000:
Sitka, Alaska 1951
Port Alexander, Alaska 1951

Green Lake Project Recreation Area

U.S.G.S. Quadrangles, 1:63,360:
Sitka (A-4), Alaska 1951
Port Alexander (D-4), Alaska 1951

Green Lake Project Site

Topography prepared by H.G. Chickering, Jr. January 1975. Horizontal and vertical control based on U.S.G.S. Quadrangle control.

THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE CITY AND BOROUGH OF SITKA ON THIS DAY OF SEPT 14, 1977
BY (ADMINISTRATOR)

CONSULTING ENGINEER: R.W. BECK & ASSOCIATES, INC. SEATTLE, WASHINGTON
APPROVED BY
DATE September 6, 1977
DRAWING NO. 462-P-13

GREEN LAKE PROJECT
CITY AND BOROUGH OF SITKA, ALASKA
EXHIBIT R
PROJECT RECREATION PLAN

0 1" 2" 3" 4" 5" 6"
Scale as noted

Appendix W - 8

Exhibit V

EXHIBIT V

STATEMENT OF THE PROTECTION, ENHANCEMENT OF NATURAL, HISTORIC AND SCENIC FEATURES IN THE DESIGN, LOCATION, CONSTRUCTION AND OPERATION OF PROJECT FEATURES

1. INTRODUCTION

In southeastern Alaska the mountainous forest setting predominates the scenery. While the Green Lake Project is located in the midst of this setting, it does not encompass any unique or exceptional historic, natural or scenic values. The Applicant's development of the Green Lake Project includes facility design and location considerations balanced by engineering requirements and reliability for visual acceptability. These considerations can assure preservation of the natural features in the project area consistent with construction and operation requirements. In discussing the required subject matter, this exhibit develops criteria for the construction and operation of the Project including temporary facilities (such as construction roads, borrow areas and cofer dams) and reservoir clearing. Each element of the Project is discussed in as much detail as present information permits.

The Applicant's planning included meetings with State and Federal agencies along with representatives of local civic and conservation groups to determine their concerns.

2. PROJECT WORKS

The following measures will be taken during construction and operation of the Project to minimize the impact to the environment and preserve scenic values.

a. Reservoir Area

At normal reservoir elevation, the proposed reservoir will inundate approximately 1,000 acres of the Green Lake, Vodopad River Valley.

The primary concerns for the reservoir area are to minimize the effects of reservoir clearing, aggregate borrow areas and construction access roads. The reservoir will be cleared of all trees and brush within the area of normal reservoir fluctuation (El 390 to El 294). Further, it is planned that all marketable timber below El 294 will be cleared from the reservoir area. To minimize conflict with scenic values and minimize environmental damage, the debris and non-marketable material from the clearing operation will be disposed of primarily by controlled burning conforming to current air pollution regulations. All floating debris will be removed from the reservoir as the water rises. There do not appear to be any potentially unstable slopes which would result in landslides in the reservoir area, but care will be taken to minimize any erosion in the cleared zone before the reservoir is filled.

Within the reservoir area will be located the proposed borrow areas for the aggregates to be used in concrete batching, the coffer dams utilized during construction of the arch dam and the general construction roads that will be required for the Project. These above mentioned items, except for one portion of construction road, will all be inundated upon filling of the reservoir and will not create any visual impact in the project area. A portion of the construction road that leads from the contractor's work area to the upstream toe of the dam will be visible due to normal reservoir fluctuations.

b. Dam

The dam will be a double-curvature, concrete arch structure located about 80 feet downstream from the mouth of the existing Green Lake. The dam will have a maximum height of 230-feet above the estimated bottom of the foundation excavation and a crest length of 460 feet at El 400.0. In the vicinity of the dam there are several project features which will have a visual impact upon the area. The dam itself will be a permanent feature of the landscape but due to its location it should not create an adverse visual impact. The type of structure will offer a low profile when viewed from the reservoir side and the difficult terrain and topography will generally preclude any viewing from the downstream side.

The contractor's work area, to be located on the north abutment, will be utilized heavily during construction. This area, except that required for project operation, will be regraded, contoured, and seeded upon completion of construction.

c. Power Conduit

The power conduit will be a 1,900-foot long, entirely underground structure and will have no adverse visual effect on the area. This mitigating effect is a consequence of normal engineering consideration and will require no additional funds for aesthetics.

d. Powerhouse

The powerhouse will be an indoor-type surface installation, located on Silver Bay about 350-feet north of the mouth of the Vodopad River. Due to its location and size, the powerhouse will be visible to boat traffic in the southern end of Silver Bay. The most apparent view of the structure will be the front elevation behind which the substation will be housed. This elevation will be treated architecturally in a manner so as to blend with, to the extent possible, the surrounding environment. The forest cover will be maintained as close to the powerhouse as possible from an operation and maintenance standpoint and still provide masking to the structure.

e. Access Road

The access road will be a single-lane, minimum standard road of 7.4 miles in length and will extend along the northeast shore of Silver Bay from Herring Cove to the project site. The road will consist of both half and full bench cut sections. Due to the required location and steep topography along Silver Bay, portions of the access road and the uphill cut slopes will be visible to boat traffic. The natural masking of the forest cover will be maintained as much as possible and where necessary and practical, re-seeding of low growth forest cover will take place. On the full bench cut sections, most of the rock material will be wasted into Silver Bay where it will create no visual impact and be readily assimilated into the environment (see Exhibit W, Section 3). In order to maintain natural scenic and environmental aspects along the road alignment, all natural drainages will be maintained either by culverts or bridges as appropriate. Bridges will be utilized over anadromous fish streams (Bear Cove drainage) and will be of log stringer type construction. This type of bridge will serve two purposes. It will be more economical to construct and it will provide a bridge more naturally pleasing to the forest scene.

In general the access road will be maintained as required to allow for access for operation and maintenance of the dam, powerhouse and transmission line while unauthorized vehicular traffic will not be permitted.

f. Transmission Line

The transmission line utilized will be 69-kV on single wood poles with a wishbone crossarm configuration. The selected line arrangement (see Exhibit J) will closely parallel the access road alignment and portions of the existing Sawmill Creek Highway to a terminus at the substation of the Blue Lake Project. While the single pole arrangement is typical for this voltage, it will have the added benefit of blending more readily into the forest scenery. The Commission's "Guidelines for the Protection of Natural, Historic, Scenic, and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities" have been utilized where they are applicable to the project environment. The use of transmission line and access road on the same right-of-way will minimize excess clearing and maintain as much of the existing tree cover as practical. Clearing for the transmission line will be carried out in a similar manner as was done for the access road, with the marketable timber being sold and the slash being disposed of in an environmentally acceptable manner. Operation of the Project will require periodic maintenance of the transmission line in the removal of what is termed "danger trees". Since the transmission line will generally be located on the downhill side of the access road alignment, this type of maintenance is expected to be minimal. The paralleling alignments of the transmission line and access road will provide dual primary use of the single right-of-way. The use of the access road as a hiking trail will be the only secondary usage of the right-of-way.

Since there are no existing transmission line right-of-ways in the project area it was required that route selection be based on economic, reliability and environmental considerations. The selected line route utilizing the transmission line and access road along the same right-of-way has been described above. This arrangement was chosen because it offers highest reliability at a lower capital cost. It is expected that this arrangement will have some visual impact along Silver Bay. These impacts will be mitigated as much as possible by natural or re-seeded forest cover. The selected transmission alternative will tie into the existing Blue Lake transmission line at the substation near the Blue Lake Powerhouse. This existing Blue Lake transmission line will be upgraded from this point into Sitka but is not considered part of this Application.

The second transmission line arrangement considered was an overland transmission line with no access road. This arrangement, while in the same general area as the previous one, would involve some line locations at higher elevations along Silver Bay. This scheme was ruled out from a reliability and economic standpoint. The reliability suffers from the difficulty of access during severe weather (most outages would occur during these periods). Elimination of the access road has a very significant effect on construction of the major project features. All construction access would have to be by water and a port facility would have to be developed to facilitate unloading equipment, materials and labor.

Although the costs of access road construction would be saved, ultimately higher project costs are accrued due to the more expensive construction camp or ferrying system that must be used to bring material and personnel to the project site. The transmission line for this alternative would be more visible than the selected arrangement because of the higher location along the mountain side.

The third alternative considered would utilize an underwater transmission cable laid on the bottom of Silver Bay. The alternative of continuing the underwater line on into Sitka was ruled out because it would cross the shipping lane to the ALP mill which would expose it to the additional hazard of ship and barge anchors. For reliability, it would be necessary for the underwater transmission line to have two separate circuits, each consisting of a three-conductor armoured copper cable laid in parallel, directly on the bottom an average distance of 250-feet apart with a minimum of 50-feet apart where necessary. Elimination of the access road has the same effect on the cost of construction of the major project features of this alternative as the previous alternative.

This alternative has the same disadvantage for maintenance of the dam and power plant in the event of an outage as does the previous alternative. In addition, this alternative has a greater disadvantage in that maintenance of underwater transmission lines is very expensive and requires a long period to accomplish repair work. It is estimated that at mid-1977 cost level, a single repair of one of the cables would cost $250,000 and would take approximately 30 days to complete under the best conditions of availability of equipment and labor. A specialized cable laying boat and equipment are required which must be brought in and difficulties are frequently encountered in locating the cable on the bottom and hauling it to the surface for repair.

Although the visual impact of this alternative would be less along Silver Bay, this alternative was judged unfeasible for the above-stated reasons.

3. ARCHAEOLOGICAL STUDY

An archaeological study has been completed for the project area by Dr. Robert E. Ackerman, of the Arctic Research Section, Laboratory of Anthropology, Washington State University. This report can be found in Appendix W-11. The study concludes that there is no evidence of any significant archaeological sites found in the area. Further, there are no listed natural or historic sites located in the project area that would be affected by the proposed hydroelectric development.

In the event that any previously unidentified archaeological sites are encountered during construction, the appropriate authorities will be notified and their guidance sought concerning the significance of the site and the removal of data.

Appendix W - 9

Preliminary Geologic Investigation

by

Converse Davis Dixon Associates, Inc.

PRELIMINARY GEOLOGIC INVESTIGATION

PROPOSED
GREEN LAKE HYDROELECTRIC PROJECT

SITKA, ALASKA

Conducted For

R. W. BECK AND ASSOCIATES
Analytical and Consulting Engineers
200 Tower Building
Seattle, Washington 98101

In Cooperation With The

CITY AND BOROUGH OF SITKA, ALASKA

Our Project No. W-74-315-AH
November 19, 1974

November 19, 1974

R. W. Beck and Associates
200 Tower Building
Seattle, Washington 98101

Attention: Mr. James V. Williamson
Supervising Executive Engineer

Gentlemen:

Enclosed is our Preliminary Geologic Investigation report of the Proposed Green Lake Hydroelectric Project, near Sitka, Alaska (Your Project No. WW-1521-HG2-MX).

The data presented herein was obtained by geologic mapping from October 30 through November 3, 1974, supplemented by photogeologic interpretations and literature research. Based on this investigation, the site appears suitable for the proposed dam and appurtenant works; no major geologic defects were observed. Subsurface exploration and testing will be required to develop design criteria.

We will be happy to discuss the enclosed report with you at your convenience.

Very truly yours,

CONVERSE, DAVIS AND ASSOCIATES, INC.

By Howard A. Spellman, Jr.

Howard A. Spellman, Jr.
Principal Geologist

HAS:ttn
Encl:

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SUMMARY AND CONCLUSIONS

The Green Lake Hydroelectric site is underlain by very hard, massive, fresh, graywacke bedrock. Through-going lineaments trending northwest and northeast, at very steep angles, are present at the site. No faults, shears or crushed zones were observed. No clay was detected on fracture surfaces. Surficial materials are not very thick at the damsite. The topography is rugged and more detailed contours will be required to show the vertical step-like bluffs which are not reflected in presently available maps. The site of the arch dam is an excellent choice and no major geologic defects were observed.

A powerhouse and power conduit can be constructed in either bank of the Vodopad River, but the right (north) side appears superior with a tunnel arrangement. The rock is adequate for an unlined tunnel if this type proves to be economic and desirable. A cofferdam may be required at the powerhouse site.

The reservoir does not appear to pose leakage problems, but peripheral slope stability must be studied further. Aggregate materials may have to be transported from other source areas or manufactured if further studies of alluvial sources reveal unsuitable quantity or quality.

The site is in an active tectonic area. Earthquakes of M7.6, at Sitka, with attendant peak accelerations to 50 to 100 percent gravity, might be expectable in any 100-year period. Access for the recommended exploration program will be by boat and air if a pioneer road is not constructed. Costs of exploration will be commensurate with accessibility and availability of supplies.

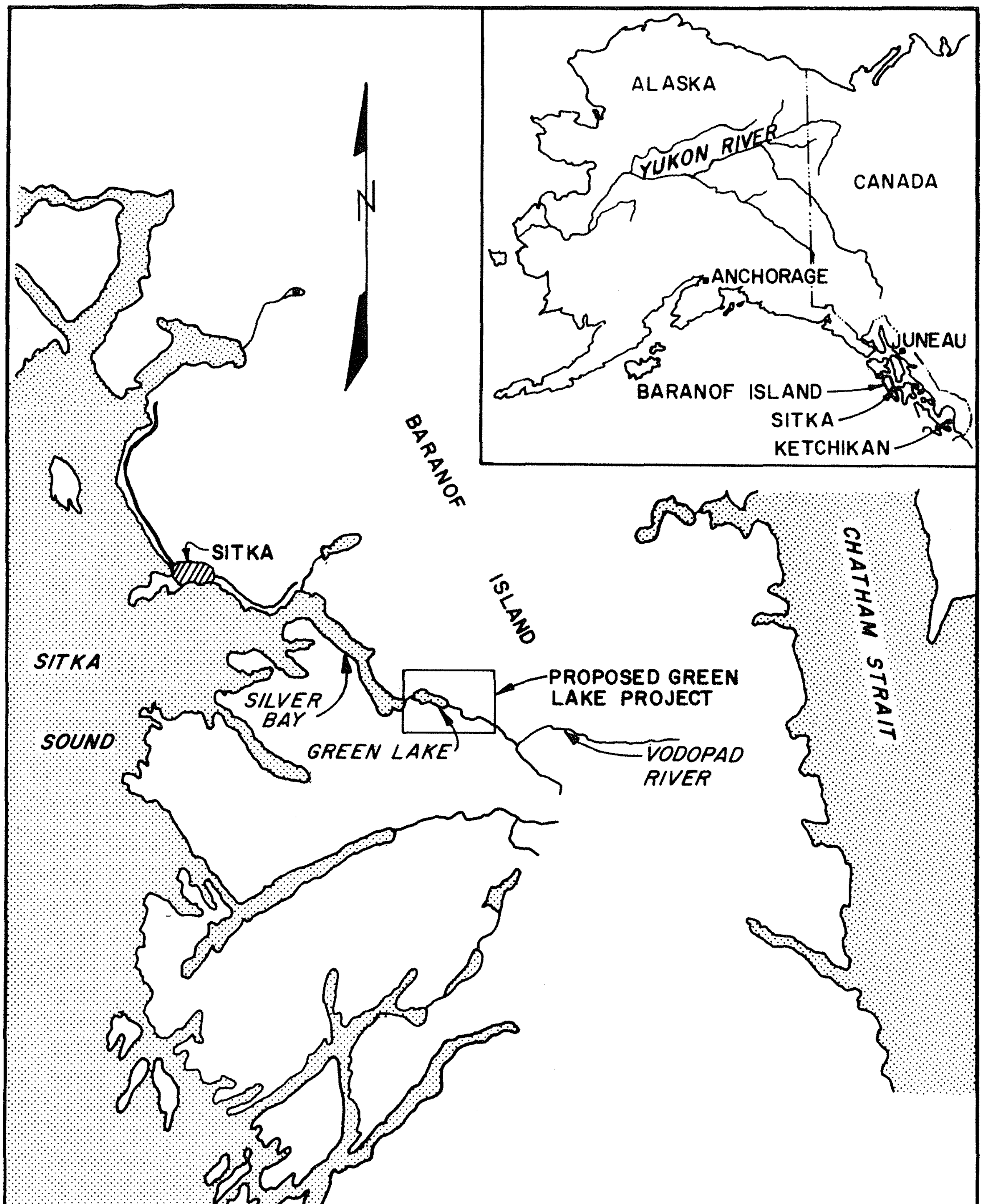
INTRODUCTION

This report presents the results of our preliminary geologic investigation of the proposed Green Lake Hydroelectric Project near Sitka, Alaska shown on the following page (Figure 1). The purpose of this investigation was to evaluate the geologic feasibility of constructing a 215-foot high concrete arch dam, power conduit, surface powerhouse, and other appurtenant works at the site. The tentative power scheme is presented on Plates 2 and 3. The scope of work included ten days of field work and eleven days of office work which included literature research, photogeologic interpretation, map compilation and report writing.

Mr. James V. Williamson, Supervising Executive Engineer, of R. W. Beck and Associates directed the study and Mr. Jon Delony of the same office assisted in the field work. Guidance and logistic support was provided by Messrs. Rocky Guitterez, Jim Dwyer, Larry Stratton and John Nelson of the City and Borough of Sitka.

A 30-foot power boat, with radio communcation and sleeping quarters, was rented and anchored at the head of Silver Bay for use as a "base camp". Mr. Dorman McGraw's 12-foot outboard motor boat provided transportation from "base camp" to shore and was also utilized for off-shore soundings and shoreline geology. Broad-scale geologic mapping of lineaments, landslides, talus, alluvium and bedrock outcrops was performed by helicopter and ground observations.

Various scaled contour maps were used for geologic mapping, i.e., 1" = 2000', 1" = 400' and 1" = 50' (USGS Planetable, 1967). H. G. Chickering's aerial photographs, flown for Alaska Lumber and Pulp, May 1957 (scale 1" = 1000') were stereoscopically examined for geologic input. Potential sources of other aerial photographs near Sitka are listed on page 4 (Table 1).



LOCATION MAP		
GREEN LAKE HYDROELECTRIC, PROJECT SITKA, ALASKA for R.W. BECK AND ASSOCIATES		FIGURE 1
DATE: NOV.19,1974	SCALE: 1"=5 MI.	PROJECT NUMBER W-74-315-AH
CONVERSE, DAVIS AND ASSOCIATES, INC.		

TABLE 1

POTENTIAL SOURCES OF VERTICAL AIRPHOTOS OF THE SITKA AREA FROM YEHLE (1974)

Areal Coverage	Scale	Date Flown	Designation of Photos	Organizations Responsible For Photography
Entire area	1:40,000	Aug. 1948	SEA 124, SEA 128, SEA 140.	U.S. Navy and U.S. Geological Survey, Washington, D.C.
Do	1:11,000	May 1957	ALP 7	H.G. Chickering and Alaska Lumber and Pulp Co., Sitka, Alaska
City of Sitka and part of Japonski Island	1:4,800	Aug. 1959	1-2 Sitka, Alaska Harbor Lines.	Photronix Inc., and U.S. Army Corps Engineers, Anchorage, Alaska
Do	1:12,000	July 1965	Sitka 1965	U.S. Bureau of Land Management Anchorage, Alaska
Unknown	1:30,000	May 1967	67L	U.S. National Ocean Survey
Do	1:30,000	June 1971	71E	U.S. National Ocean Survey
Do	1:10,000	July 1972	72E(C)	U.S. National Ocean Survey
Do	1:9,600	May 1968	Sitka	Alaska Department of Highways
Do	1:7,200	1971	Sitka	Alaska Department of Highways
Sitka & N. Portion Silver Bay	1:15,840	1969	EMC 13 EMC 14	U.S. Dept. of Agri-culture, Forest Service

No known site geologic investigation has been made prior to this one. Some broad-scale geology, performed by the U.S. Geological Survey, provided regional background information; especially Loney, 1964[(18)*] and Yehle, 1974[(40)]. Other pertinent geologic literature for Sitka and vicinity, is presented in the attached Reference list.

GEOGRAPHY

The Green Lake Hydroelectric Project is on the west side of Baranof Island in southeastern Alaska. The site is 12 miles east of Sitka at the head of Silver Bay. The topography is precipitous, rising approximately 4,000 feet within 1-1/2 miles of the shoreline. The steep-walled fiord at Silver Bay cuts sharply into Baranof Island. Several valley glaciers and small icefields have streams draining into Silver Bay and Green Lake. Silver Bay is cut as much as 600 feet below the general level of the floor of Sitka Sound[(34, 35, 36)].

Sitka's mean temperature in January, the coldest month, is 32.3°F and the mean temperature in August, the warmest month, is 55.5°F. Annual precipitation averages 96.57 inches[(37)]. Unofficial information indicates nearly 28 inches of rain fell in Sitka in October 1974, breaking all previous October rainfall records (October mean is about 11 inches). Snow cover is generally gone by June at lower elevations and by August at higher elevations.

Vegetation from shoreline to timberline (2,250 feet) consists of thick stands of coniferous pine trees and dense shrubs. Gentler slopes, saddles and valleys support spongy muskeg and moss.

Daily tidal range near Sitka averages 9.9 feet. U.S. Coast and Geodetic tidal records, tabulated on the following page, are relative to mean lower low water:

*Numbers in parenthesis (18) correspond to those in the attached Reference list.

	Feet
Highest tide observed (November 2, 1948)	14.6
Mean higher high water	9.9
Mean high water	9.1
Half tide level	5.3
Mean low water	1.4
Lowest tide observed (January 16, 1957)	-3.8

The population of Sitka and vicinity is about 7,000[39]. A paved road has been constructed up Silver Bay to the Alaska Lumber and Pulp mill at Sawmill Creek (See Plate 1). This is approximately 8 miles short of the Green Lake Hydroelectric Project. Present access to the site is by boat, air or foot.

REGIONAL GEOLOGY

Sitka probably was covered by glacier ice several times in the Pleistocene Epoch. The last interval may have been 2,750 feet thick, and most ice probably disappeared before 10,000 years ago. Landforms left after retreat of the last ice, includes elevated terrace deposits, rounded knobs of bedrock, U-shaped valleys (Green Lake) and steep-walled fiords (Silver Bay); the latter has been eroded hundreds of feet deeper than accompanying water surfaces.

The core of Baranof Island consists largely of Jurassic and Cretaceous granitic rocks, chiefly quartz diorite, intruded parallel to the metamorphosed stratified rocks on the east and west sides of the Island. The northeast and southeast sides of Baranof Island are bounded by two great northwest-trending lineaments that are major faults. These are the Chatham Strait and Peril Strait lineaments; developed along zones of intense crushing that are as much as one mile wide[39]. The Chatham Strait lineament is an extension of the "Denali lineament, a great arcuate fault that extends for 1,600 miles from Lynn Canal to Bristol Bay"[29].

Regional geologic conditions from Sawmill Creek easterly to the Vodopad River are presented on Plate 1. Bedrock consists chiefly of gray to dark gray graywacke of fine- to medium-grain. It is interbedded with subordinate amounts of very fine-grained phyllite and argillite. Foliation strikes northwest and is nearly vertical. Through-going joints trend northeast and are also nearly vertical.

The Chichagof-Sitka fault trends northwest, up Silver Bay, passing 3,000 feet northeast of the proposed damsite. An unnamed subordinate fault splays southeast from the Chichagof-Sitka fault near Bear Cove and its trace passes 3,000 feet southwest of the damsite. Neither fault was observed on the ground in the field due, in part, to the limited nature of the reconnaissance and, in part, to concealment beneath muskeg deposits. However, photogeologic interpretation, combined with a helicopter overview, strongly suggest these lineaments are fault-related. The integrity and soundness of the damsite bedrock, lying between these two faults, has not been impaired by these faults.

Plate 1 also delineates major surficial deposits. These include alluvium, which may be a potential source of construction materials; landslide and talus deposits are shown for consideration in the proposed power project and proposed access road alignment to the project site.

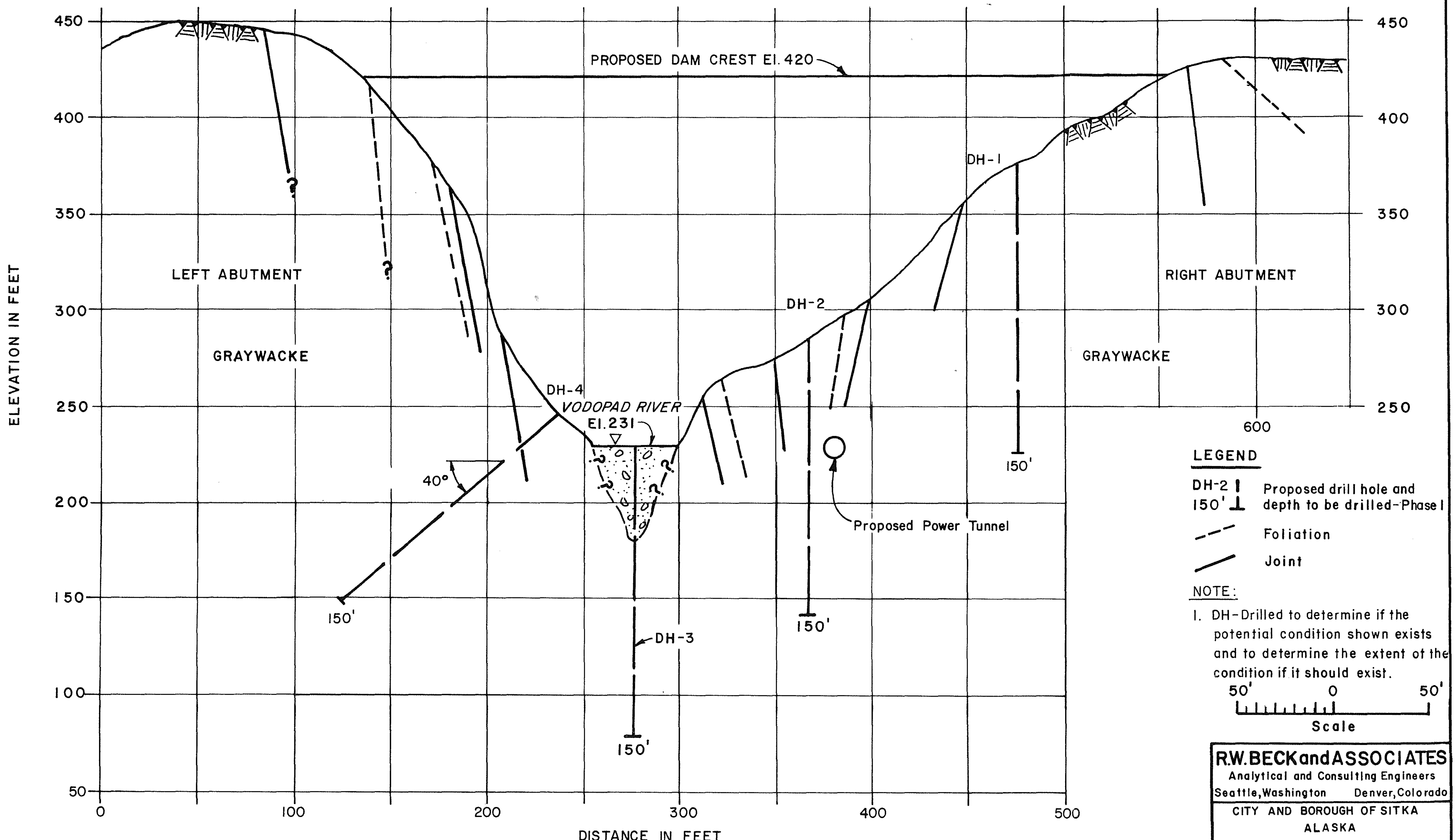
Bedrock and surficial deposits between Bear Cove and Green Lake are shown on Plate 2, in greater detail than Plate 1, for use in evaluating the dam and appurtenant works; e.g., powerhouse, power conduit, reservoir and road construction.

DAMSITE GEOLOGY

The proposed damsite is at the outlet of Green Lake. The lake, fed by the Vodopad River, is at approximately elevation 230 feet. From the lake outlet, water cascades through a narrow steep-walled canyon to tidal waters at the head of Silver Bay; a drop of 230 feet in a distance of about 1,500 feet. The average width of the creek bed is 40 feet and vertical drops of 20 to 30 feet are commonplace. Although riverbed conditions in the water cascades are not known, the swiftness of the water strongly suggests surficial material (gravels and weathered bedrocks) have been swept clean. This must be confirmed by boring in the riverbed. Several small, 50 to 100 foot high, "hanging" tributaries were observed in bluffs between the Green Lake outlet and the head of Silver Bay.

The damsite (Plate 3) is underlain by very hard, competent graywacke bedrock interbedded with subordinate phyllite and argillite. The graywacke is massive and breaks with a hackly fracture. The foliation is ill-preserved, but where observed it consists chiefly of hard, brittle, tight northwest trending phyllite - argillite plates, spaced 3 inches to 50 feet apart, averaging perhaps 20 feet apart. The northeast trending joints are also tight at the surface and are spaced 3 inches to 40 feet apart averaging 4 feet or more apart. Although the foliation and joint surfaces are tight, they are less resistant to erosion than the graywacke, consequently the northwest and northeast trending lineaments are pronounced. Exploration will be required to provide information needed to evaluate rock quality and the tightness of lineaments at depth. The location of proposed diamond drill holes are shown on Plate 3, and, in the Geologic Section at the dam axis on the following page (Figure 2).

No evidence of gouge or shear movement was observed on foliation or joint surfaces. The graywacke is not schistose and all lineaments appear to be very tight. The damsite bedrock is classified as fresh. Weathering is limited to minor iron stains, perhaps extending 5 to 10 feet vertically into the rock due to tree root growth and freeze-thaw effects near the



Elevations based on Mean Sea Level (MSL) datum.

SECTION A-A

(SEE PLATE 3)

Prepared By
CONVERSE, DAVIS and ASSOCIATES
Consulting Engineers and Geologists

R.W. BECK and ASSOCIATES
Analytical and Consulting Engineers
Seattle, Washington Denver, Colorado

CITY AND BOROUGH OF SITKA
ALASKA

GREEN LAKE HYDROELECTRIC PROJECT

GEOLOGIC SECTION - DAM AXIS

DATE:	DRAWN:	APPROVED:	FIG:
NOV 1974	G. L. F.	H. A. S.	2

surface. Weathering does not detract from the integrity of the damsite foundation, except on steep bedrock slopes which exhibit some surficial evidence of creep (tilted and bent tree trunks) due to frost heave. For preliminary cost purposes for the proposed arch dam, foundation excavation should not exceed 20 feet, measured normal to the slope.

The existing contour maps at the damsite do not reflect the step-like vertical faces which rise 40 to 50 feet on both abutments. The abutments appear to be free of landslides and thick talus accumulations. Surficial deposits consist of soil-muskeg mixtures which support a dense stand of pine trees. The depth of surficial material is unknown, but could range from 0 feet on bare rock faces to more than 15 feet on the muskeg covered bench-like feature at elevation 350 to 450 feet on the right (north) abutment.

A spillway can be located over the center of the dam or in the abutment. Bedrock conditions at either location must be evaluated in more detail for stability and erosional tendencies.

Partial "clearings" on the right abutment (see Plate 3) afford the best site for a helicopter landing or campsite and would require falling the least number of trees to prepare the ground.

In summary, the bedrock conditions indicate this is an excellent site for a concrete arch dam.

POWERHOUSE GEOLOGY

A powerhouse could be built on either the north or south side of the Vodopad River waterfalls at the head of Silver Bay (see Plate 2). From a geologic standpoint, the bedrock on the north side is slightly less fractured and there are no rock slides near the site. From an access standpoint, assuming the construction road is on the north shore of Silver Bay, the north side would also be favored. Both sites pose some design and construction problems due to:

1. 11-foot tides,
2. Near vertical rock bluffs at tide line,
3. Steep 1/2:1 to 1:1 drop-offs below tide line, e.g., as much as 66 feet only 15 feet from the shoreline (see Plate 4),
4. Lack of "level" construction space on the slopes above the shoreline, and
5. Possibly some talus accumulations at scattered points above the sites.

Excellent bedrock exposures at tide line indicate the shoreline is underlain by sound graywacke. No faults, shears, or crushed zones were observed. Near vertical joint and foliation surfaces are spaced 1 to 5 feet apart on the north side and 1/2 to 4 feet on the south side.

A small rock slide, with an attendant underwater toe, is present approximately 250 feet south of the mouth of the Vodopad River (see Plate 2). The depth of water at the toe (at low tide) is 4.5 to 15 feet. Another rock slide was observed approximately 700 feet north of the mouth of the Vodopad River. The depth of water at the toe (at low tide) is 13 feet (see Plate 4). Both slides occur on slopes steeper than 1:1 and are apparently related to intersecting fractures. The slides could have been triggered by freeze-thaw or ground shaking events.

About 73 earthquakes have been felt in the Sitka area[40] suggesting powerhouse construction should consider seismic and seiche wave design, and, the site should not be located below slides or steep talus deposits.

Should it be impractical to construct a cofferdam around the powerhouse excavation in the tide zone, a rock wall between tide zone and the powerhouse excavation could be considered. This simply means setting back from the shoreline the thickness of the rock wall (possibly 25 feet) and starting the excavation. Upon completion of work, below the tide-effected area, the rock wall can be removed, or, outlets mined through the rock wall.

POWER CONDUIT GEOLOGY

The power conduit could be a pressure tunnel or tunnel above ground steel penstock combination in either abutment. Due to some very rugged (vertical) bluffs and steep V-shaped reentrants along possible conduit alignments, on either abutment, it appears a route entirely in tunnel is most preferable; especially so in the right abutment when considering access to construction of the powerhouse.

The tunnel route in either abutment would be driven through rocks similar to that described at the damsite. The major lineaments are nearly vertical joints and foliation planes, e.g., joints that strike N20°-40°E, and, foliation which strikes N60°-80°W. These will intersect at approximately right angles along tunnel alignments. Overbreak could develop at these intersections, or, where the tunnel line is driven parallel to closely spaced fractures. If it is economic and desirable, it appears that the tunnel need not be lined, except perhaps at intersections of closely spaced fractures. The joints and foliation surfaces should be tight but could leak where the side cover of the tunnel is minimal, such as at V-shaped reentrant gullies. The tunnel should be driven upslope (eastward). A few borings, with water-pressure tests, along the selected route (see Plate 2) should provide definitive answers to tunnel rock and ground water conditions. Cursory observations indicate tunnel portals can be started in sound bedrock, at both ends.

A diversion tunnel could be driven from the power tunnel to by-pass water around the dam during construction (see Plate 3). An impervious rockfill cofferdam, constructed at the mouth of Green Lake, would direct the Green Lake water into the diversion tunnel, allowing construction of the dam foundation "in the dry". Foundation conditions beneath the cofferdam site are not presently known and should be investigated.

GREEN LAKE RESERVOIR GEOLOGY

Most of the reservoir was not examined in the field, and, available aerial photography did not cover much of the area. However, some impressions obtained from a helicopter flight, literature review, and limited aerial photo examination are worth noting. The east end of Green Lake is known to be at least 89 feet deep and the west end 54 feet deep. Some "shallows" (about 4 feet deep) occur 2,000 feet east of the damsite (see Plate 1). This "shallow" could represent a source of fine-grained aggregate and should be explored further, if practical.

The reservoir is underlain by graywacke which rises abruptly from the shoreline. Because of the rugged terrain about the lake, landslides and talus deposits occur at the base of steep slopes, including a few avalanche chutes along well-defined joints and foliations. The nearest known large talus deposit is approximately 1,000 feet upstream (east) of the damsite on the left (south) bank of Green Lake (see Plates 1 and 2). Stability of this, and other deposits around the reservoir perimeter, could be effected by rapid water level fluctuations and/or earthquake events and deserve more comprehensive evaluation.

The joint and foliation system appears to be tight, similar to the damsite rocks, thereby minimizing any concern for reservoir leakage. The rate of siltation should be negligible for the life of the reservoir since minor quantities of organic silt and rock flour are the only known sediments being contributed by tributary glaciers and streams. A dense stand of timber in the reservoir bottom land, as well as on the banks, will require thorough clearing and grubbing up to maximum water line to keep debris from collecting at trash racks, inlets and spillways. The southeastern trace of the Chichagof-Sitka fault trends through the center of the Green Lake reservoir (see Plate 1) but should not be a source of leakage, and, "the possibility of movements causing large earthquakes is concluded to be very slight."(40)

A boring should be drilled at the mouth of Green Lake, just upstream of the dam axis, to determine the depth of sediments, bedrock profile and establish the foundation conditions for the cofferdam (see Plate 3).

ACCESS ROAD GEOLOGY

The anticipated access road alignment along Silver Bay shoreline, from Herring Cove to the Green Lake Hydroelectric Project will be generally close to the shoreline. The salient geologic features noted below are based on a helicopter flight, photogeologic interpretations and shoreline observations from a boat (see Plates 1 and 4):

1. Herring Cove to Bear Cove - Several landslides, potential landslides and avalanche chutes are present and periodic maintenance should be anticipated. Based on soundings, it is quite possible that the landslide on the north side of Bear Cove can be circumvented by placing fill in the tide zone. This may be the solution at other landslides noted along the route.

2. Bear Cove Ridge at Point Ranus - Soundings around the periphery of this rock nose strongly suggest that underwater slopes are steeper than 1:1 and that there is no "shelf" to place a rockfill road at tide line. The alternatives are: (1) bench the road into near vertical cliffs; (2) go up-and-over the nose, or (3) tunnel through 1/2 mile of the nose.

3. Bear Cove to Head of Silver Bay - A one mile section, immediately south of Point Ranus, has 40 to 50-foot vertical rock bluffs rising from the tide line; the section southerly of this is less steep and a road can be constructed relatively easily. No significant landslides or unstable talus deposits were observed on this section of road.

4. Head of Silver Bay to Powerhouse and Damsite - The powerhouse section will require drilling and blasting a bench approximately 50 feet above tide line and the road will cross gullies and one landslide. The damsite section will require several switchbacks and must cross a moderately large landslide.

CONSTRUCTION MATERIALS

The graywacke is suitable for the quarrying and manufacture of coarse aggregate for concrete, rock fill and riprap(40). In decreasing order of abundance, quartz, quartzite, plagioclase, chert and rock fragments are present in the graywacke. Bedrock in the damsite area appears to be siliceous and should break into angular fragments. Coarse aggregate is also available from talus deposits and dredging large subround to subangular cobbles in alluvial deposits.

Local sources of fine aggregate for concrete, requiring further investigation, could be alluvial cobbles, gravel and possibly sand deposits at the following locations:

1. At the mouth of an unnamed stream approximately 1 mile west of the damsite in Silver Bay (see Plates 1 and 2),

2. At the head of Bear Cove approximately 2.5 miles north of the damsite (see Plate 1),

3. At the head of Green Lake approximately 2 miles east of the damsite (see Plate 1), and

4. Possibly the "shallows" about 2,000 feet east of the damsite (see Plate 1).

These potential sources should be investigated as thoroughly as possible, for if suitable, could provide substantial economy.

PHYSICAL PROPERTIES OF CONSTRUCTION MATERIALS

Listed below are physical properties of graywacke at Sitka, as determined by the Alaska Department of Highways, from samples obtained from the quarry about 600 feet east of Indian River and from preconstruction core drilling for the bridge from Sitka to Japonski Island [40]:

1. Hard and durable.
2. Good resistance to chemical and physical weathering.
3. Specific gravity 2.74.
4. Unconfined compressive strength averages 11,600 pounds per square inch (psi) ranging from 7,745 to 18,825 psi based on cores from the Sitka bridge.
5. Has good drilling and blasting properties[9].
6. Used as riprap for the Crescent Bay small-boat harbor breakwater and the Sitka Airport runway.

Physical properties of muskeg (peat) as reported by Yehle are:

1. In-place shear strength values at depth 6 feet = 100 to 400 pounds per square foot.
2. Estimated average shear wave velocity = 130 feet per second.
3. Moisture contents range = 120 to 860 percent of dry weight of solid matter.
4. Highly compressible.

EARTHQUAKE HISTORY[40]

Southeastern Alaska is part of an active tectonic belt that rims the Pacific Ocean. Some of the major active faults are shown on the following pages (Figures 3 and 4). Movement along faults in the Fairweather-Queen

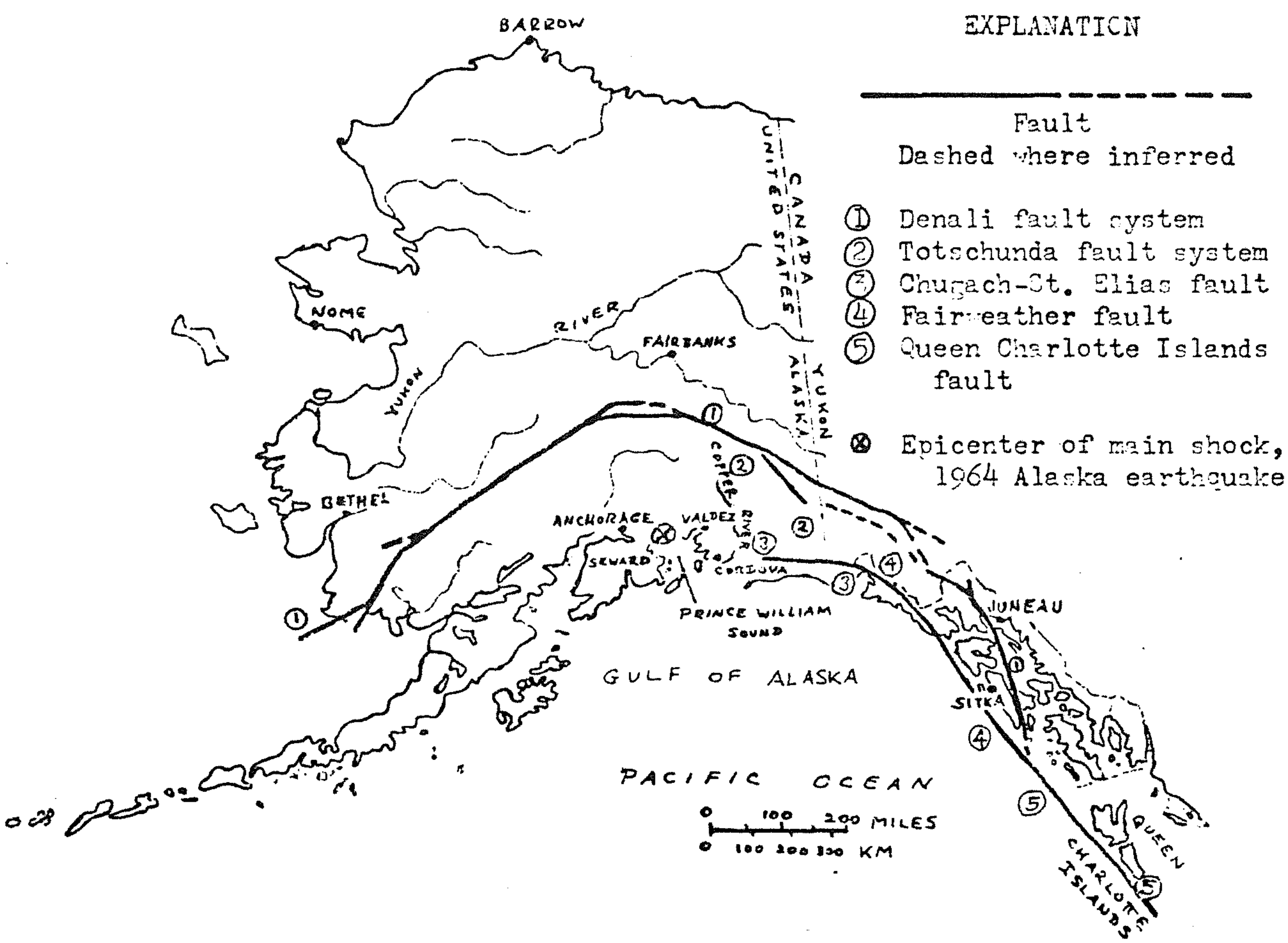


Figure 8.--Major elements of the Denali and Fairweather-Queen Charlotte Islands fault systems, Alaska and adjacent Canada. Modified from Grantz (1966), Tobin and Sykes (1968), Plafker (1969; 1971), Richter and Matson (1971), Berg, Jones, and Richter (1972), Berg and Plafker (1973), and Page and Gawthrop (1973).

REFERENCE: USGS Open-File Report 74-53 (1974)

FIGURE 3

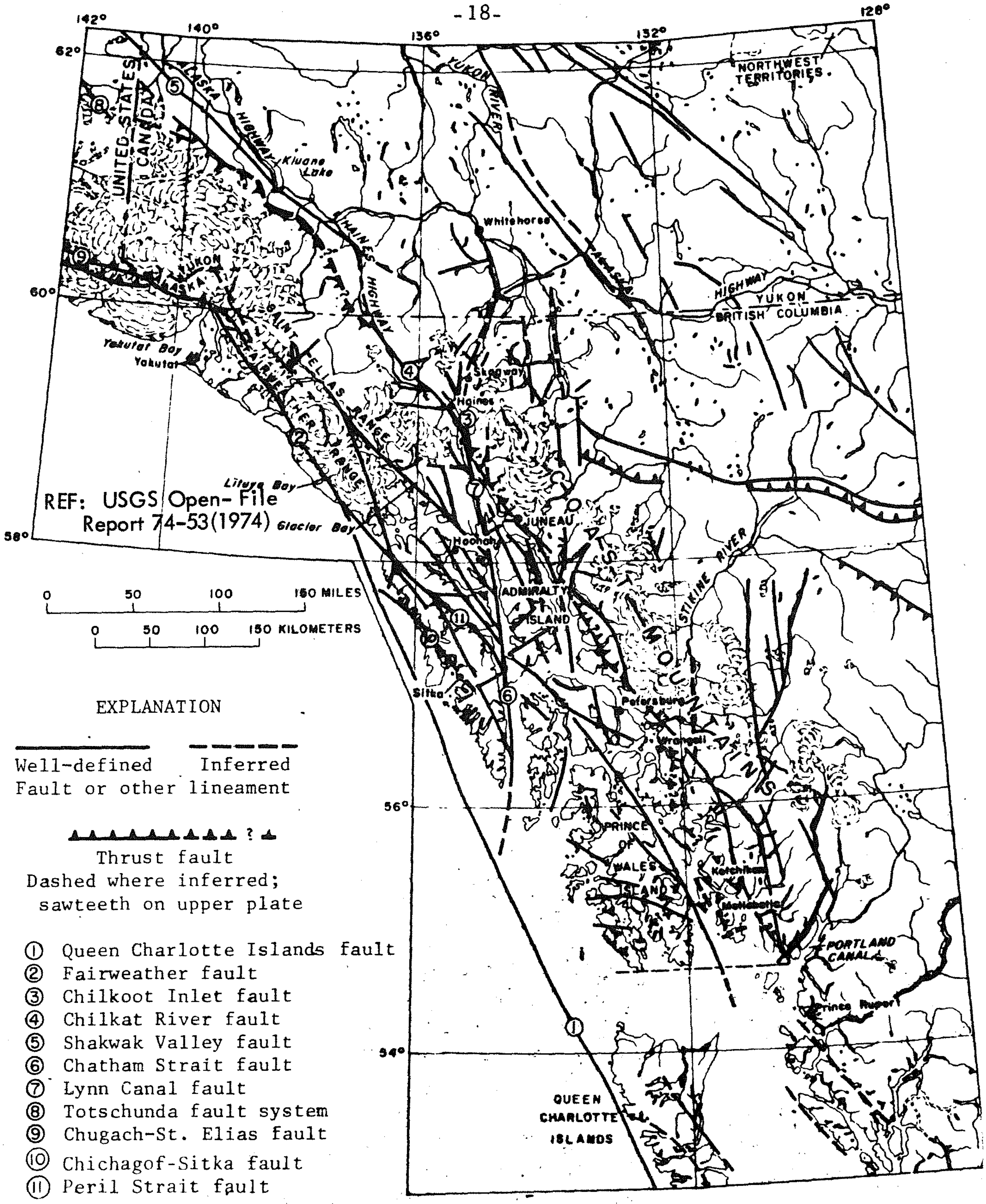


Figure 9.--Map of southeastern Alaska and adjacent Canada showing major faults and selected other lineaments interpreted to be probable or possible faults, shear zones, or joints. Taken from St. Amand (1957), Twenhofel and Sainsbury (1958), Gabrielse and Wheeler (1961), Brew, Loney, and Muffler (1966), Tobin and Sykes (1968), Canada Geological Survey (1969a, b), King (1969), Plafker (1969, 1971), Souther (1970), Richter and Matson (1971), and Berg, Jones, and Richter (1972), with additions and modifications by the writer.

FIGURE 4

Charlotte Islands fault system is thought to be similar to movement along the San Andreas fault system in California and is part of the Pacific plate. Theoretical calculations indicate that motion may average 2-1/4 inches per year. The total relative right-lateral horizontal slip along the Fairweather fault may be as much as 150 miles. After the M8.0 earthquake of July 10, 1958, 21.5 feet of right-lateral movement was measured at one place along the onland segment of the fault[32]. An area of active thrust faulting at depth is indicated by the M6.7 July 1, 1973 earthquake about 35 miles offshore from the northwestern part of Chichagof Island [10]. This fault probably merges with the Fairweather fault.

Several major faults cross Chichagof and Baranof Islands in a northwest direction following linear valleys and fiords (Figure 4). No historic movement along any of the faults on Chichagof and Baranof Islands has been reported. Among the major faults are the Peril Strait and Chichagof-Sitka faults.

Peril Strait Fault

The right-lateral Peril Strait fault is a concealed feature about 110 miles long which appears to join the Fairweather fault with the Chatham Strait fault. Movement has been dominantly right-lateral in direction[4]. Major movements probably took place sometime after the Miocene; minor movements may have continued into the Holocene time.

Chichagof-Sitka Fault

The Chichagof-Sitka fault zone traverses Silver Bay and Green Lake. About 3 miles of right-lateral offset is evident near its southeast end. The exposed part of the fault zone forms a conspicuous linear depression of sheared bedrock that may be as much as 1/2 mile wide. The possibility of movements causing large earthquakes along the Chichagof-Sitka fault is concluded to be very slight according to Yehle[40]. More detailed studies for the Green Lake Project will be required to confirm this opinion.

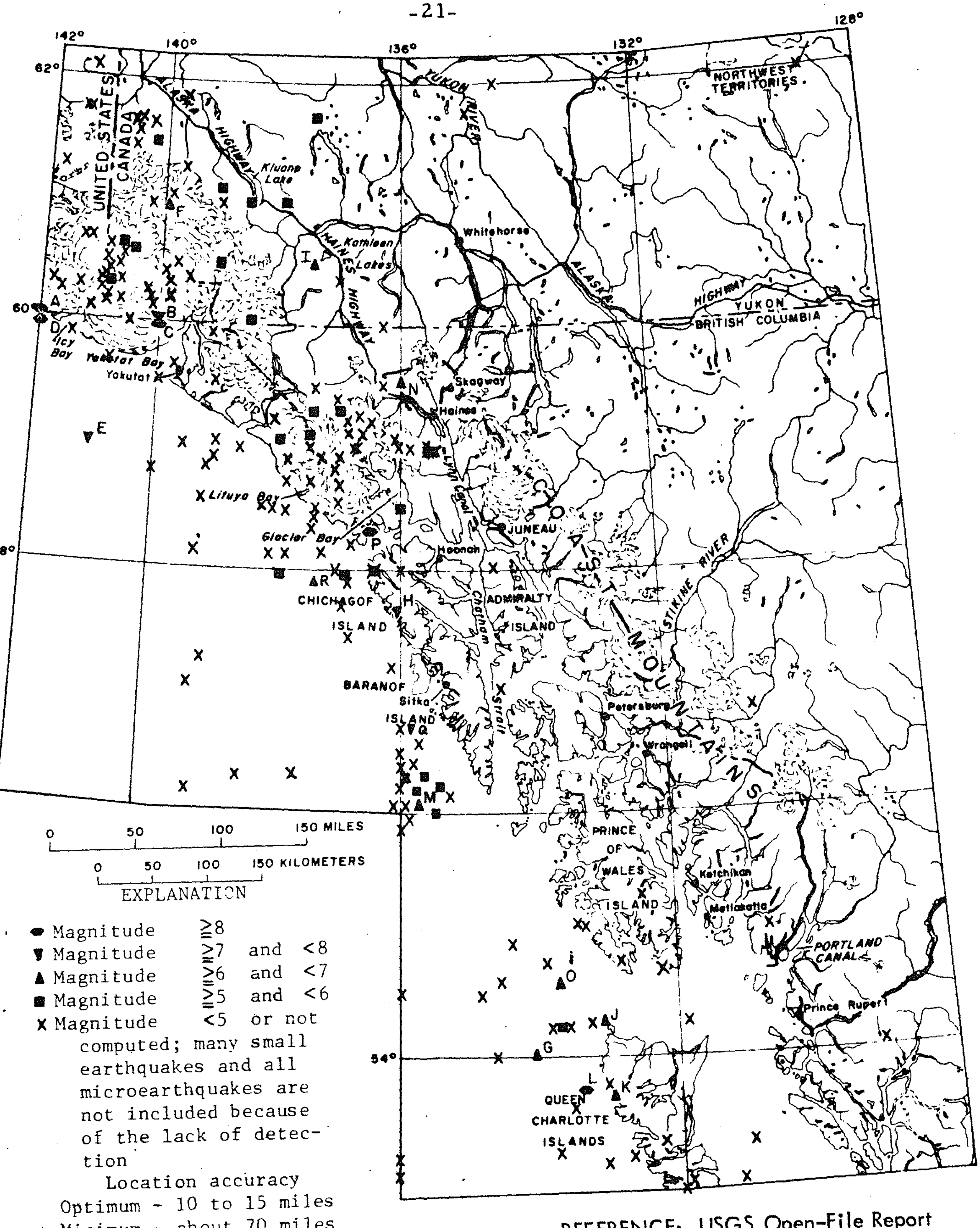
Unnamed Fault

A fault about 10 miles long trends northeastward in a valley whose mouth is at Bear Cove in Silver Bay (see Plate 1). The valley is along the route of a proposed highway from Sitka to Chatham Strait[1]. This fault is the only one reported near the Green Lake Project for which estimates of a substantial offset have been determined. Movement along the fault caused a left-lateral offset of about 0.6 mile and probably occurred in post-Eocene and pre-Miocene time. This fault is about 2-1/2 miles north of the proposed damsite and should not have any significant influence on the project.

SEISMICITY[40]

The earthquakes that have been instrumentally recorded and located by permanent stations during the period 1899 to 1972 are shown on Figure 5. Except in rare cases, these events are shallow (less than 18 miles). Figure 5 indicates nine earthquakes, of M7.0 or greater, have occurred near the coastline of southeastern Alaska. It also shows that within 100 miles of Sitka there have been three M7+, two M6+ and six M5+ events in historic time. Table 2 lists 73 earthquakes felt at Sitka from 1832 through 1973.

The U.S. Army Corps of Engineers seismic probability map, which relates possible damage to earthquake magnitudes in the Sitka area, is shown on Figure 6. The Uniform Building Code map, 1970 Edition, relating



REFERENCE: USGS Open-File Report 74-53 (1974)

Figure 11.--(See facing page for caption.)

FIGURE 5
(See next page for captio

Dates and magnitudes of some earthquakes of magnitude ≧6

Designation on map	Date (universal time)	Magnitude
A	September 4, 1899	8.2-8.3
B	September 10, 1899	7.8
C	September 10, 1899	8.5-8.6
D	October 9, 1900	8.3
E	May 15, 1908	7
F	July 7, 1920	6
G	April 10, 1921	6.5
H	October 24, 1927	7.1
I	February 3, 1944	6 1/2
J	August 3, 1945	6 1/4
K	February 28, 1948	6 1/2
L	August 22, 1949	8.1
M	October 31, 1949	6 1/4
N	March 9, 1952	6
O	November 17, 1956	6 1/2
P	July 10, 1958	7.9-8.0
Q	July 30, 1972	7.1-7.6
R	July 1, 1973	6.7

Figure 11.--Map showing locations of epicenters and approximate magnitude of earthquakes in southeastern Alaska and adjacent areas, 1899-1972, and July 1, 1973. Data from Canada Dept. Energy, Mines and Resources, Seismological Service (1953, 1955, 1956, 1961-1963, 1966, 1969-1973), Davis and Echols (1962), Internat. Seismological Centre (1967-1972), Milne (1963), Tobin and Sykes (1968), U.S. Coast and Geodetic Survey (1930-1970, 1964-1970, 1969), Wood (1966), U.S. Natl. Oceanic and Atmospheric Adm. (1971, 1972, 1973a, b), Lander (1973), and Page and Gawthrop (1973; written commun., 1973).

REFERENCE: USGS Open-File Report 74-53 (1974)

FIGURE 5 - CAPTION

TABLE 2

Partial list of earthquakes felt and possibly felt at Sitka, Alaska, 1832 through 1972, and July 1, 1973

Date[1]	Comment[2]	Reference[3]	Distance, miles (and km), and direction to epicenter shown on fig. 11	Magnitude	Possible radius of perceptibility, miles (and km) (Gutenberg and Richter, 1956)	Distance, miles (and km), direction, and place nearest Sitka at which felt
Dec. 1832	Quite strong----------------	1	?	?	-----------	----------------
Dec. 15, 1843	Two light shocks------------	2	?	?	-----------	----------------
Dec. 16, 1843	Strong shock 3 sec. long, and a feeble shock.	2	?	?	-----------	----------------
Apr. 6, 1847	Very severe; seven shocks; ground crack, "Lincoln St."	2, 3	?	?	-----------	----------------
Apr. 21, 1861	Shaking---------------------	2	?	?	-----------	----------------
Oct. 26, 1880	Severe shock 18 sec., ground-surface waves, three later slight shocks (see description, table 6).	4	?	?	-----------	----------------
Oct. 27, 1880	Five slight to sharp shocks-	4	?	?	-----------	----------------
Oct. 29, 1880	Five shocks-----------------	4	?	?	-----------	----------------
Nov. 13, 1880	Shock-----------------------	4	?	?	-----------	----------------
Nov. 14, 1880	Two shocks, first 6 sec. long.	4	?	?	-----------	----------------
Sept. 4, 1899	Felt?-----------------------	2	320 (510) NW	~8.3	>360 (>575)	95 (150) NE Juneau.
Sept. 10, 1899	Very slight shock-----------	2	270 (430) NW	~8.6	>360 (>575)	----------------
Sept. 23, 1899	Felt? (Possibly felt, according to Tarr and Martin, 1912.)	2	?	?	-----------	----------------
Oct. 9, 1900	Felt?-----------------------	2	320 (510) NW	8.3	>360 (>575)	170 (270) N Skagway.
Sept. 24, 1907	Very pronounced shock-------	5	?	?	-----------	----------------
Oct. 5, 1907	Felt?-----------------------	2	?	?	-----------	35 (55) NE near Angoon.
May 15, 1908	Slight shock----------------	2	250 (400) NW	7	240 (380)	----------------
Feb. 16, 1909	----do----------------------	2	?	?	-----------	----------------
July 11, 1909	Distinct shock, III---------	2	?	?	-----------	----------------
Mar. 14, 1910	Felt------------------------	6	?	?	-----------	----------------
July 7, 1910	----do----------------------	6	?	?	-----------	----------------
Nov. 21, 1912	Moderate shock--------------	6	?	?	-----------	----------------
Dec. 15, 1917	Heaviest shock in years-----	6	?	?	-----------	----------------
Mar. 18, 1919	Felt?-----------------------	7	80 (130) SW	?	-----------	----------------
Dec. 15, 1919	Felt------------------------	8	?	?	-----------	----------------
May 8, 1920	Felt?-----------------------	7	80 (130) SW	?	-----------	----------------
Apr. 25, 1923	----do----------------------	8	170 (270) NW	5.75	125 (200)	95 (150) NE Juneau.
June 22, 1923	----do----------------------	7	75 (120) SW	?	?	----------------
Oct. 25, 1925	----do----------------------	7	75 (120) SW	?	?	----------------
Oct. 24, 1927	Felt; cracks in some buildings.	6	55 (90) NW	7.1	260 (415)	----------------
Nov. 13, 1927	Generally felt--------------	6	75 (120) SW	?	-----------	----------------
Nov. 21, 1927	Felt------------------------	6	75 (120) SW	?	-----------	----------------
Dec. 31, 1927	----do----------------------	6	75 (120) SW	?	-----------	----------------
Mar. 3, 1929	Two shocks------------------	6	?	?	-----------	----------------
Sept. 1, 1929	Felt------------------------	6	?	?	-----------	----------------
Dec. 10, 1932	Felt by a few---------------	6	?	?	-----------	----------------
May 4, 1934	Felt------------------------	6	?	?	-----------	----------------
May 29, 1936	----do----------------------	6	?	?	-----------	----------------
Sept. 28, 1937	Felt?-----------------------	6	?	?	-----------	72 (115) N Hoonah.
Oct. 15, 1945	Felt------------------------	8	210 (335) NW	?	-----------	----------------
Nov. 16, 1945	----do----------------------	9	75 (120) NW	~5.6	120 (190)	----------------
Apr. 30, 1947	----do----------------------	8	195 (310) NW	?	?	----------------
Nov. 30, 1948	Felt?-----------------------	8	?	?	-----------	55 (90) SSW Little Port Walter.
Aug. 22, 1949	Felt------------------------	3	250 (400) SSE	8.1	>360 (>575)	----------------
Oct. 31, 1949	Felt and felt?--------------	10 10	75 (120) SW	6.5 and ~6.	180 (290), and 132 (210).	----------------

REFERENCE: USGS Open-File Report 74-53 (1974)

TABLE 2 (Cont'd.)

Partial list of earthquakes felt and possibly felt at Sitka, Alaska,

1832 through 1972, and July 1, 1973--Continued

Date[1]	Comment[2]	Reference[3]	Distance, miles (and km), and direction to epicenter shown on fig. 11	Magnitude	Possible radius of perceptibility, miles (and km) (Gutenberg and Richter, 1956)	Distance, miles (and km), direction, and place nearest Sitka at which felt
Mar. 9, 1952	Felt------------------------	6	175 (280) NNW	6	132 (210)	-----------------
Sept. 28, 1952	----do----------------------	6	170 (270) NW	?	-----------	-----------------
Oct. 28, 1955	----do----------------------	6	145 (230) NW	?	-----------	-----------------
Apr. 27, 1956	Felt?-----------------------	6	?	?	-----------	50 (80) NW Chichagof.
Nov. 17, 1956	----do----------------------	6	190 (300) SSE	6.5	180 (290)	95 (150) ESE Petersburg.
June 1, 1957	----do----------------------	10	100 (160) NW	?	-----------	-----------------
June 5, 1957	----do----------------------	7	80 (130) NNW	?	-----------	-----------------
June 23, 1957	Felt------------------------	6	115 (185) NW	~5.6	120 (190)	-----------------
Apr. 9, 1958	----do----------------------	6	165 (265) SW	?	-----------	-----------------
May 5, 1958	V, felt by nearly all, numerous alarmed.	6	60 (95) NW	?	-----------	-----------------
July 10, 1958	VI, VII---------------------	11, 6	100 (160) NNW	~8	360 (575)	-----------------
July 13, 1958	Felt------------------------	6	85 (135) NW	~5.6	120 (190)	-----------------
July 17, 1958	----do----------------------	6	80 (130) NW	?	-----------	-----------------
July 8, 1963	----do----------------------	6	30 (50) E	3.7	35 (55)	-----------------
Mar. 28, 1964	II, not felt Japonski Island.	6	525 (840) NW	8.4	>360 (>575)	-----------------
Mar. 29, 1964	Felt, at Japonski Island----	6	?	?	-----------	-----------------
Mar. 25, 1966	Felt------------------------	6	37 (60) SW	~4.7	80 (130)	-----------------
Apr. 16, 1966	Felt?-----------------------	6	37 (60) SW	4.1	52 (85)	-----------------
Oct. 10, 1966	----do----------------------	6	30 (50) WNW	4.8	85 (135)	-----------------
Apr. 12, 1967	Felt------------------------	6	65 (105) SSW	4.4	68 (110)	-----------------
July 15, 1971	----do----------------------	6	210 (335) SSE	5.2	100 (160)	-----------------
July 30, 1972	VI+, strong; felt for probably 40 sec.; many aftershocks felt.	6, 12	30 (48) SW	7.1-7.6	~280 (~450)	-----------------
Aug. 4, 1972	II--------------------------	6, 12	65 (105) SW	5.0	90 (145)	-----------------
Aug. 4, 1972	V, probably several aftershocks felt.	6, 12	60 (95) S	5.8	125 (200)	-----------------
Aug. 15, 1972	III-------------------------	6, 12	55 (90) SSW	5.0?	90 (145)	-----------------
Nov. 17, 1972	Felt------------------------	6	75 (120) S	5.0	90 (145)	-----------------
Dec. 8, 1972	Felt?-----------------------	6	57 (90) SW	4.2	58 (95)	-----------------
July 1, 1973	Felt. Minor damage----------	6	90 (145) NW	6.7	200 (320)	-----------------

[1]Dates are u.t. (universal time) except first 10 entries; among these, only entries of 1832, 1843, 1848, and 1861 might be Julian Calendar (12 days after Gregorian Calendar in 19th century); all other entries use Gregorian (present-day) Calendar.

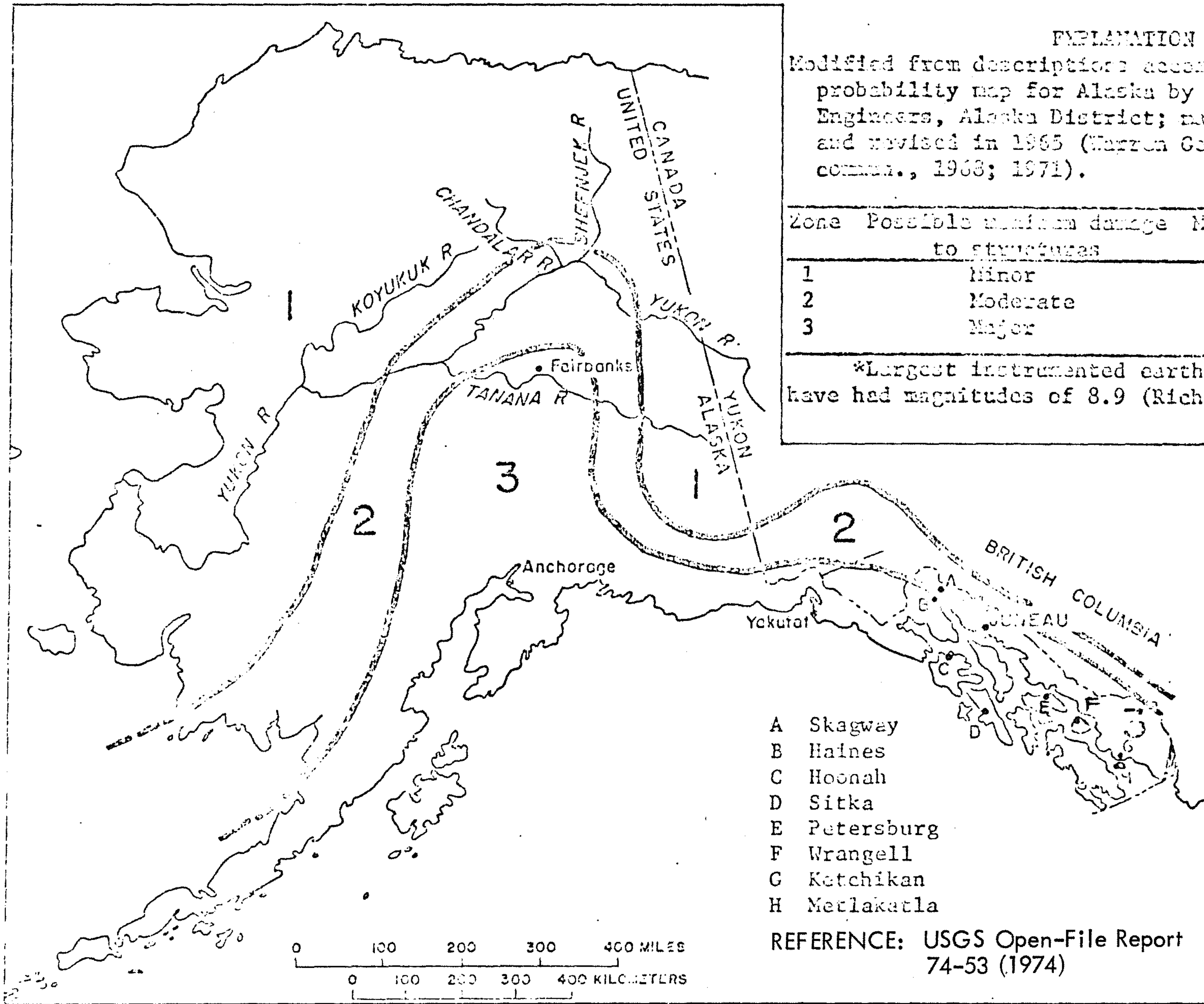
[2]Felt, Published report of single or multiple earthquake shocks of unknown intensity at Sitka.

Felt?, Earthquake possibly felt at Sitka but as far as can be determined there is no readily available published report of the event's being felt at Sitka. However, an earthquake did occur, known because of (1) a published report of its being felt elsewhere in the region, and (or) (2) an instrumental record and epicenter plot (fig. 11) of the earthquake by seismologists. (Tabulation based on (1) radius of average distance perceptibility of earthquakes as described by Gutenberg (1956, p. 141) if epicenter and magnitude are known, and (2) general evaluation of regional geologic structure.) Newspapers published at Sitka were not examined; these probably would provide many additional accounts of earthquakes.

III, Published report of earthquake intensity, Modified Mercalli intensity scale (see table 5).

[3] 1 Krause (1885).
2 Tarr and Martin (1912).
3 L. E. Thielke (Sitka Historical Soc., oral commun., 1965); M. Reid (Sitka Borough Office, oral commun., 1971).
4 Monthly Weather Review, U.S. War Department (1881).
5 Reported in the Fairbanks [Alaska] Daily News for September 24, 1907.
6 U.S. Coast and Geodetic Survey (1930-1970); Heck (1958); Eppley (1965); Wood (1966); U.S. National Oceanic and Atmospheric Administration (1973a, b); or Lander (1973).
7 Milne (1956 or 1963).
8 U.S. Weather Bureau (1918-1958).
9 Davis and Echols (1962).
10 Tobin and Sykes (1968); Sykes (1971).
11 Davis and Sanders (1960).
12 Page and Gawthrop (1973, written commun., 1973).

REFERENCE: USGS Open-File Report 74-53 (1974)



EXPLANATION

Modified from descriptions accompanying the seismic probability map for Alaska by U.S. Army, Corps of Engineers, Alaska District; map prepared in 1957 and revised in 1965 (Warren George, written commun., 1968; 1971).

Zone	Possible maximum damage to structures	Magnitude of largest probable earthquake
1	Minor	3.0-4.5
2	Moderate	4.5-6.0
3	Major	>6.0*

*Largest instrumented earthquakes of the world have had magnitudes of 8.9 (Richter, 1958).

Figure 12.--Seismic probability map for most of Alaska as modified from U.S. Army Corps of Engineers, Alaska District.

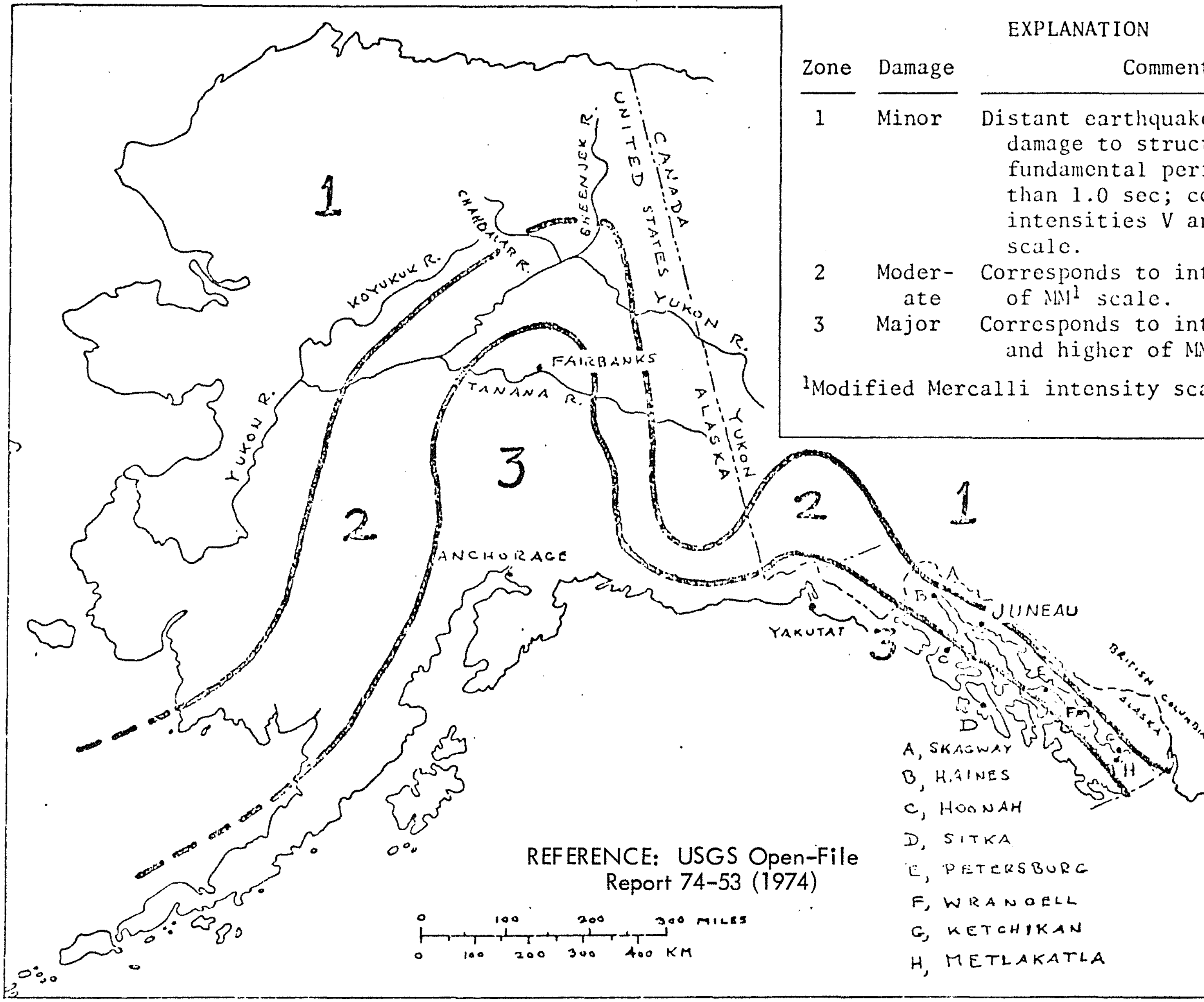
FIGURE 6

possible damage to Modified Mercalli intensities of earthquakes in the Sitka area, is shown on Figure 7.

A map showing probable peak accelerations[23] in the Sitka area is presented on Figure 8. The map indicates that a peak acceleration of about 50 to 100 percent gravity (M7.2 to 7.6) might be expected within any 100-year period. Additional seismic and ground response information must be compiled and evaluated for use in design of the Green Lake dam and appurtenant works.

In the Sitka area, small landslides, including numerous rockfalls, occurred on steep slopes during the earthquake of July 30, 1972[16]. At Sitka, at least 14 tsunamis and other earthquake-induced waves have been experienced. The maximum wave, crest to trough, was 14.3 feet high, and arrived March 27, 1964, as one of the group resulting from the March 27, 1964 Anchorage earthquake. At Sitka, the seismic seiche developed about 4 minutes after the initial March 27, 1964 Anchorage earthquake, and was 1.0 foot high; it had a duration of 3.5 minutes[20]. Probably the world's record height of wave runup was 1,740 feet, triggered by a landslide in Lituya Bay, 135 miles northeast of Sitka during the July 10, 1958 earthquake[21].

In the fiords near Sitka, neither distant nor nearby earthquakes in historic time are recorded to have formed waves clearly attributable to subaerial or subaqueous landsliding. However, waves occurred in Redoubt Lake, 12 miles southeast of Sitka during the October 26, 1880 event[38], and, in Blue Lake during the August 22, 1949 earthquake (per Mr. M. Reid, Sitka Borough Office).



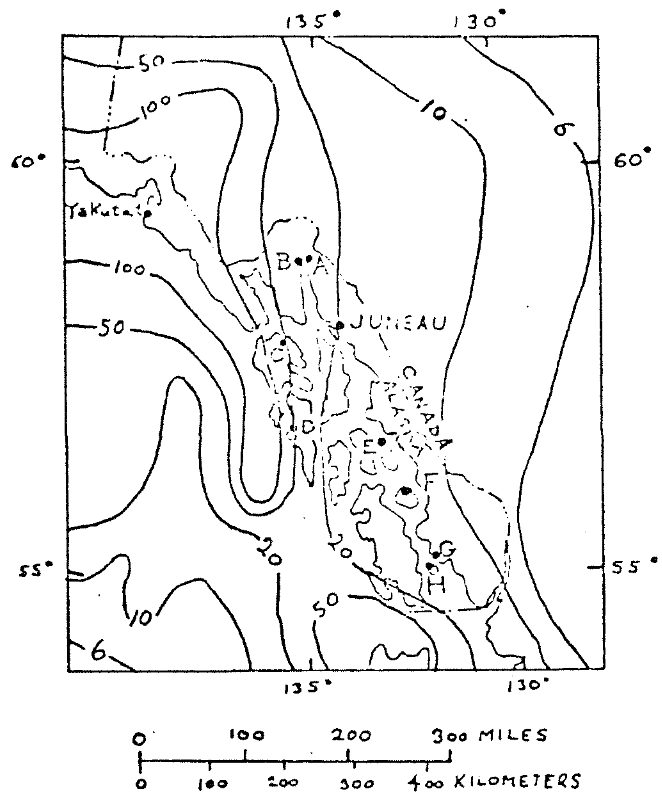
EXPLANATION

Zone	Damage	Comment
1	Minor	Distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 sec; corresponds to intensities V and VI of MM[1] scale.
2	Moderate	Corresponds to intensity VII of MM[1] scale.
3	Major	Corresponds to intensity VIII and higher of MM[1] scale.

[1]Modified Mercalli intensity scale (table 5).

Figure 13.--Seismic zone map of Alaska. Modified from the 1970 edition of the Uniform Building Code (Internat. Conf. Building Officials, 1970).

FIGURE 7



EXPLANATION

—— 10 ——

Contour, showing peak earthquake acceleration as a percent of gravity. See table 5 for approximate relations between earthquake acceleration, magnitude, energy, and intensity.

A	Skagway	E	Petersburg
B	Haines	F	Wrangell
C	Hoonah	G	Ketchikan
D	Sitka	H	Metlakatla

Map is based upon the amount of energy released by the largest earthquake (above magnitude 2.5) that occurred each year in a unit area of 3,860 mi^2 (10,000 km^2) during the period from 1898 through 1960, projected to a 100-year interval.

Figure 14.--One-hundred-year probability map showing distribution of peak earthquake accelerations as percents of gravity for southeastern Alaska and part of adjacent Canada. Modified from Milne and Davenport (1969).

REFERENCE: USGS Open-File Report 74-53 (1974)

FIGURE 8

RECOMMENDED EXPLORATION PROGRAM

A subsurface investigation, supplemented by detailed geologic mapping, should be implemented in order to confirm, or modify, the conclusions of this preliminary geologic study. Since the subsurface and surface mapping compliment each other, they should be done concurrently. The investigation should be performed in two phases:

Phase I	Preliminary Design Information; during the feasibility investigations, before the Silver Bay access road is constructed.
Phase II	Final Design Information; preferably after the Silver Bay access road is constructed.

The purpose of this approach is to reduce investigative costs. Phase I should consist of a "minimal" subsurface exploration program, to develop preliminary design data essential to determining feasibility of the project, at a time when access to the site is difficult. Phase II would be an "expanded" subsurface investigation, adequate to provide final design parameters, at a time access is improved and logistical problems are more favorable. From a weather standpoint, July to November, 1975 appears best for exploration.

The scope of work for developing Phase I preliminary design information should include (1) core borings at the damsite, (2) exploratory trenches or borings for construction materials (concrete aggregate), (3) geophysical surveys, (4) additional geologic mapping and (5) additional research on faults and earthquakes. These items are described in more detail on the following pages.

1. NX-Sized Core Borings at the Damsite - for visual classification, seismic refraction and laboratory tests of the dam and appurtenant structures as tabulated below:

Drill Hole No.	Depth (ft.)	Approx. Location	Approx. Elevation (ft.)	Purpose of Hole
DH-1	150	R. Abut.	370	Dam foundation & seismic refraction
DH-2	150	R. Abut. & Tunnel	290	Dam foundation, tunnel conditions & seismic refraction
DH-3	150	Vodopad River	230	Riverbed conditions & seismic refraction
DH-4 (angle 40°)	150	L. Abut.	250	Dam foundation conditions
DH-5	150	Mouth Green Lake	230	Cofferdam foundation conditions
DH-6	100	Powerhouse & Tunnel	80	Excavation conditions & seismic refraction
Total Footage	850			

2. Exploratory Trenches or Borings for Construction Materials (concrete aggregate) - At potential borrow sites shown on Plate 1 and 2 should be excavated by locally rented equipment or drilled by a jeep-mounted power auger and/or barge mounted core drill with special adaptors for possible drive sampling and casing of holes. Representative samples should be obtained for sieve analysis, laboratory tests, chemical composition and visual classification. The exploratory equipment; e.g., backhoe, bulldozer, drill rigs, should be barged to each site.

Trench No.*	Depth (ft.)	Location	Approx. Elevation (ft.)	Purpose & Location
T-1	15	Plate 2	20	Concrete aggregate; "Cabin" alluvials
T-2	15	"	20	Also fault
T-3	15	"	20	
T-4	15	Plate 1	20	Concrete aggregate; Bear Cove alluvials
T-5	15	"	20	Also fault
T-6	15	"	20	
T-7	15	Plate 1	250	Concrete aggregate & impervious cofferdam materials; in the "shallows" Green Lake alluvials
T-8	15	Plate 1	250	Green Lake delta alluvials
T-9	15	"	250	Also fault
T-10	15	"	250	Also fault

* Exploratory trench locations that have encouraging signs of sand and gravel, more than likely will require drilling to define quantity and quality of concrete aggregate.

3. Geophysical Surveys - Utilizing bedrock core borings for down-hole, or up-hole, compressional and shear wave velocities in order to develop dynamic moduli data in selected holes. This includes Young's modulus of elasticity and Poisson's ratio. The data is inputed into a computer program to obtain the dynamic moduli values. The compressional wave velocities will also be used to evaluate rock defects (fractures) and depth of weathering. A two-man team would require approximately two field days per core hole to develop this data. The equipment can be hand-carried from hole to hole. Exploratory adits for performing in-situ rock tests, are not deemed necessary, unless the bedrock quality determined from core borings, is much poorer than anticipated. Laboratory tests and geophysical surveys should provide adequate information for dam design.

4. Additional Geologic Mapping - Should be performed, at the same time the subsurface exploration is in progress, to refine information on:

    a. Surficial deposits - talus, landslides, borrow materials.

    b. Quarry rock - suitable location, site preparation, accessibility.

    c. Spillway conditions - stability, potential for erosion.

    d. Geologic conditions along the Silver Bay access road - rippability, blasting, topographic benches.

    e. Faults - activity and rock conditions adjoining the faults.

5. Perform Additional Research on Faults and Earthquakes - develop seismic and earthquake engineering information for dam design criteria.

6. Access for Exploration - Will be by boat and air, since the road to the site will not be constructed before starting the Phase I exploration program. Some "clearings" on the right (north) abutment, near elevation 350-450 feet (see Plate 3) appear to be suitable for an exploration campsite (if required), supply center and helicopter landing area provided a few trees are removed in advance. It is estimated that daylight will be available from about 5:00 a.m. to 8:00 p.m. The following exploration procedures and alternatives are suggested:

a. Scout the best campsite, supply center, helicopter landing site and clear the area.

b. Rent a small bulldozer, with operator, to blaze access "roads" from the head of Silver Bay to drill sites, power-house; clear helicopter landing area and develop level landing and loading area on the shore of Green Lake.

c. Assemble all required drilling equipment, bulldozer, living trailers, generators, supplies, and two-way radio communication system on a barge in Sitka. Rent an outboard motor boat for barge to shore use, and for geologic mapping.

d. Pull the barge to the head of Silver Bay and anchor.

e. An alternative would be to rent a helicopter, as needed, and lift equipment to the damsite clearing. A Hughes 500 is capable of lifting 1,400 pounds dead weight, which is ample for most disassembled Chicago Pneumatic or Joy-type NX skid rigs. (The Hughes 500 can carry 4 passengers, plus pilot).

f. Either (1) retain the barge for living quarters, (2) set up camp on top of the right abutment (the weather may not permit flights or boat trips from Sitka to the site, therefore, regular schedules may not be dependable), or (3) plan to fly (or boat) the exploration crews in and out on a daily basis. Establish radio communication systems from the damsite to Sitka and from the damsite to drill holes (walkie-talkies may be adequate).

g. First, drill the highest hole (DH-1) on the right abutment, and, skid the rig downslope to DH-2. Cut several tall trees in such a manner that they fall across the Vodopad River; trim, tie together and use as the platform to drill the river-bed (DH-3). Skid rig to DH-4 on the left abutment. Make a barge from on-site materials, or air lift parts, and drill the cofferdam hole (DH-5).

Fresh water for drilling is available from creeks high on the right and left abutments so it may not be necessary to pump and lift all the water from Green Lake. Fresh water for the powerhouse site can be obtained from the Vodopad River, with the aid of a bulldozed trail. Fresh water for the construction materials (concrete aggregate) borings should be available from nearby creeks.

h. Lastly, drill the powerhouse site (DH-6).

i. Drill two 10-hour shifts per day (this allows 4 hours per day for equipment maintenance). The drill crews, geologists and engineers could work six days on and one day off per week or 10 days on and 4 days off. The drilling schedule should be made by the company selected.

j. An alternative for drilling the cofferdam hole and concrete aggregate holes would be to airlift parts for a barge to the shore of Green Lake. Assemble and drill cofferdam (DH-5) and construction material (concrete aggregate) holes from barge. Anchor barge by long stout cables (from all four corners) because the current at the cofferdam location is swift and dangerous. If results of the cofferdam hole are conclusive as to bedrock overburden, underwater bedrock profile and bedrock quality, it may not be necessary to drill riverbed hole (DH-3) at the dam axis.

k. Boxes of core can be stored at the site until they are shipped or air-lifted to Sitka for permanent storage.

l. Drilling equipment more than likely will originate from Juneau, Seattle, or California and be shipped to Sitka for assembling. Backhoe and/or bulldozer should be available for rental in Sitka.

8. <u>Phase 1, Estimated Time</u> - The estimated time for the recommended exploration program is as follows:

Item No.		Time (Work Days)
1.	Dam core borings	60 10-hour days
2.	Construction material (trenches)	10 10-hour days
	Construction material (boring)	25 10-hour days
3.	Geophysical	6 10-hour days
4.	Additional geologic mapping	20 10-hour days (concurrent with #1)
5.	Seismic and earthquake engineering	To be determined.

9. The above exploration should be based on a new topographic map that reflects actual field conditions.

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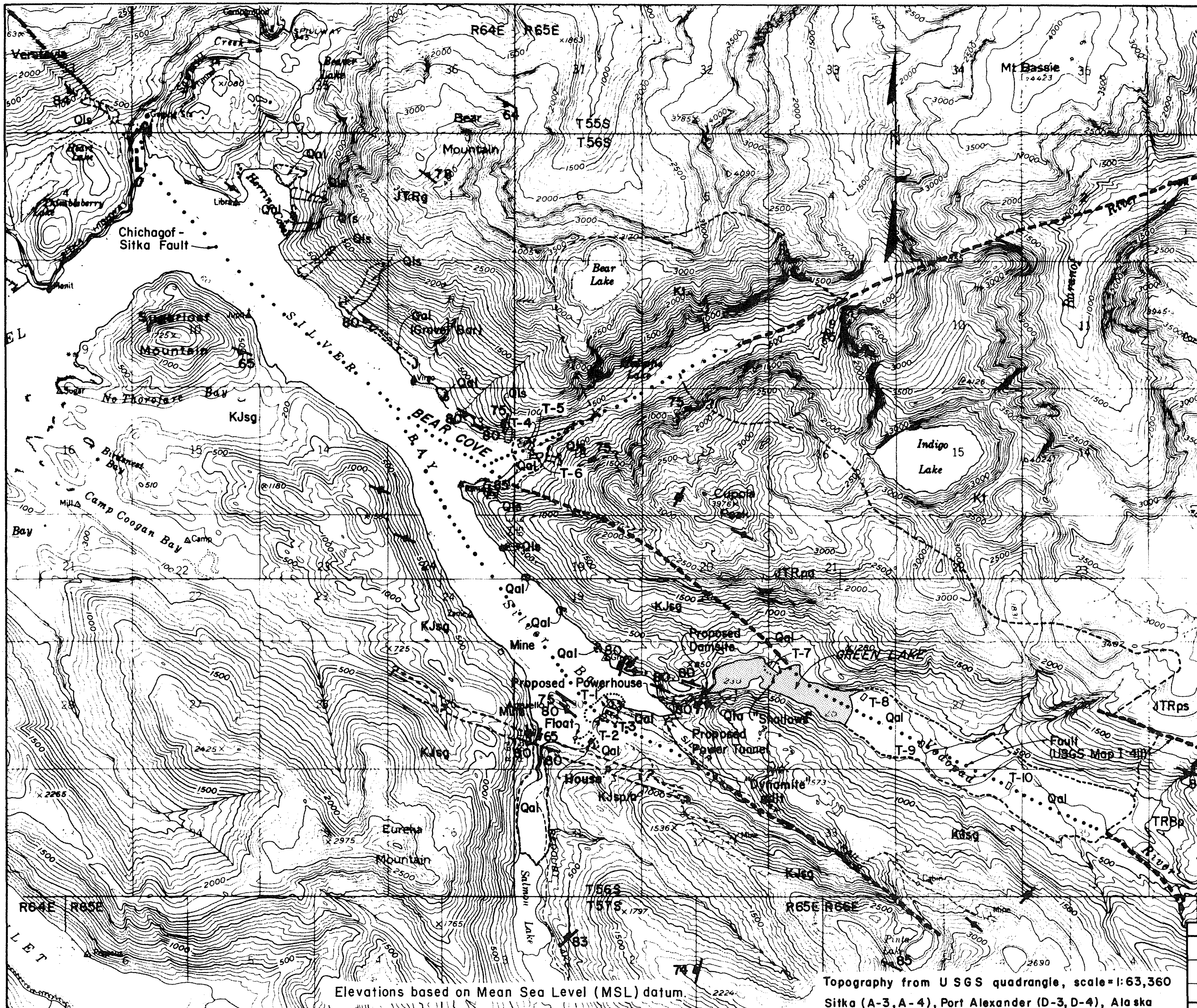


Topography from U S G S quadrangle, scale = 1:63,360
Sitka (A-3, A-4), Port Alexander (D-3, D-4), Alaska

LEGEND

Quaternary

Qal	Alluvium; includes Modern beach and delta deposits; Holocene alluvial and terrace deposits
Qta	Talus; large angular blocks at angle of repose
Qls	Landslide; rock slides on slopes steeper than 1:1

U. Jurassic - L. Cretaceous

KJsg	Sitka Graywacke; gray to dark gray, massive, very hard metamorphosed siltstone and sandstone
KJsp/a	Sitka Phyllite & Argillite; dark gray to black, platy, very hard metamophosed shale
Kt	Intrusive Igneous Rocks; gray, medium grained granitic rocks
JTRps	Schist & Gneiss; biotite, fine-grained
JTRpa	Amphibolite & Greenschist; metamorphic grade related to intrusives
JTRg	Greenstone; chaotically interlayered and metamorphosed
TRPp	Phyllite; dark gray with fine-grained quartzite

SYMBOLS

- ?? Geologic Contact; approximately located, dotted where concealed, queried where location inferred
- Fault; approximately located, dotted where concealed
- 80 Strike and dip of joint
- Strike of vertical joint
- 80 Strike and dip of foliation (relic bed)
- Strike of vertical foliation
- T-1 Proposed exploration trench

NOTE

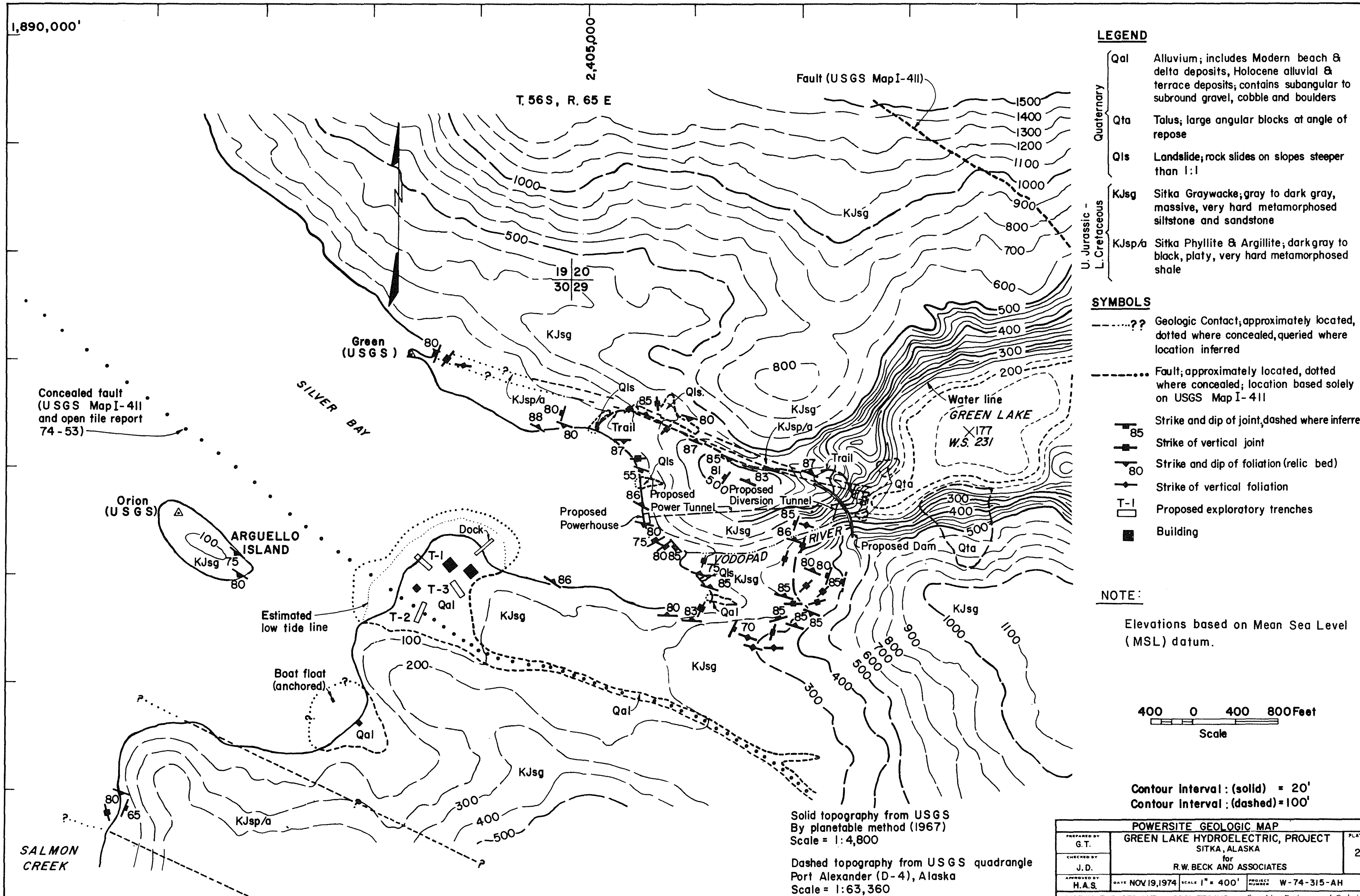
Source of geologic data derived, in part, from USGS Misc. Geologic Investigations Map I-411 (1964), USGS Open File Report No. 74-53 (1974) and, in part from photogeologic interpretations, field reconnaissance and offshore soundings Oct. - Nov. 1974

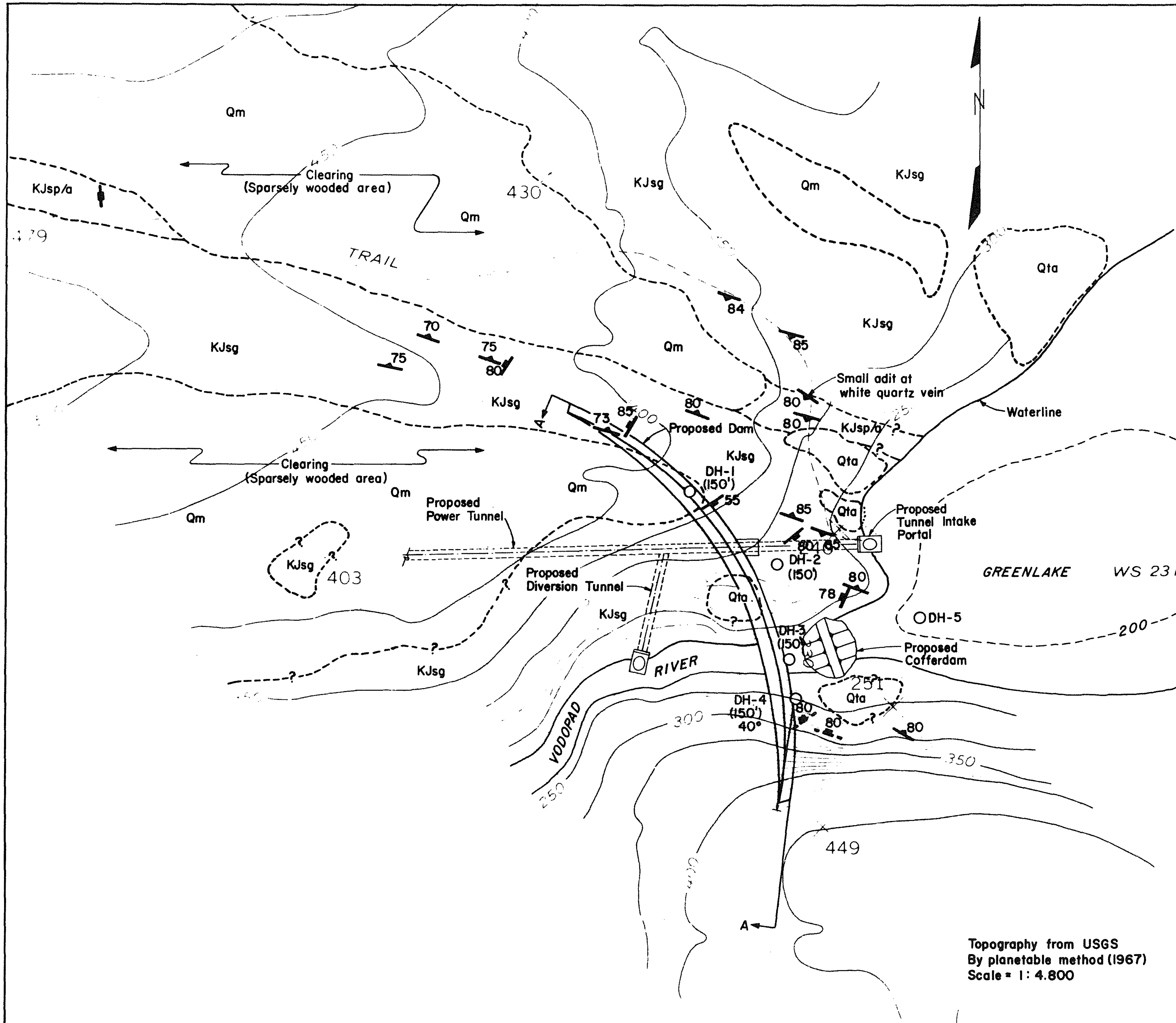
5,000 0 5,000 Feet
Scale

Contour Interval 100'

	REGIONAL GEOLOGIC MAP	
PREPARED BY G.T.	GREEN LAKE HYDROELECTRIC, PROJECT SITKA, ALASKA for R.W. BECK AND ASSOCIATES	PLATE 1
CHECKED BY J.D.		
APPROVED BY H.A.S.	DATE NOV. 19, 1974 SCALE 1" = 2000' PROJECT NUMBER W-74-315-AH	

CONVERSE, DAVIS AND ASSOCIATES, INC. *Consulting Engineers and Geologists*


1,890,000'
2,405,000
T. 56 S, R. 65 E
LEGEND
Quaternary
Qal Alluvium; includes Modern beach & delta deposits, Holocene alluvial & terrace deposits; contains subangular to subround gravel, cobble and boulders
Qta Talus; large angular blocks at angle of repose
Qls Landslide; rock slides on slopes steeper than 1:1
U. Jurassic - L. Cretaceous
KJsg Sitka Graywacke; gray to dark gray, massive, very hard metamorphosed siltstone and sandstone
KJsp/a Sitka Phyllite & Argillite; dark gray to black, platy, very hard metamorphosed shale
SYMBOLS
Geologic Contact; approximately located, dotted where concealed, queried where location inferred
Fault; approximately located, dotted where concealed; location based solely on USGS Map I-411
Strike and dip of joint, dashed where inferred
Strike of vertical joint
Strike and dip of foliation (relic bed)
Strike of vertical foliation
Proposed exploratory trenches
Building
NOTE:
Elevations based on Mean Sea Level (MSL) datum.
400 0 400 800 Feet
Scale
Contour Interval: (solid) = 20'
Contour Interval: (dashed) = 100'
Fault (USGS Map I-411)
Concealed fault (USGS Map I-411 and open file report 74-53)
Green (USGS)
SILVER BAY
Orion (USGS)
ARGUELLO ISLAND
Estimated low tide line
Boat float (anchored)
SALMON CREEK
Dock
Trail
Proposed Powerhouse
Proposed Power Tunnel
Proposed Diversion Tunnel
VODOPAD RIVER
Proposed Dam
Water line
GREEN LAKE
W.S. 231
Solid topography from USGS By planetable method (1967) Scale = 1:4,800
Dashed topography from USGS quadrangle Port Alexander (D-4), Alaska Scale = 1:63,360
POWERSITE GEOLOGIC MAP
GREEN LAKE HYDROELECTRIC, PROJECT
SITKA, ALASKA
for
R.W. BECK AND ASSOCIATES
PREPARED BY G.T.
CHECKED BY J.D.
APPROVED BY H.A.S.
DATE NOV 19, 1974
SCALE 1" = 400'
PROJECT NUMBER W-74-315-AH
PLATE 2
CONVERSE, DAVIS AND ASSOCIATES, INC. Consulting Engineers and Geologists



Topography from USGS
By planetable method (1967)
Scale = 1: 4.800

LEGEND

Quaternary

- Qm — Muskeg; wet, organic, boggy peat deposits in various stages of decay
- Qta — Talus; large angular blocks at angle of repose
- Qls — Landslide; rock slides on slopes steeper than 1:1

U. Jurassic-L. Cretaceous

- KJsg — Sitka Graywacke; gray to dark gray, massive, very hard metamorphosed siltstone and sandstone
- KJsp/a — Sitka Phyllite & Argillite; dark gray to black, platy, very hard metamorphosed shale

SYMBOLS

- ---……?? Geologic Contact; approximately located, dotted where concealed, queried where location interred
- 80 Strike and dip of joint; dashed where inferred
- Strike of vertical joint
- 80 Strike and dip of foliation (relic bed)
- Strike of vertical foliation
- A A Location of geologic section
- DH-1 ○ Proposed diamond drill hole
- DH-6 ○ 50° Proposed angle hole; showing direction and angle from horizontal

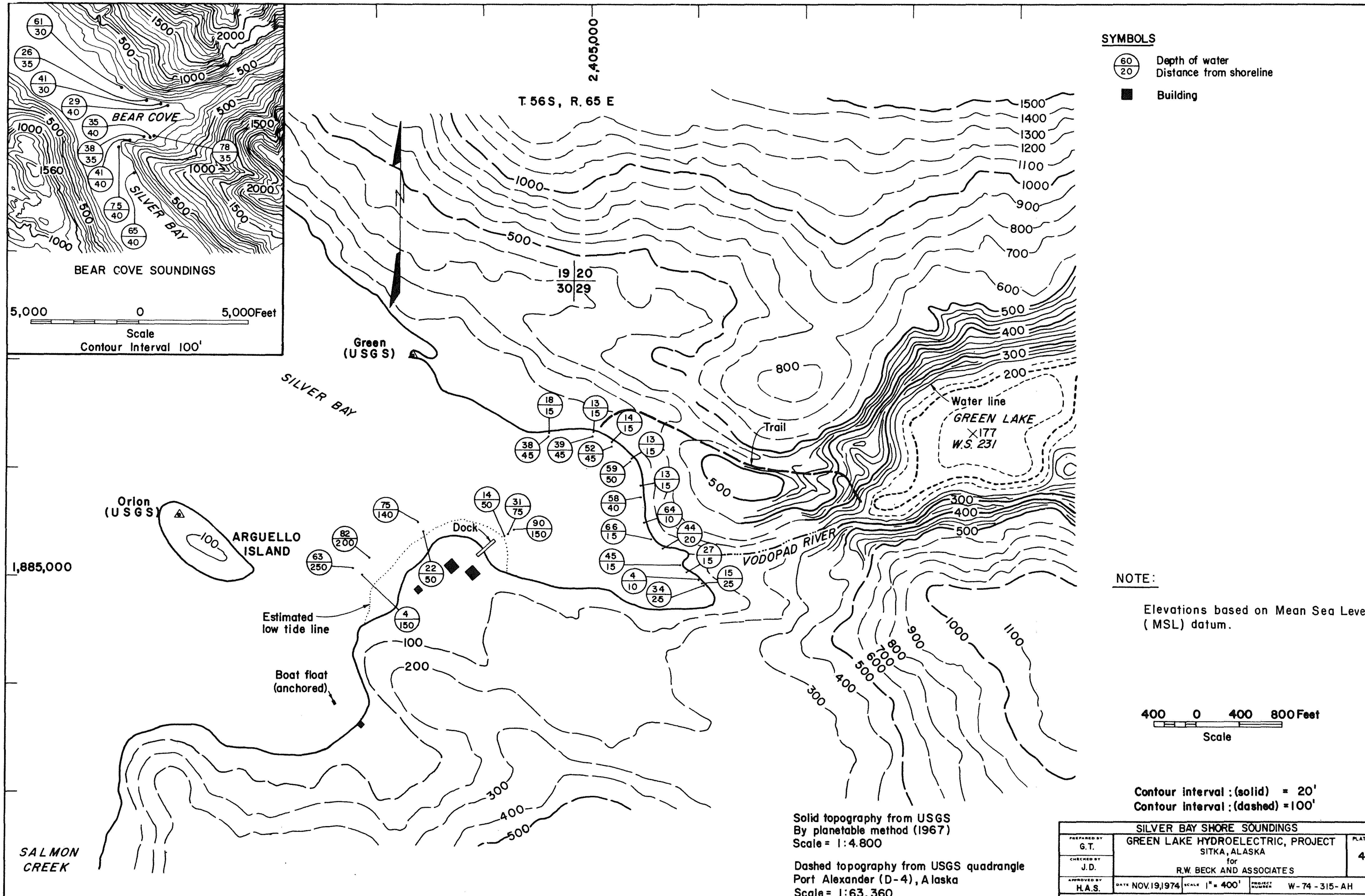
NOTES:

1. Dam, Cofferdam, Power Tunnel and Diversion Tunnel are approximately located, and are not intended for design purposes.
2. Elevations based on Mean Sea Level (MSL) datum.

50 0 50 100 Feet
Scale

Contour Interval = 10'

DAMSITE GEOLOGIC MAP		
PREPARED BY G.T.	GREEN LAKE HYDROELECTRIC, PROJECT SITKA, ALASKA for R.W. BECK AND ASSOCIATES	PLATE 3
CHECKED BY J.D.		
APPROVED BY H.A.S.	DATE NOV. 19, 1974 — SCALE 1" = 50' — PROJECT NUMBER W-74-315-AH	
CONVERSE, DAVIS AND ASSOCIATES, INC.	Consulting Engineers and Geologists	



PREPARED BY G.T.	SILVER BAY SHORE SOUNDINGS	PLATE
CHECKED BY J.D.	GREEN LAKE HYDROELECTRIC, PROJECT SITKA, ALASKA for R.W. BECK AND ASSOCIATES	4
APPROVED BY H.A.S.	DATE NOV.19,1974 SCALE 1" = 400' PROJECT NUMBER W-74-315-AH	

CONVERSE, DAVIS AND ASSOCIATES, INC. *Consulting Engineers and Geologists*

Appendix W - 10

Investigation of Biotic Resources

by

David Townsend Hoopes, Ph.D.

WW-1521-HG2-MC
Green Lake FPC License
3711

AN INVESTIGATION OF THE BIOTIC
COMMUNITIES IN THE VICINITY
OF GREEN LAKE, BARANOF ISLAND, ALASKA

Prepared for

R.W. Beck and Associates, Inc.

by

David T. Hoopes

July 15, 1977

DAVID TOWNSEND HOOPES, Ph.D.
ENVIRONMENTAL CONSULTING

P.O. BOX 373
CLARK FORK
IDAHO 83811
U.S.A.

July 15, 1977

Mr. Donald E. Bowes
Executive Engineer
R.W. Beck and Associates
200 Tower Building
Seattle, Washington 98101

Dear Don:

Herewith is transmitted one (1) final copy of my report of investigations covering the ecosystems involved in the Green Lake hydroelectric project, lists of the flora and fauna associated with these systems and an evaluation of the impact this project will have on these systems and their associated species.

Please contact me if you have any questions regarding this report.

Sincerely yours,

David Hoopes

David T. Hoopes

Encl:

TABLE OF CONTENTS

INTRODUCTION

This report describes the biotic communities adjacent to Green Lake, Baranof Island, Alaska, the site of a proposed hydroelectric power project for the City and Borough of Sitka, Alaska. The report includes an evaluation of the environmental impact of constructing and operating a facility consisting of a 405-hectare impoundment with a normal maximum water surface at an elevation of 119 meters to be formed by a 70-meter high concrete arch dam located at the present outlet to Green Lake. Water from the reservoir will be diverted through a 580-meter tunnel to a powerhouse located at the outlet of the Vodopad River into Silver Bay. A single lane access road will connect the existing road at Herring Cove to the dam site and powerhouse. The proposed road alignment will follow the north-east shore of Silver Bay and will be generally paralleled by a 12.8 kilometer 69-kV transmission line to connect with an existing transmission system at Sawmill Cove, site of the City's present hydroelectric power facility.

This study has been divided into three segments. First, the author reviewed the available literature to collect all existing information on the flora and fauna of the area, including special studies made of the limnology of Green Lake and the oceanography of Silver Bay. Next, two separate field investigations were conducted in late May, 1977, to determine existing conditions and gather data on the plant and animal communities now present in the project area. Finally, personnel of concerned State and Federal agencies were apprized of project details and potential impacts. Personal contacts made by the author with members of the Alaska Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service and U.S. Forest Service during May and June, 1977, resulted in obtaining recent field data collected by these agencies and their current evaluations of the possible impact the proposed project would have on the flora and fauna in the areas affected by project construction and operation.

THE EXISTING ENVIRONMENT

Topography:

The landscape of the area has been shaped largely by glacial action. Green Lake and the Vodopad River lie at the head of Silver Bay, some 16 or so kilometers southeast of Sitka. The Vodopad River valley tends generally eastward for approximately 14.5 kilometers from the outlet of the river into Silver Bay. The U-shaped valley averages less than a kilometer in width for the first 6-1/2 kilometers then narrows abruptly to little more than the width of the river until it terminates at a glacier-topped headwall towering 900 meters above the valley floor. Surrounding slopes, exceeding 75 percent grade, extend steeply upward to a rim of peaks 1,200 to 1,500 meters high.

Green Lake is a relatively shallow, oligotrophic body of water lying at the lower end of the valley less than one kilometer from Silver Bay. Green Lake is subrectangular, being approximately 2 kilometers long and averaging a little over 300 meters in width. A shallow bar (1/2-1 meter below the present lake surface) separates the lake into east and west basins. The major tributary, the Vodopad River, flows into the east end of the lake. The outlet lies at the extreme west end. The lake is relatively shallow, having an average depth of 12 meters and a maximum depth of only 26 meters.

Silver Bay is a narrow (average 0.8 kilometers) fiord running approximately 7.2 kilometers southeast from its entrance into Eastern Channel just south of Sitka. Depths average from slightly over 73 meters at the mouth to about 36 meters at the head of the bay. Shorelines drop off sharply below the water and rise abruptly to a series of ridges and peaks 460 meters or so high along the southwest shore to 1,200 meters on the northeast shore.

Forest Ecosystems:

The coastal forests of southeast Alaska are an extension of the rainbelt forests of the Pacific Northwest. Timber stands in the vicinity of Green Lake and Silver Bay are composed primarily of old-growth western hemlock and Sitka spruce. A few hardwoods, mostly red alder and an occasional cottonwood, occur along the Vodopad River and on slide areas. Lodgepole pine, growing mostly as a scrub tree, is found on poorer sites, on and adjacent to muskegs. The best stands of timber generally are found near tidewater and along the valley floor. Timberline occurs at an elevation of about 610 meters.

Varied landforms below about 305 meters support well stocked stands of Sitka spruce and western hemlock. On deep, well drained sites spruce volumes reach approximately 16 million board feet per hectare. Poorly drained soils have a predominently hemlock overstory with volumes running about 18 million board feet per hectare. Understory vegetation is generally composed of blueberry, red huckleberry, bunchberry, rusty menziesia and devils club with a moss ground cover. Less productive forest slopes support mostly western hemlock with an understory containing generally more skunk cabbage and devils club than on the better drained locations. Several large stands of alder grow on the valley floor and alder appears along the main river banks and the braided overflow channels where soils are shallow and composed of extensive alluvial deposits.

Muskegs occur on gently rolling to fairly steep slopes and benches in the vicinity of the dam site at the outlet of Green Lake. These open, boggy areas support a scattered, poor open stand of lodgepole pine, Alaska cedar and mountain hemlock. The understory is dominated by sedges with lesser amounts of sphagnum, skunk cabbage, braken fern, grasses and other forbs. Common shrubs are Labrador tea, bog rosemary, swamp laurel and crowberry.

Soil type governs plant distribution to a large extent and influences the type and method of construction required during development of roads and other physical alterations. The soil types found in the vicinity of Green Lake and the lower Vodopad River valley are representative of soil conditions found throughout much of southeast Alaska. The following description of soil types present in the project area is based upon the U.S. Forest Service soil classification system developed for soil typing in southeast Alaska.

Unconsolidated soil materials include glacial till, volcanic debris, alluvium, colluvium, residuum and organics. Indications of soil mass movement are common throughout the area. Soil mass movement is the dominant process of natural erosion in southeast Alaska. Many landslides occur during or immediately after periods of heavy rainfall when soils are saturated. Particularly hazardous areas include steep slopes characterized by compact glacial till or bedrock sloping parallel to the surface. When subjected to heavy rainfall, these areas have a high propensity for mass movement, especially if disturbed by blasting during periods of soil saturation, side casting or excavating borrow. A study of distribution patterns of natural debris avalanches and flows in southeast Alaska by the U.S. Forest Service has shown the west coast of Baranof Island to lie within one of two regions identified as areas of high landslide occurrence.

Moderately well to well drained soils (F1) occur throughout much of the area on footslopes, lower slopes, benches and elevated alluvial terraces. These soils are comprised mainly of silt loams with much gravel and cobbles overlain by an often prominent gray A2 horizon. More complex soils (F2) occur on many side slopes over a highly fractured graywacke bedrock. These soils are freely drained and comparatively shallow. Both F1 and F2 soils support good stands of Sitka spruce and western hemlock. Stands on F2 soils are predominantly western hemlock with lesser amounts of Sitka spruce.

Imperfectly drained soils (F4) occur at some locations associated with less productive forest slopes where the overstory vegetation is dominated by western hemlock. These soils are black, mucky and may be highly thixotropic.

Some poorly drained sites near the outlet of Green Lake on gentle side slopes or benches are comprised of brown to black, greasy, woody mucky peat (F5). They often occur as transitional zones between muskeg and timber and support scrubby, somewhat open stands of western and mountain hemlock, Alaska cedar and a scattering of Sitka spruce.

Soils in the vicinity of the proposed contractor work area at the dam site are predominently Kina sedge peats (M2). These very poorly drained soils have a water table at or within 30 centimeters of the surface. Kina soils commonly have 1 to 1-1/2 meters of dark reddish brown, partially decomposed, firm woody sedge peat over a meter or so of compact till. They support a scattered, poor open stand of lodgepole pine, Alaska cedar and mountain hemlock. Use of these soils is severely limited by wetness and low bearing strength, requiring a thick base and added drainage for good roads.

The alluvial soils of the flood terraces (Flt) and flood plains (flt) along the Vodopad River are thin and underlain by gravel and cobbles. The better drained sites support good stands of Sitka spruce while in the more poorly drained sites western hemlock dominates the overstory. Red alder occurs in thin strips along the stream courses or, occasionally, as almost solid stands at certain locations along the valley floor.

The following key identifies soil types and other soil features on the accompanying aerial photographs of Green Lake and the lower Vodopad River valley in the vicinity of the proposed impoundment (Figure 1 & Figure 2).

F1 - Deep, well-drained mineral soils, 1/2 to 1-1/2 meters deep

F2 - Shallow, well-drained mineral soils, 12 to 50 centimeters deep

F4 - Imperfectly drained mineral soils, 25 to 120 centimeters deep

F5 - Poorly drained forest organic soils

F12 - A complex of F1 and F2 soils containing approximately half of each

F14 - A complex of F1 and F4 soils containing approximately half of each

F1d - Deep F1, 1-1/2 meters plus

F1t - Flood terrace alluvial soils

f1t - Flood plain alluvial soils that flood annually

M2 - Kina sedge peats

MF5 - A complex of F5 soils interspersed with about 50 percent sedge muskeg soils

B - Snow avalanche track

V - V-notch drainage

A single line under the soil type designation denotes slopes of 35 to 75 percent

A double line under the soil type designation denotes slopes greater than 75 percent, or severe landslide hazard

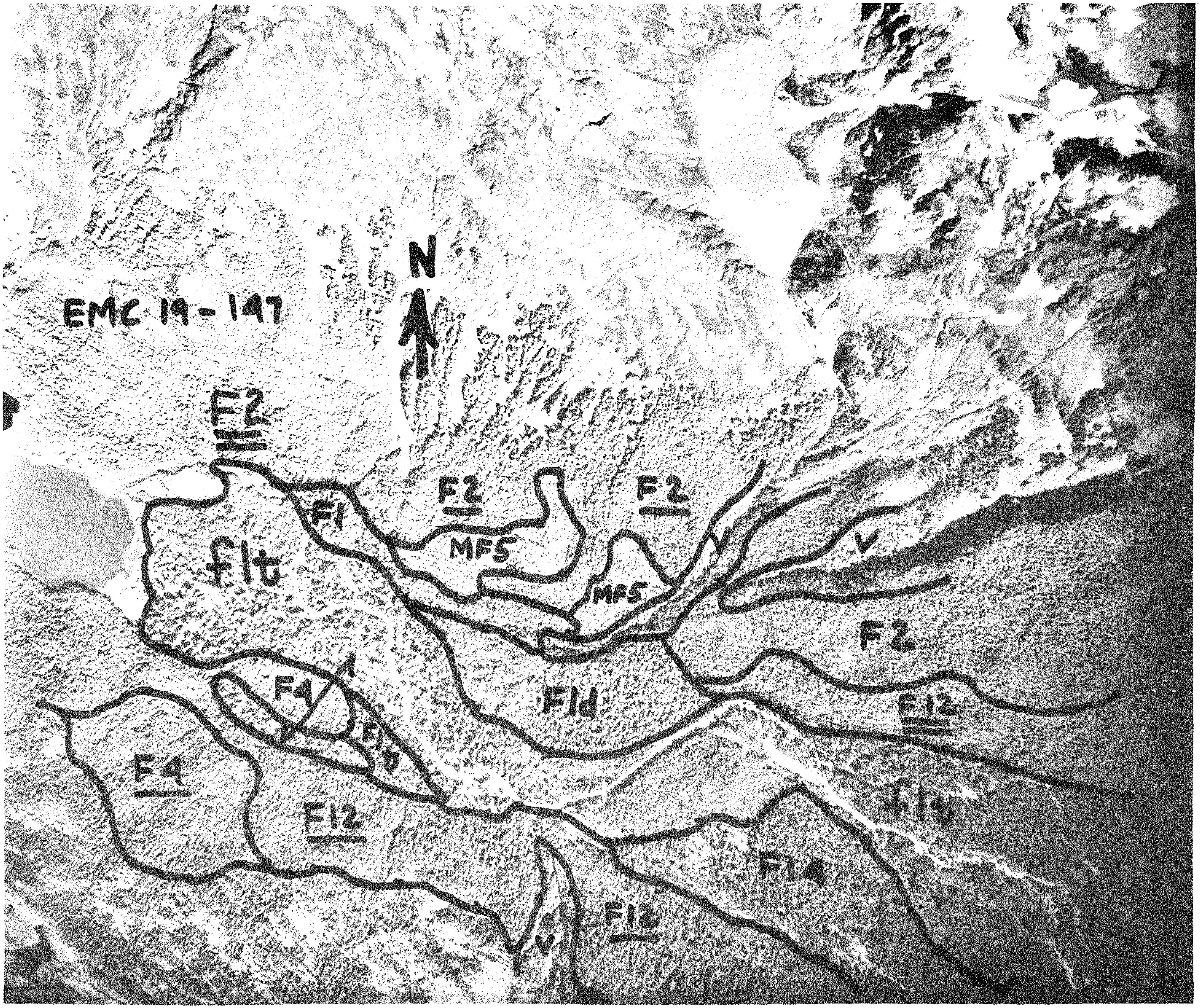
Sight Index - Height in feet of the average dominant Sitka spruce

Soil types F1, F2, F1t, F1d and f1t have site indices of 150

Soil type F4 has a site index of 120

Soil type F5 has a site index of 80

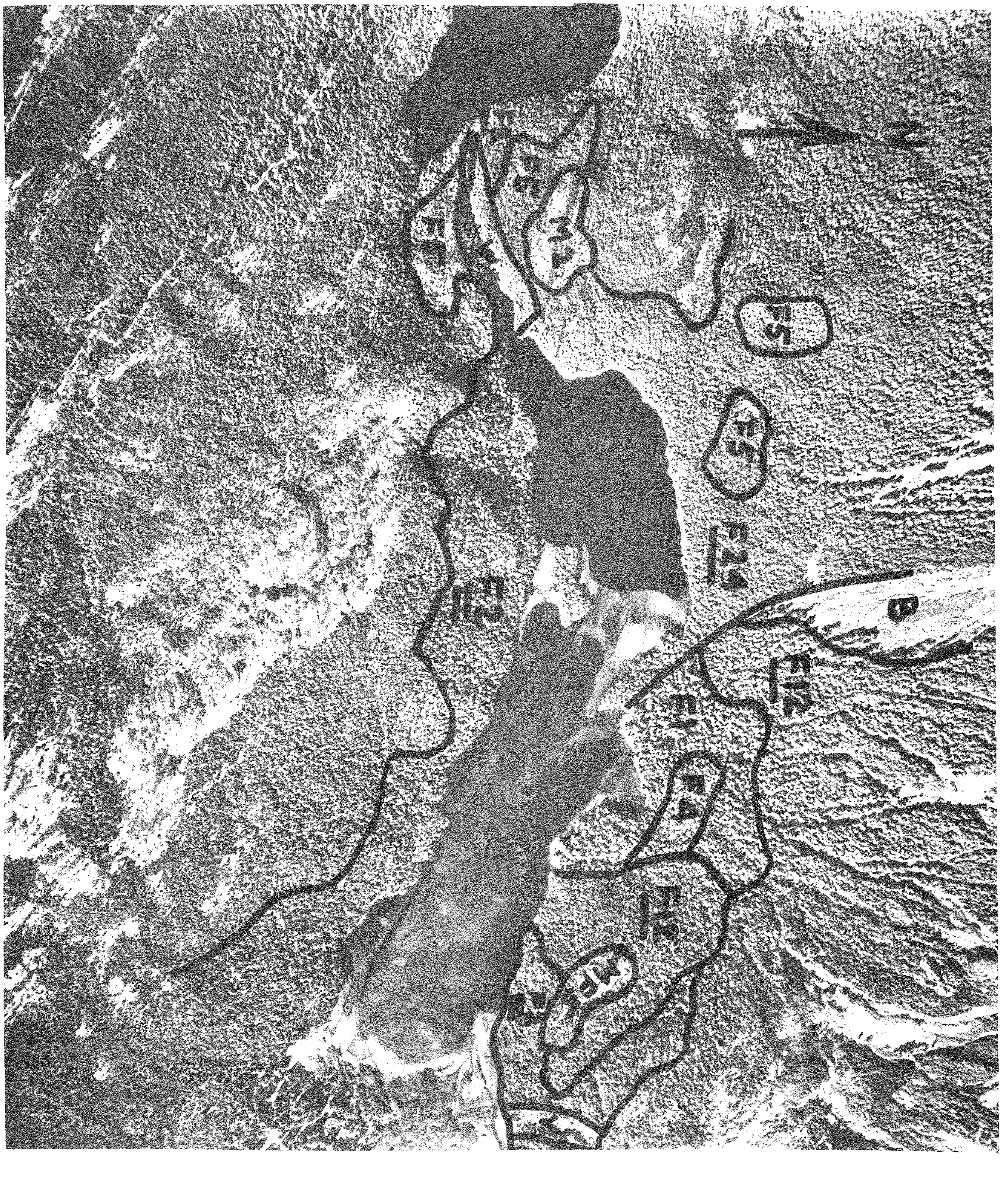
Figure 1. Lower Vodopad River valley soil types as determined from aerial photographic reconnaissance by Mr. Richard F. Billings, Soils Scientist, U.S. Forest Service, Sitka, Alaska on May 31, 1977 (personal communication).



EMC 19 - 147
N
F2
F2
F2
F1
MF5
MF5
flt
F2
F4
F1d
F12
F1b
F4
F12
flt
F14
F12
V
V

Figure 2. Green Lake soil types as determined from aerial photographic reconnaissance by Mr. Richard F. Billings, Soils Scientist, U.S. Forest Service, Sitka, Alaska on May 31, 1977 (personal communication).

ALP7 39 - 3



Green Lake Ecosystem:

Green Lake has a surface area of 0.70 km^2 , a maximum depth of 26.2 m. , an average depth of 12.3 m. and a volume of 8.62 hm^3 (Table 1). Approximately 74.6 sq. km. of watershed supply the Vodopad River and Green Lake, mostly in the form of meltwater from the winter snow pack.

The lake is divided into two basins whose limnological characteristics are similar except that water in the west basin is warmer and exhibits slightly greater temperature stratification, probably because of the warming of the lake water as it passes over the shallow bar and the shorter fetch in the west basin. Stratification is so weak in both basins that warming occurs to the bottom and wind action may mix the lake periodically during that part of the year the lake is unfrozen.

Limnological data have been collected for Green Lake by the Alaska Department of Fish and Game (ADF&G) on May 18 and August 24, 1974. These data have been evaluated by ADF&G Fishery Biologists Artwin Schmidt and F. Stuart Robards to arrive at a morphoedaphic index for 12 lakes in southeast Alaska. Of the 12 lakes studied, Green Lake ranked third with a rating of 1.79 (Table 2). Detailed limnological data are presented in Appendix II. Plankton composition and density for Green Lake were also determined during the summer of 1974 (Appendix II).

Although limnological studies indicate low turbidity, natural levels may increase markedly under certain conditions. Photos taken by Schmidt 36 hours after heavy rains on the night of September 14-15, 1976, show a pronounced discoloration in Silver Bay as a result of silt from stream scouring in the Vodopad River valley. Much of the silt undoubtedly had already been flushed from Silver Bay by tidal action by the time the pictures were taken. Similar conditions in Green Lake must have accompanied the significant increase in turbidity noted in Silver Bay at this time.

Table 1. Morphometry of Green Lake

Parameter Measured	Value
Water Area	
Hectares	70.2
Acres	173.4
Percent of Depth Zone Areas	
0 - 5 m.	31.3
5 - 10 m.	11.3
10 - 15 m.	6.3
15 - 20 m.	33.3
20 - 25 m.	11.7
25+ m.	6.1
Water Volume	
Cubic meters x 10^6	8.62
Acre feet x 10^3	6.99
Percent Volume of Depth Strata	
0 - 5 m.	34.1
5 - 10 m.	25.6
10 - 15 m.	22.1
15 - 20 m.	13.4
20 - 25 m.	4.7
25+ m.	0.1
Maximum Depth	26.2 m.
Mean Depth	12.3 m.
Shoreline Development	0.5
Volume Development	1.41
Shoreline Length	5,974 m.

Table 2. Morphoedaphic Index of Green Lake

Parameter Measured	Value
Specific Conductance (μ mho)	39
Residue Dissolved Calculated Sum (mg/l)	22
Surface Area (ha)	70
Mean Depth (m)	12.3
MEI 1/	1.79
Potential Yield (kg/ha)	1.29

1/ MEI = Morphoedaphic Index = Total Dissolved Solids/Mean Depth

Silver Bay Ecosystem:

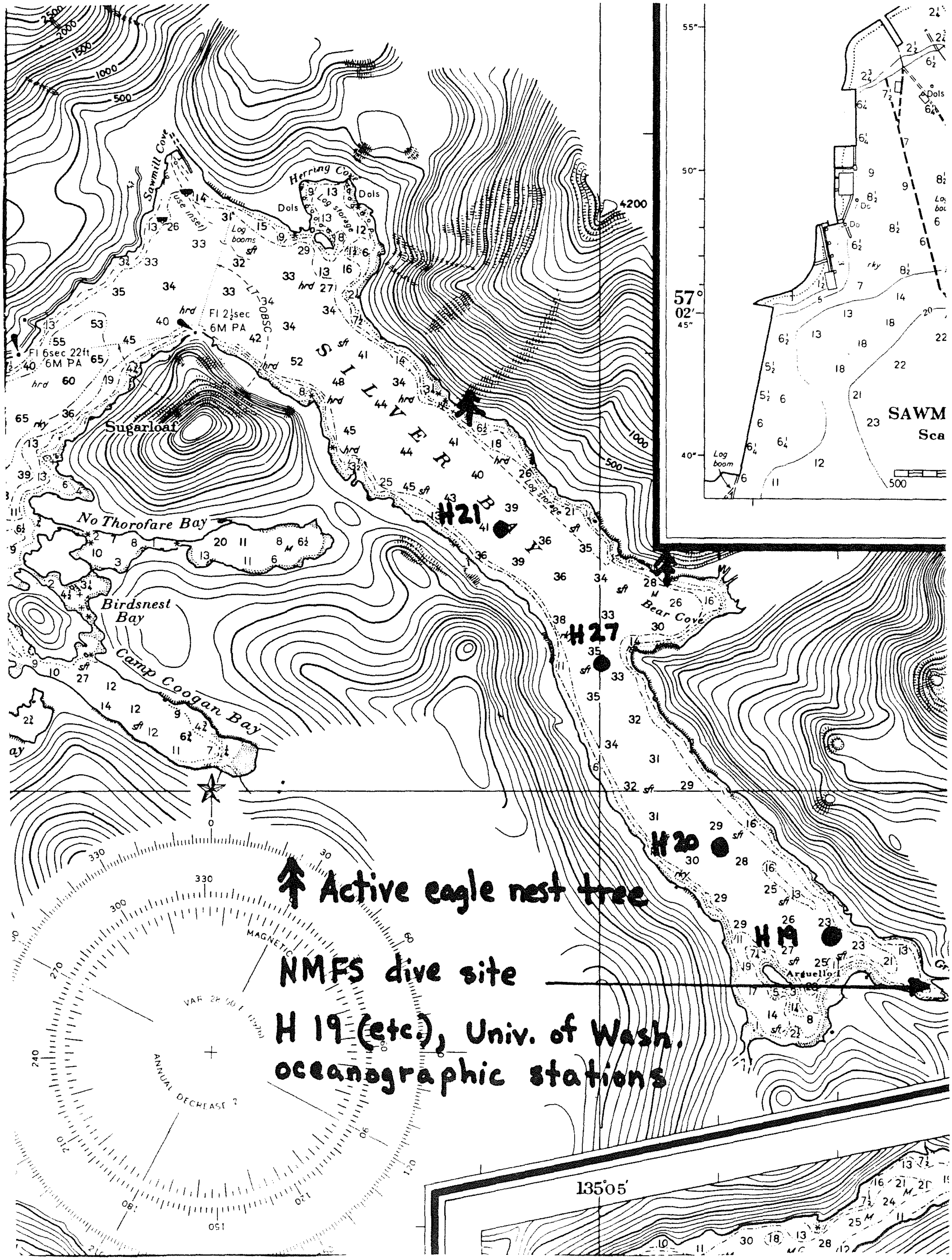
Oceanographic and biological data have been collected from Silver Bay at several different times during recent years. Data are available from work done by the University of Washington in 1956 and 1957, the National Marine Fisheries Service in 1967, 1971, 1976 and 1977 and by the U.S. Fish and Wildlife Service in 1976. The following description relies heavily upon these sources as well as field investigations conducted by the author on May 28, 29 and 30, 1977.

The physical oceanography of Silver Bay is dominated by a typical fiord surface circulation where the effects of runoff predominate over those due to tidal mixing. From autumn through winter to early spring prevailing southeast winds tend to speed up circulation in Silver Bay, driving the surface waters outward. Conversely, the predominant northwest to southwest winds of late spring and summer tend to retard surface outflow.

Most of the water below 6-9 meters has salinity values comparable to those in coastal ocean waters. Freshwater entering Silver Bay overrides a lower layer of relatively dense salt water. As it proceeds seaward, this upper layer of freshwater entrains salt water from below and gradually becomes more saline until, in the region off the mouth of the inlet, surface salinities correspond to typical coastal salinities (Table 3, Figure 3).

Currents in the bay are oscillatory, following the tides, but a net nontidal circulation results from the addition of large volumes of freshwater from the Vodopad River at the head and smaller tributaries along the inlet. This loss of saline water due to entrainment is compensated

Figure 3. Map of Silver Bay showing sampling locations and other features identified during studies of this area by the author and various Federal and private organizations.



Sawmill Cove
Herring Cove
Dols
Log storage
Log booms
Sugarloaf
No Thorofare Bay
Birdsnest Bay
Camp Coogan Bay
SILVER BAY
Bear Cove
Arguello I
Fl 6sec 22ft 6M PA
Fl 2½sec 6M PA
H21
H27
H20
H19
SAWM
57° 02′
135°05′
MAGNETIC
ANNUAL DECREASE
Active eagle nest tree
NMFS dive site
H 19 (etc.), Univ. of Wash. oceanographic stations

Table 3. Salinity profiles (S^{o}/oo) at four stations in Silver Bay, Alaska, made on July 24 and July 27, 1968, by oceanographers from the University of Washington.

Station	Date July 24	July 27
H 19		
Depth (m)		
0	13.81	15.52
2	23.23	27.51
5	30.83	29.92
10	31.09	30.47
20	31.22	31.26
30	31.33	31.36
40	31.41	31.45
H 20		
0	17.62	16.65
2	29.29	28.79
5	30.97	29.64
10	31.12	30.60
20	31.24	31.31
30	31.32	31.33
40	31.46	31.39
H 27		
0	17.90	22.78
2	30.13	29.94
5	30.99	30.03
10	31.13	30.64
20	31.26	31.32
30	31.40	31.45
40	31.51	31.54
H 21		
0	22.05	22.03
2	30.52	29.57
5	30.56	29.65
10	31.21	30.99
20	31.32	31.37
30	31.41	31.53
40	31.52	31.66

for by an inflow of salt water at depth. Observations by University of Washington oceanographers in July, 1956, indicate that this layer of inflowing water is concentrated immediately beneath the outflowing layer. The surface layer is from 1-1/2 to 6 meters deep and the inflowing layer extends to approximately 50 meters. There is little net flow below 20 meters. If surface runoff is large, tidal velocity may not be sufficient to do more than cancel the opposing velocities from the pressure field. When a short flood follows a strong ebb, the surface ebb may carry over into, and perhaps completely obscure, the flood.

During a period of low runoff from March 27 to 31, 1957, runoff was 4.25 m^3s^{-1}. Outflows during this period occurred in an upper layer extending to almost one-third of the total depth of the inlet with inflow taking place below this level. A large velocity shear was found to exist in the upper few meters of the water column. High runoff circulation was studied between July 4 and 11, 1956, when runoff reached 49 m^3s^{-1}. Under these conditions the surface outflow was restricted to the upper 6 meters, a strong inflow occurred between 6 and 37 meters while the bottom layer exhibited a small outward velocity.

The total freshwater discharge into Silver Bay was estimated at 4.25 cubic meters per second (m^3s^{-1}) for the low flow period in March and 49 m^3s^{-1} for the July high flow. When the freshwater from streams or other surface sources flows over the more saline bay water, a pressure head is created and the freshwater runs "downhill" toward the bay entrance. As it flows out it accelerates and the entrained salt water from the underlying saline layer makes it brackish.

The effects of entrainment and acceleration balance to maintain a nearly uniform thickness of the surface layer along the channel. Since more water leaves the estuary as brackish water in this outflowing layer than enters the estuary as freshwater inflow, saline water must enter at a depth to maintain the volume of water in the bay. In July, 1968, more water was entering the bay in this inflowing layer than was transported out at the surface, hence there existed a small but positive inward transport near the bottom during this, and probably all, period of high freshwater runoff.

Bottom sediments predominate at the head of the bay, in Bear Cove, and at the base of steep slopes along the shoreline. These sediments are composed primarily of coarse to fine sand. In general, sediments from all areas except the Medvetcha delta exhibit a strong odor of hydrogen sulfide, indicating anaerobic conditions in the bottom of the bay. Core samples taken from the area near the head of Silver Bay (see Figure 3 for sample locations) were composed of very fine sandy silt containing Formanifera, shell fragments and organic detritus. The color of these sediments was grayish olive green.

Concentrations of benthic marine life in Silver Bay occur in the intertidal and subtidal areas. The population density of bottom-dwelling animals decreases very rapidly with increasing depth below the lowest tidal levels. The intertidal area and bottom extending downward to about 30 meters below low tide supports an estimated 85 to 90 percent of the sedentary life in the area. The bottom deeper than 40 meters supports only a small faunal population.

The benthic fauna of Silver Bay and vicinity consists almost exclusively of bottom-dwelling invertebrates. There appear to be no significant differences in the type and density of animals from area to area. The amount of life at depths greater than 40 meters is very small and it appears that organisms are sparse below about 20 meters.

Bottom invertebrates found within Silver Bay proper consist mainly of the shellfishes Compsomya subdiapinana and Macoma calcarea and the scaphopod, Dentalium pretiosum. These forms and ophuroids (brittle stars), tentatively identified as the genus Amphiodia, comprise the dominant life throughout the bottom of the bay. The worms are mainly represented by maldanids belonging to the genus Asychis. A few large nemerteans and the nearly transparent holothurians, Leptosynapta sp., are abundant at a few locations. Typical non-burrowing fauna consist of numerous small gastropods, small urchins, chitons (Tonicella sp.), sea stars and an abundance of blennies.

The characteristic flora of the intertidal zone is a dense growth of the algae, Fucus. Fucus exists from the high tide line to the region of the low water line where it intermixes with the green algae, Ulva.

Diver-biologists of the National Marine Fisheries Service made an exploratory dive in the vicinity of the outlet to the Vodopad River on November 5, 1976 (Figure 3). They found a poorly defined intertidal zone consisting of a cobble/bedrock/mud substrate with highly scattered patches of Fucus, Desmarestia, and Zostera. Below the intertidal zone, the primary plant form was the brown algae, Agarum, scattered in patches varying in concentration from about two plants per 20 $cm.^2$ to one plant

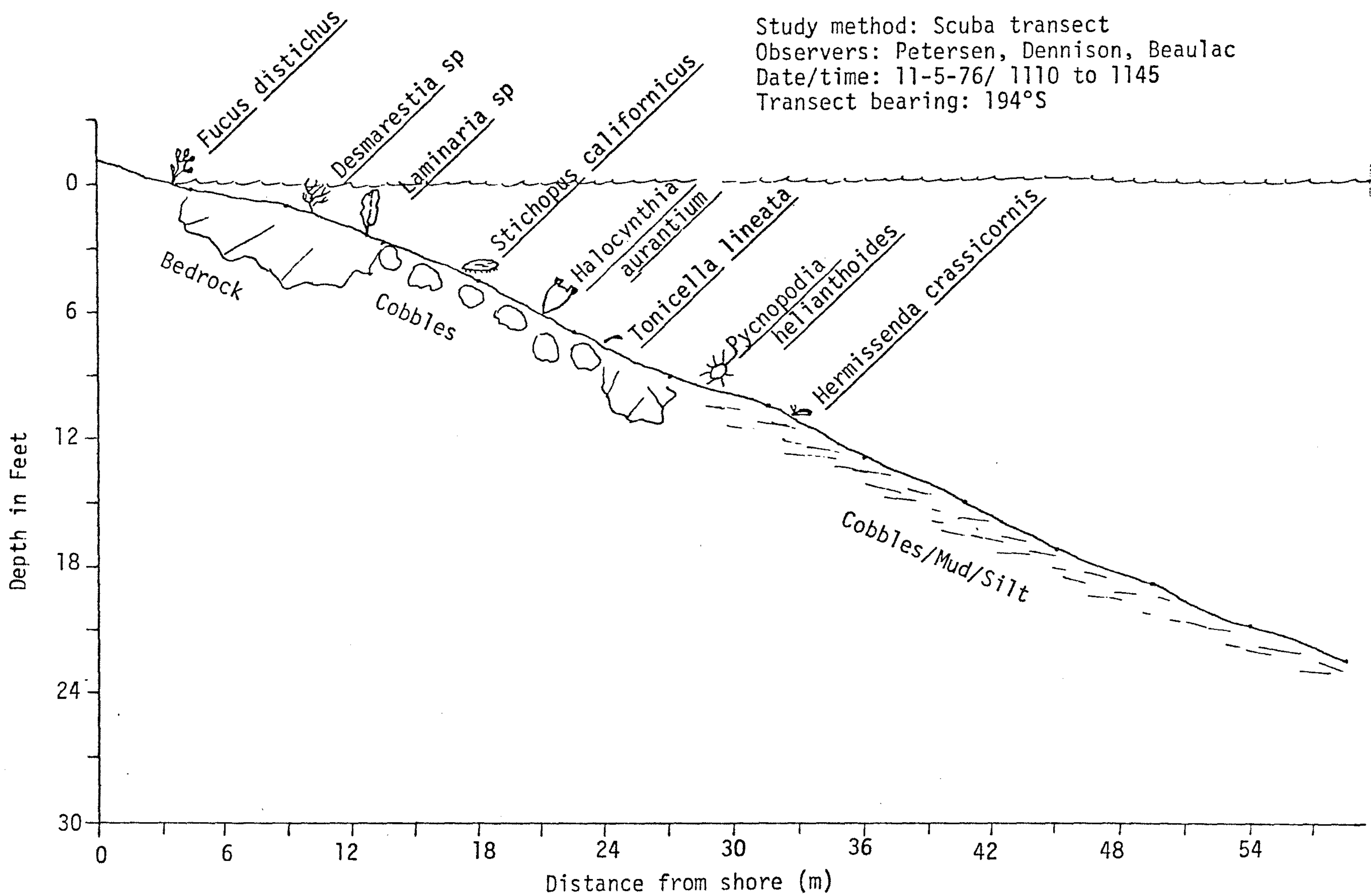


Figure 4. Life zone profile in Silver Bay, near the mouth of Vodopad River.

per 2 m.^{2} Laminaria was also observed periodically during the dive.

The principal animal observed in the subtidal area was a nudibranch, Hermissenda crassicornis, in concentrations of about four organisms per 20 cm.^{2} Other organisms were very sparsly represented. A life zone profile of the dive transect was prepared by the participating divers to depict conditions at the site (Figure 4).

Faunal Resources:

Three species of big game inhabit the Green Lake drainage during all or part of the year. They include brown bear, mountain goats and Sitka black-tailed deer. Of these, the brown bear probably frequents the area the least. Three sets of tracks were observed in the snow fields at high elevations and one set on a river bar during a big game survey flown by helicopter on May 28, 1977. While the area above timberline may be used for denning and feeding during the time berries are ripening, the absence of grass flats and anadromous fish runs precludes extensive use of the valley by bears. No bears have been reported killed in the area and the habitat is not considered important by the local ADF&G big game biologist, Loyal J. Johnson (personal communication; May 31, 1977).

A small population of mountain goats frequents the steep cliffs and mountain sides at the head of the Vodopad River valley. Some goats are known to winter below timberline above the north shore of Green Lake. Goats were introduced on Baranof Island in 1923 and populations have been relatively stable until the early 1970's when severe winters caused area-wide declines. A big game survey of the Vodopad River drainage in 1973 accounted for five animals. The 1977 survey flown by the author resulted in the same number being observed. A small harvest of goats has been made by hunters during recent years from the vicinity of this drainage. In 1976 seven hunters spent 16 days hunting, saw 28 goats (this number probably includes some duplicate sightings of the same animals) and killed three goats. Five hunters accounted for a kill of three goats in 1975. Prior to that time no record of hunting in the area was kept.

Three deer were observed at the upper end of Green Lake on May 28, 1977. Fresh tracks were also seen along sandbars and side channels during the field study. An estimated 60 or so deer probably inhabit the drainage. The shoreline of Silver Bay provides good to excellent deer winter range and deer would probably winter in the area of Green Lake during mild winters; however, the area is not classified as critical winter habitat by the ADF&G. Deer harvest reports are available for 1975 for a reporting area that includes Silver Bay, Herring Cove and Green Lake. During the 1975 hunting season 41 hunters reported spending 56 days hunting in this area and killed 33 deer. No deer were reported taken from the Green Lake watershed but a Sitka resident, Mr. Vern Eliason, reported that he and one other hunter killed four deer at Green Lake in 1976 (personal communication, May 28, 1977). It appears from all available information that hunter use of the area immediately around Green Lake is low. This area is not considered an important deer hunting locality by ADF&G personnel.

Furbearer species present in the Green Lake drainage include the short tailed weasel, mink, marten and river otter. No records of fur harvest are available but the absence of anadromous fishes and the low resident brook trout population in Green Lake would serve to limit both mink and river otter in the area. Marten feed primarily on red squirrels and both species are present, although data on population numbers are lacking.

Willow ptarmigan (Lagopus lagopus) may frequent the alpine zone in the vicinity of Green Lake and blue grouse (Dendragapus obscurus) are present on Baranof Island. The area was visited at a time when blue grouse mating calls were heard elsewhere but none were heard within the Green Lake drainage and the presence of blue grouse in the area is doubtful.

Several waterfowl species probably utilize Green Lake to some extent during the ice-free period. At least two pairs of Vancouver Canada geese were nesting in the area along the lake shore at the time of the May 28, 1977 survey. ADF&G biologists report that loons, mallards, green-winged teal, mergansers, scoters, golden-eye and bufflehead ducks may be present and some Canada geese reportedly use the lake for resting in the fall. One golden-eye and two mergansers were seen on the lake May 28, 1977. The lake appears well suited for osprey nesting but the lack of a good resident fish supply probably renders the area unattractive since there have been no recorded sightings of this bird.

Sea birds are year-round residents of Silver Bay and include murres, murrelets, guillemots, grebes, cormorants and loons. Scoters, golden-eye, harlequin, mallard, Old Squaw and bufflehead ducks are also present in Silver Bay on a seasonal basis. No population estimates are available for these species but their use of the area is not considered to be heavy, primarily due to the steep shoreline and lack of feeding areas.

Green Lake supports a small population of Eastern brook trout but present angler usage is low according to Artwin E. Schmidt, ADF&G sport fish biologist for the area (pers. comm., May 31, 1977). Nine fish sampled by gill net on November 14, 1974, averaged 23 cm. in length. Thirty-seven fish sampled the same way in July, 1968, averaged 22 cm. in length. The largest fish sampled was 36.5 cm long and weighed 1.1 kg.

Green Lake brook trout feed mainly on larvae of the chironomid genus Pseudodiamesa. This genus inhabits soft organic sediments present on the lake bottom at water depths of from 5 to 20 meters. Usually there is but one generation a year, adult emergence taking place in late fall or in the spring, depending upon the species.

Bear Creek and Medvejie Lake currently support a Dolly Varden char sport fishery for which no creel census data are available. No creel census has been taken of Green Lake anglers either because of its minor importance as a sport fishery.

Silver Bay is not a significant producer of commercial marine fishes but may serve as a rearing area for several species of flatfishes. In the past herring used the bay for spawning, but no spawning has occurred in recent years. The National Marine Fisheries Service has conducted two trawl surveys in Silver Bay. The first, on October 1, 1967, included two 20-minute hauls at the head of the bay in about 55 meters and one at the entrance to the bay begining at 55 meters and ending at 110 meters. Juvenile flatfish, mostly English sole, flathead sole and lemon sole, made up the bulk of the catch at the head of the bay while flathead sole, rex sole and rockfishes comprised the better part of the haul made at the bay mouth. All flatfishes taken were juveniles, indicating that Silver Bay may serve as a rearing area for these species. Adult rockfishes were found mostly at the bay mouth where habitat and higher salinities provide a more suitable environment for these species.

In May 1971 the National Marine Fisheries Service made three more trawl hauls in Silver Bay. A single trawl haul at the entrance to the bay yielded a catch comprised mostly of rockfish as before with small amounts of flatfish and invertebrates (Table 4). Two hauls in the center of the bay contained mostly flatfish with very small amounts of gadids, rockfish and invertebrates (Table 5).

Table 4. Composition of fish catches taken by trawl at the entrance to Silver Bay, May 1971

Depth Range (m)	Bottom Time (min)	Catch (lbs)	Weight of Organisms				
			Flatfish	Gadids	Rockfish	Other	Invertebrates
55-110	10	80.0	8.0	-	64.0	-	8.0

Table 5. Composition of fish catches taken by trawl in the center of Silver Bay, May 1971

Depth Range (m)	Bottom Time (min)	Catch (lbs)	Weight of Organisms				
			Flatfish	Gadids	Rockfish	Other	Invertebrates
64-91	47	21.5	19.4	0.7	0.7	tr	0.7

On May 30, 1977 large numbers of small herring were observed schooling in the vicinity of log rafts stored along the northeast shore of Silver Bay. One hair seal was spotted near Herring Cove and two active eagle nests were located and marked (Figure 3). Humpback whales are known to frequent Silver Bay at certain times of the year, especially in the fall.

Rare or Endangered Species

No resident or rare endangered species are known to inhabit or use any area adjacent to Green Lake or Silver Bay. It is recognized that the humpback whale is an endangered species and has received international protection since 1966. Bald Eagles are protected by the National Bald Eagle Act of June 8, 1940 (as amended).

Critical Habitat:

The only habitat area of any concern to ADF&G biologists is the outlet of Bear Creek into Silver Bay along the alignment of the proposed access road. This stream is considered important as a sport fishing and anadromous fish stream and, at the State's request, bridges, rather than culverts, will be used for crossing Bear Creek.

ENVIRONMENTAL IMPACT OF THE PROJECT

Physical Impacts:

The proposed normal maximum pool elevation of 119 meters will increase the area of Green Lake from its present size of 70.2 hectares to approximately 405 hectares. This impoundment will extend 4.8 kilometers up the Vodopad River valley from the present upper, or eastern, end of the lake. The result will be an artificial lake approximately 6.4 kilometers long by 0.8 kilometers wide. The 335 hectares of land to be inundated contains about 240 to 285 hectares of mixed spruce-hemlock old-growth forest with the remainder a mixture of stands of red alder, small patches of grass meadow and unvegetated overflow channels and gravel bars.

The normal maximum lake depth will increase from the existing 26 meters to approximately 75 meters at normal maximum reservoir. The minimum reservoir elevation above mean higher high water is proposed to be at 85 meters, the normal maximum pool at 119 meters. Given the most extreme situation, a drawdown of 33 meters might occur. The frequency of a maximum drawdown is estimated at once in every 40 years. At normal pool elevation, the shoreline will increase from 5,974 meters to approximately 15,700 meters.

Construction of the required access roads, contractor's staging area, dam site, power house and transmission line will result in an alteration of 34.2 hectares of land. Of this total, 16.8 will be cleared only, the remaining 17.4 hectares will be permanently altered by construction, primarily as a result of building the access roads (10+ hectares).

Road, power tunnel and site preparation will result in the wasting of an estimated 92,880 cubic meters of material as follows: 64,220 cubic meters during access road construction south of Bear Cove, 6,970 cubic meters during power tunnel construction, 19,400 cubic meters from power house site preparation and 2,290 cubic meters as a result of coffer dam construction (Table 6). Almost all of this surplus material will be wasted into Silver Bay, resulting in a major source of turbidity at certain times during construction. The major rock type to be excavated, graywacke, is very hard and geologists have estimated that only about five percent of the excavated volume will be fine enough to pass a 200-mesh sieve. Based on this estimate, the expected fraction of excavated and wasted material that will result in significant turbidity is about 4,650 cubic meters. This volume of wasted material equals about 0.026 percent of the total water mass of Silver Bay and the estimated fraction composed of fines about 0.001 percent of the total volume of the bay, if we were to assume homogeneous mixing. Under natural conditions, however, most of this material is expected to be carried out of the bay and dispersed by the upper, less saline, layer of water.

The time of year and duration of activities resulting in turbidity are important factors in determining the impact of additions of fines to the waters of Silver Bay. The most recent construction schedule available (Douglas Brawley, RWB, pers. comm., June 27, 1977) indicates that the wasting operations south of Bear Cove will commence about August 1, 1978, and be completed by about November 30, 1978. This is the time period during access road construction when fines will be wasted into the bay south of Bear Cove. Almost all fines resulting from road construction are expected to come from this segment of the road due to the extensive amount of full bench excavation required.

In addition to wasting material into Silver Bay, all construction will require blasting. Coffer dam construction will be done during March, 1979, power house site excavation during May, 1979, and the power tunnel will be excavated from June through September, 1979.

Table 6. Estimated time, duration, amount of material, and amount of fines passing a 200-mesh sieve that will be wasted into Silver Bay during construction of the Green Lake hydroelectric project

Activity	Time Period	Amount of Material to be Wasted (m^3)	Amount of Fines (m^3)
Access Road Construction South of Bear Cove	1 Aug.-Nov. 30 1978	64,220	3,210
Coffer Dams	March 1979	2,290	115
Power House	May 1979	19,400	970
Power Tunnel	June-Sept.1979	6,970	350

Biological Impacts:

Biological impacts resulting from the construction and operation of the Green Lake hydroelectric power project will occur as a result of impoundment and construction and will affect both the flora and the fauna of the immediate project area, Green Lake, the Vodopad River valley and Silver Bay.

Impacts upon flora; There will be a direct loss of vegetative production from roughly 335 hectares of forested lands, some 240 to 285 hectares of which supports stands of commercial timber averaging anywhere from 8,000 to 13,000 board feet per hectare. Initially all commercial timber will be removed from the impoundment area and sold. Thus, the old-growth timber that would be inundated as the reservoir fills will be salvaged. The area will, however, be taken out of future timber production. This removal will represent an estimated future timber loss of between 20 and 40 million board feet during the next 100 year rotation. Road construction will result in the loss of about 24 hectares of old-growth timber and a corresponding amount of winter deer range along the northeast shore of Silver Bay in addition to the undetermined amount of range lost through impoundment.

Impacts upon fauna in the Green Lake drainage; Flooding the lower 4.8 kilometers of the Vodopad River will virtually eliminate the majority of brook trout spawning grounds. It is difficult to determine at this time whether or not suitable spawning areas will still be available once the reservoir reaches the planned elevation of 119 meters. At present, however, it appears that the natural reproductive capability of the resident trout population will be lost as a result of habitat alteration. The lower Vodopad River between the outlet of Green Lake and Silver Bay flows through a steep gorge. This segment of the river is blocked to anadromous fishes by an impassable falls at the river mouth. The entire gorge is insignificant as wildlife habitat.

Something less than 335 hectares of potential deer habitat will be lost through impoundment. The amount of actual habitat loss is difficult to ascertain without intensive investigation but not all the land to be flooded represents usable habitat. Displaced deer may not find adjacent areas below carrying capacity, however, and any adjustment in deer populations in the vicinity of Green Lake as a result of this project must be expected to include some loss of animals that otherwise would not have occurred. The same may be said for furbearers, other small mammals and birds that presently rely on habitat that will be flooded. Mountain goat populations, on the other hand, will probably not be greatly affected directly by the project, although improved access to the area may result in future increases in hunting pressure. Bear populations will be little affected by the project.

Birds, especially waterfowl, currently nesting, resting or feeding at Green Lake will also suffer a loss of habitat. Although the shoreline will be increased almost three times, this increase does not represent a gain in shoreline habitat due to drawdown effects and loss of shallow water areas important for food production. The lake will still serve as a resting area for migrating birds.

Impacts upon the fauna of Silver Bay; Two factors of major importance will exert an influence upon the biotic community of Silver Bay as a result of project construction. First, the spoiling of materials into the bay along the access road and at the power station site will disturb the littoral habitat and result in an initial loss of invertebrates and marine macrophytes. This effect will be transitory in nature because materials spoiled do not differ significantly from the existing substrate. As recolonization occurs there exists a very strong possibility of additional production due to the presence of more interstices in the deposited materials than are now present in the natural state. At any rate, recolonization will occur within a period of two to three years with an expected increase in some species, particularly some shrimps and juvenile rockfishes, and possible declines in other forms more dependant on a soft substrate. The assumption that recolonization will occur in approximately the manner described is based upon the author's 12 years of experience observing similar situations as a diver-biologist in southeast Alaska.

Second, the addition of fine sediments during certain periods of construction will create abnormal turbidity levels. Turbidity will directly affect some forms by its physical presence. For example, sight feeding birds and fishes will have reduced visibility. Turbidity also decreases the ability of light to penetrate the water column and thereby reduces photosynthetic activity of the phytoplankton and marine macrophytes. Reduced plankton and algal production, in turn, lowers the food web base and all other aquatic production as well.

Two factors have considerable bearing on the impact of excessive turbidity upon the marine ecosystem of Silver Bay. First, the timing and duration of sediment introduction influences the effect of increased turbidity. Second, the natural circulation of water in Silver Bay governs, to a large extent, the dissipation of introduced sediments. These two factors are dependent to a great degree upon each other because of the typical fiord-type circulation pattern described in an earlier section. Should addition of sediments be timed to coincide with expected periods of high runoff, adverse impacts may be expected to be less than if introduction of sediments occurs during periods of low runoff. The reason for this is that the outward movement of the layer of freshwater on top of the bay will serve to carry out and disperse introduced sediment more readily during high runoff periods. Heavy sediment introductions resulting in marked increases in turbidity are known to occur naturally in Silver Bay. While such natural introductions are obviously of shorter duration, the amount of materials introduced, their impact on the existing environment and the pattern of their dissipation has not been studied.

Blasting and heavy equipment operation during road construction and excavation of the power house site will create a noise disturbance that will affect the use of the bay by marine birds and other animals. The actual effect of such disturbances cannot be measured easily but is assumed to be an adverse, though temporary, impact of the project.

These same disturbances will have an adverse impact on the use of the two active eagle nests situated along the shore between Herring Cove and Bear Cove close to the proposed road alignment. Scheduling of road construction may reduce this impact considerably if construction near these sites is completed prior to nesting or curtailed until after the young eagles have fledged. Nest building commences in early April and most eaglets are fully feathered and ready to fly by the end of July.

Impacts upon recreation; During field investigations of the Green Lake dam site on May 30, 1977, the study team met a party of two hiking into Green Lake with a rubber raft. On May 28, four pleasure craft were observed at the upper end of Silver Bay. Recreational angling in Green Lake is not considered significant by ADF&G personnel stationed at Sitka. Nonetheless, some residents do make use of the recreational opportunities and scenic values afforded by Green Lake. The access trail, though relatively short (about 1 kilometer), is arduous and lake use is limited by the ruggedness of the intervening terrain and the difficulty of fishing the lake without a boat.

The impact of the project on recreational use of the area will be two-fold. During construction the access road and construction areas will be closed to the public for safety reasons. After construction is completed, however, the road will provide much easier foot access to Green Lake and, in conjunction with a fish stocking program by the ADF&G, can afford increased angling opportunities. A boat mooring bouy proposed for installation in Silver Bay in the vicinity of the power house will enhance access to Green Lake. Any ADF&G stocking program for Green Lake will depend upon the City's granting public access to the lake shore.

MEASURES TO ENHANCE OR AVOID ADVERSE EFFECTS TO THE ENVIRONMENT

The possibility of using tail race water from the power house as a water source for a State operated salmon hatchery has been under consideration for some time by ADF&G biologists. No decision has been reached to date because of certain unanswered water quality questions. Namely, periodic natural high levels of turbidity would render the water supply unsuitable for hatchery use. Natural discharges of sediment from the Green Lake watershed have created excessive turbidity in Silver Bay on past occasions. The ADF&G will not commit itself to such a project until certain that appropriate quality water is available at all times according to Kenneth Leon, F.R.E.D. Division, ADF&G, Juneau, Alaska (pers. comm., May 26, 1977).

Water temperatures taken twice daily (0700 and 1900 hrs.) at the Blue Lake power house between May 25, 1977, and June 6, 1977, show that the temperature of the tailrace water averages about 1^{o}C. lower than that of water entering the plant from Blue Lake. The proposed Green Lake project is similar enough to the Blue Lake facility to infer that some slight drop in temperature might be expected at the Green Lake tailrace as well. For the purpose of rearing salmon, water temperatures slightly colder than normal may have the advantage of reducing the incidence of early emergence from the incubators should that factor be a problem.

The State will consider stocking the resulting impoundment with either brook trout or rainbow trout if public access to the lake is assured by the City and Borough of Sitka. Blue Lake was stocked after impoundment and became relatively productive for a period of about 10 years or so as decomposing organic debris added nutrients to the reservoir waters. Blue Lake productivity has now stabilized at a comparatively low level, ranking 11th among 13 lakes studied by the ADF&G with a morphoedaphic index of only 0.42. A similar evolution in productive capacity can be anticipated for the proposed Green Lake reservoir.

With the advent of easier foot access and installation of a mooring bouy, coupled with a stocking program, the Green Lake impoundment will provide increased angling opportunities to Sitka area residents. In addition, access road passage over the two main channels of Bear Creek in Bear Cove will be accomplished by bridging to prevent any impediment to fish movement (Figure 5).

Other measures that can be taken to mitigate adverse impacts include the scheduling of blasting to coincide with periods of low waterfowl use in the vicinity of Silver Bay. The fall migration period is perhaps the most critical. To provide protection for humpback whales it is recommended that blasting operation be delayed should humpback whales appear within one (1) nautical mile of the blasting site. This should provide adequate protection for this species since no underwater blasting will be taking place. Impacts of wasting materials that will result in increased turbidity can be reduced by scheduling wasting to coincide with periods of anticipated high runoff whenever possible. The time of the spring melt and fall rains would encompass two such periods. Road construction activities in the vicinity of the two active eagle trees should be completed prior to nesting or delayed until after the young eagles have left the nests. Insulators on power transmission poles should be spaced so as to prevent the electrocution of large birds such as eagles that might use power transmission poles as perching sites.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

No agency has identified any critical wildlife habitat within the proposed project area. There will be a loss of approximately 23 hectares of good deer winter range along the northeast shore of Silver Bay due to construction of the 10.5 kilometer access road.

Inundation will preempt the use of the area around Green Lake and the Vodopad River valley for future timber production. Portions of the approximately 405 hectares to be flooded will be lost as habitat for deer, furbearers, small mammals and terrestrial feeding and nesting birds. Waterfowl use of Green Lake will be reduced, except as a resting area for migrating birds and this use may also decline as well since shallow areas now producing some feed will be removed from production as the lake level rises. Spawning areas in the Vodopad River now available to the resident brook trout population will be greatly reduced or lost. This loss may be

Figure 5. Bear Creek, flowing from Medvejie Lake into Bear Cove, is an anadromous fish stream and will be bridged to insure access by fish at all water stages.

offset in the event the ADF&G decides to stock the lake with the same or another species of sport fish.

Diver-biologists of the National Marine Fisheries Service have concluded that rock debris wasted into Silver Bay will smother any attached life forms (Appendix 3). They note in their report, however, that the rock introduced to top of the natural rock habitat already present should be repopulated by the same attached life forms that presently occur in the area. Infauna on soft bottoms, however, may not recolonize if these areas are smothered by rock debris. Hence, a change in the local exosystem may occur in areas having soft bottoms due to the change in habitat brought on by alterations in the composition of the substrate.

Turbidity resulting from wasting materials into Silver Bay may temporarily reduce the numbers of sight-feeding fishes and birds. Estimates of the amount of fines (Table 6) have been set conservatively high and the impact of their introduction into the marine ecosystem will probably be, if anything, less than anticipated. This reduction of sight-feeding forms will only last for the construction period and populations of such fishes and birds should reach pre-project levels soon after turbidity reaches normal concentrations in the affected areas.

The ADF&G has long recognized that any hydroelectric project proposed for Green Lake will, in their estimation, have little or no major impact on fish and wildlife resources in the project area. In an April 17, 1969, memo from Larry J. Heckart, Fishery Biologist, Sport Fish Division, Sitka, to Tom Richardson, Area Management Biologist, Commercial Fish Division, Juneau, Heckart cited no objections to such a proposed project. Several years later in a memo dated July 15, 1975, to Raymond Estess, State-Federal Coordinator, Division of Policy and Planning, Office of the Governor, James W. Brooks, Commissioner of Fish and Game, stated that no major impact was forseeable to fish and wildlife from such a proposed project. The Department has not changed its viewpoint over the intervening years according to Richard D. Reed, Regional Habitat Coordinator (pers. comm., May 26, 1977) and Dr. Ronald O. Skoog, Director of the Department's Habitat Division (pers. comm., May 26, 1977).

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The local short-term use of Green Lake as a reservoir for hydroelectric generation will alter the impacted ecosystem for the Green Lake area for the life of the project as a result of the installation of the dam and power house facility and the construction of access roads to the power house and dam site. The ecosystems of approximately 405 hectares of forest land and the existing lentic and lotic freshwater environments will be transformed from their present state to one common to cold water impoundments. The use of the area by terrestrial and aquatic species currently present will not be restored in less than 100 years after termination of the project, which has a conservative life span of 50 years. Thus, for a period of approximately 150 to 200 years the productivity of the project area will be that associated with an impoundment situation, undoubtedly resulting in a marked lowering of the biomass on a per hectare basis.

The short-term effects of spoiling materials into Silver Bay as a result of construction will impact the marine ecosystem for a much briefer period of time. While some permanent shifts in aquatic associations may take place in areas where soft substrate is overlain with wasted rock, these areas will become productive as altered ecosystems within a relatively short period (approximately 2 to 5 years). Of the six sites investigated during the most recent National Marine Fisheries Service diving survey (Appendix 3), two had soft bottoms. Assuming one third of the shoreline is thus represented, approximately three kilometers of littoral zone may be so affected. Productivity in these areas will not be lost, however, only altered to accommodate other species of flora and fauna.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Permanent changes in habitat within the project area will occur within the impoundment area (approximately 405 hectares) and on an additional 34.5 hectares involved in construction of access roads, facilities and power line rights of way. In addition, the littoral and sublittoral zone of approximately three kilometers of Silver Bay shoreline will undergo some alteration in ecosystem type due to the wasting of materials during road, power house and power tunnel construction. These changes will be accompanied by a concomitant loss of species and individuals associated with these habitats.

Permanent changes in present species composition and numbers will be most marked within the impoundment area. Terrestrial species of flora and fauna within the area to be inundated will, for the most part, be lost unless adjacent areas are below the carrying capacity for the species involved. Quantification of these losses is extremely difficult without exhaustive population studies of all forms present. The area is, however, not considered a critical one for any of the species involved and their loss must simply be accepted as a trade-off should the project be authorized and constructed as planned.

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July 15, 1977

To: Donald E. Bowes
From: David T. Hoopes
Subject: City and Borough of Sitka, Alaska
Green Lake Project
Follow-up on Consultations with Concerned Federal and State Agencies

June 3: Visited aboard R/V Curlew, FWS research vessel, in Sitka to discuss further the FWS survey of Green Lake and Silver Bay. Gave party leader, Donald T. Montgomery, data on eagle nest locations and reiterated a request for the results of their survey.

June 6: Met with NMFS Regional Director, Harry L. Rietze, and Supervisor of NMFS' Division of Environmental Assessment, Fred Thorsteinson, and received additional assurance that results of the NMFS diving survey in Silver Bay would be made available in a timely manner (they were).

Obtained species lists of flora and fauna common to southeast Alaska for inclusion in report from Dr. William L. Sheridan, Fisheries and Wildlife Management Coordinator, U.S. Forest Service, P.O. Box 1628, Juneau, Alaska 99802.

Obtained list of aquatic insects from Mr. Steven T. Elliott, Sport Fish Division, Alaska Department of Fish and Game, Juneau, Alaska.

APPENDIX I

TABLE 1. Terrestrial flora common to the Green Lake watershed and the northeast shore of Silver Bay, Baranof Island, Alaska.

Common Name	Scientific Name
Lodgepole pine	*Pinus contorta*
Sitka spruce	*Picea sitchensis*
Western hemlock	*Tsuga heterophylla*
Mountain hemlock	*Tsuga mertensiana*
Alaska-cedar	*Chamaecyparis nootkatensis*
Black cottonwood	*Populus trichocarpa*
Scouler willow	*Salix scouleriana*
Sitka willow	*Salix sitchensis*
Red alder	*Alnus rubra*
Sitka alder	*Alnus sinuata*
Sitka mountain-ash	*Sorbus sitchensis*
Douglas maple	*Acer glabrum*
Alaska blueberry	*Vaccinium alaskensis*
Beach ryegrass	*Elymus mollis*
Bog blueberry	*Vaccinium uliginosum*
Bog rosemary	*Anadromeda polifolia*
Bracken fern	*Pteridium aquilinum* ssp. *langinosum*
Buckbean	*Menyanthes trifoliata*
Bunchberry	*Cornus canadensis*
Buttercup	*Ranunculus* spp.
Chocolate lily	*Fritillaria camschatcensis*
Cloudberry	*Rubus chamaemorus*
Clubmoss	*Lycopodium* spp.
Common hair moss	*Polytrichum commune*
Common juniper	*Juniperus communis*
Copperbush	*Cladothamnus pyrolaeflorus*
Cow parsnip	*Heracleum lanatum*
Crowberry	*Empetrum nigrum*
Deerberry	*Maianthemum dilatatum*
Deer cabbage	*Veratrum viride*
Deerfern	*Blechnum spicant*
Devilsclub	*Oplopanax horridus*
Dwarf blueberry	*Vaccinium caespitosum*
Early blueberry	*Vaccinium ovalifolium*
Feather moss	*Rhytidiadelphus loreus*
Fireweed	*Epilobium angustifolium*
Five-leaved bramble	*Rubus pedatus*
Foamflower	*Tiarella trifoliata*
Goatsbeard	*Aruncus sylvester*
Juniper-leaved hair moss	*Polytrichum juniperinum*
Laborador tea	*Ledum groenlandicum*

TABLE 1. (cont.)

Lowbush cranberry	*Vaccinium vitis-idaea*
Lupine	*Lupinus nootkatensis*
Marsh marigold	*Caltha biflora*
Marsh violet	*Viola palustris*
Nagoon berry	*Rubus arcticus*
Northern geranium	*Geranium erianthum*
Oak fern	*Gymnocarpium dryopteris*
Oregon crabapple	*Malus diversifolia*
Ostrich-plumed feather moss	*Ptilium crista-castrensis*
Pacific red elder	*Sambucus callicarpa*
Rattlesnake root	*Prenanthes alata*
Red huckleberry	*Vaccinium parvifolium*
Rusty menziesia	*Menziesia ferruginéa*
Salmonberry	*Rubus spectabilis*
Sedge	*Carex* spp.
Shooting star	*Dodecatheon* spp.
Silverweed cinquefoil	*Potentilla anserina*
Single delight	*Moneses uniflora*
Skunk cabbage	*Lysichiton americanum*
Sphagnum moss	*Sphagnum* spp.
Spreading wood fern	*Dryopteris dilatata*
Star flower	*Trientalis europaea*
Stink currant	*Ribes bracteosum*
Swamp laurel	*Kalmia polifolia*
Swedish dwarf cornel	*Cornus suecica*
Thimbleberry	*Rubus parviflorus*
Thread moss	*Mnium glabrescens*
Trailing black currant	*Ribes laxiflorum*
Twisted stalk	*Streptopus amplexifolius*

TABLE 2. Invertebrates collected from Green Lake during September, 1976. Specimens were obtained from brook trout (*Salvelinus fontinalis*) stomach samples and should be representative of their feeding habits (data from ADF&G Fishery Biologist Steven T. Elliott, Juneau, Alaska, June 6, 1977. (personal communication)

Scientific Name	Collection Locality	
	Inlet	Lake
Sphaeridae		x
Gammarus sp.		x
Hydracarina	x	
Ephemeroptera		
Ameletus sp.	x	
Plecoptera		
Nemoura (*Zapada*) sp.	x	
Capnia sp.	x	
Alloperla sp.	x	
Kathroperla sp.	x	
Trichoptera		
Rhyacophila sp.	x	
Linmephilidae	x	x
Coleoptera		
Agabus sp.		x
Hydroporus sp.		x
Ilybius sp.		x
Diptera		
Dicranota sp.	x	x
Tipula sp.	x	x
Pseudodiamesa spp. 1/	x	x
Micropsectra spp.	x	x
Atherix sp.	x	
Dolichopodidae	x	

1/ Dominant fish food species

TABLE 3. Checklist of amphibians that may occur in the Green Lake watershed.

Common Name	Scientific Name
Order Caudata	
Rough-skinned newt	*Taricha granulosa*
Order Anura	
Western toad	*Bufo boreas*

TABLE 4. Common species of birds either present or believed to occur in the Green Lake watershed and Silver Bay area of Baranof Island, Alaska.

Common Name	Scientific Name
Order Gaviiformes	
Common loon	Gavia immer
Arctic loon	Gavia arctica
Red-throated loon	Gavia stellata
Order Podicipediformes	
Western grebe	Aechmophorus occidentalis
Order Procellariiformes	
Northern fulmar	Fulmaris glacialis
Sooty shearwater	Puffinus griseus
Fork-tailed storm petrel	Oceanodroma furcata
Leach's storm petrel	Oceanodroma leucorhoa
Order Pelecaniformes	
Double-crested cormorant	Phalacrocorax auritus
Pelagic cormorant	Phalacrocorax pelagicus
Order Ciconiiformes	
Great blue heron	Ardea herodias
Order Anseriformes	
Vancouver Canada goose	Branta canadensis fulva
Mallard	Anas platyrhynchos
Pintail	Anas acuta
Green-winged teal	Anas crecca
Blue-winged teal	Anas discors
American wigeon	Anas americana
Northern shoveler	Anas clypeata
Greater scaup	Aythya marila
Lesser scaup	Aythya affinis
Common goldeneye	Bucephala clangula
Barrow's goldeneye	Bucephala islandica
Bufflehead	Bucephala albeola
Oldsquaw	Clangula hyemalis
Harlequin duck	Histrionicus histrionicus
White-winged scoter	Melanitta deglandi
Surf scoter	Melanitta perspicillata
Common merganser	Mergus merganser
Red-breasted merganser	Mergus serrator

TABLE 4. (cont.)

Order Falconiformes	
Goshawk	Accipiter gentilis
Sharp-shinned hawk	Accipiter striatus
Bald eagle	Haliaeetus leucocephalus
Marsh hawk	Circus cyaneus
Order Charadriiformes	
Black oystercatcher	Haematopus bachmani
Semipalmated plover	Charadrius semipalmatus
Black turnstone	Arenaria melanocephala
Common snipe	Capella gallinage
Whimbrel	Numenius phaeopus
Spotted sandpiper	Actitis macularia
Greater yellowlegs	Tringa melanoleuca
Lesser yellowlegs	Tringa flavipes
Wandering tattler	Heteroscelus incanus
Least sandpiper	Calidris minutilla
Dunlin	Calidris alpina
Western sandpiper	Calidris mauri
Sanderling	Calidris alba
Red phalarope	Phalaropus fulicarius
Northern phalarope	Lobipes lobatus
Parasitic jaeger	Stercorarius parasiticus
Glaucous gull	Larus hyperboreus
Glaucous-winged gull	Larus glaucescens
Herring gull	Larus argentatus
Mew gull	Larus canus
Bonaparte's gull	Larus philadelphia
Black-legged kittiwake	Rissa tridactyla
Arctic tern	Sterna paradisaea
Common murre	Uria aalge
Pigeon guillemot	Cepphus columba
Marbled murrelet	Brachyramphus marmoratus
Ancient murrelet	Synthliboramphus antiquus
Cassin's auklet	Ptychoramphus aleuticus
Rhinoceros auklet	Cerorhinca monocerata
Horned puffin	Fratercula corniculata
Tufted puffin	Lunda cirrhata
Order Strigiformes	
Boreal owl	Aegolius funereus
Order Apodiformes	
Rufous hummingbird	Selasphorus rufus
Order Coraciformes	
Belted kingfisher	Megaceryle alcyon

TABLE 4. (cont.)

Order Piciformes	
Yellow-bellied sapsucker	Sphyrapicus varius
Hairy woodpecker	Picoides villosus
Downy woodpecker	Picoides pubescens
Order Passeriformes	
Western flycatcher	Empidonax difficilis
Violet-green swallow	Tachycineta thalassina
Tree swallow	Iridoprocne bicolor
Bank swallow	Riparia riparia
Barn swallow	Hirundo rustica
Steller's jay	Cyanocitta stelleri
Common raven	Corvus corax
Northwestern crow	Corvus caurinus
Chestnut-backed chickadee	Parus rufescens
Dipper	Cinclus mexicanus
Winter wren	Troglodytes troglodytes
American robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	Catharus ustulatus
Golden-crowned kinglet	Regulus satrapa
Ruby-crowned kinglet	Regulus calendula
Water pipit	Anthus spinoletta
Northern shrike	Lanius excubitor
Orange-crowned warbler	Vermivora celata
Yellow warbler	Dendroica petechia
Townsend's warbler	Dendroica townsendi
Wilson's warbler	Wilsonia pusilla
Pine grosbeak	Pinicola enucleator
Gray-crowned rosy finch	Leucosticte tephrocotis
Pine siskin	Carduelis pinus
Red crossbill	Loxia curvirostra
Savannah sparrow	Passerculus sandwichensis
Dark-eyed junco	Junco hyemalis
Oregon junco	Junco oreganus
White-crowned sparrow	Zonotrichia leucophrys
Fox sparrow	Passerella iliaca
Lincoln's sparrow	Melospiza lincolnii
Song sparrow	Melospiza melodia

TABLE 5. Checklist of mammals known or believed to occur in the Green Lake watershed and Silver Bay, either as resident or transient species, both terrestrial and marine.

Common Name	Scientific Name
Order Insectivora	
Masked shrew	*Sorex cinereus*
Dusky shrew	*Sorex obscurus*
Northern water shrew	*Sorex palustris*
Pygmy shrew	*Microsorex hoyi*
Order Chiroptera	
Keen's bat	*Myotis keeni*
Little brown bat	*Myotis lucifugus*
Order Lagomorpha	
Pika	*Ochotona collaris*
Order Rodentia	
Deer mouse	*Peromyscus maniculatus*
Northern bog lemming	*Synaptomys borealis*
Brown lemming	*Lemmus sibiricus*
Northern red-backed vole	*Clethrionomys rutilus*
Meadow vole	*Microtus pennsylvanicus*
Long-tailed vole	*Microtus longicaudus*
Tundra vole	*Microtus oeconomus*
Meadow jumping mouse	*Zapus hudsonius*
Red squirrel	*Tamiasciurus hudsonicus*
Order Carnivora	
Brown (grizzly) bear	*Ursus arctos*
Pine marten	*Martes americana*
Ermine	*Mustela erminea*
Mink	*Mustela vison*
Order Pinnipedia	
Northern sea lion	*Eumetopias jubata*
Harbor seal	*Phoca vitulina*
Order Cetacea	
Minke Whale	*Balaenoptera acutorostrata*
Humpback whale	*Megaptera nodosa*
Killer whale	*Grampus rectipinna*
Harbor porpoise	*Phocoena phocoena*
Dall porpoise	*Phocoenoides dalli*
Order Artiodactyla	
Sitka black-tailed deer	*Odocoileus hemionus sitkensis*
Mountain goat	*Oreamnos americanus*

TABLE 6. Common marine plants known to occur in Silver Bay and the surrounding waters, Baranof Island, Alaska.

Scientific Name	Common Name
Phylum Chlorophyta	
Ulva sp.	Sea lettuce
Phylum Phaeophyta	
Agarum cribrosum	
Fucus distichus	Pop kelp
Laminaria sp.	Sugarwrack
Desmarestia intermedia	
Phylum Rhodophyta	
Corallina sp.	Coralline algae
Lithothamnion sp.	Red rock crust
Rhodymenia pertusa	Red eyelet silk
Marine Phanerogams	
Zostera marina	Eelgrass

TABLE 7. Common marine invertebrates known to occur or believed present in Silver Bay and adjacent waters, Baranof Island, Alaska.

Scientific Name	Common Name
Phylum Chordata	
Class Ascidiacea	Tunicates
Cnemidocarpa joannae	Broad base sea squirt
Corella willmeriana	
Halocynthia aurantium	Sea peach
Halocynthia sp.	Sea squirt
Phylum Cnidaria	
Class Hydrozoa	
Aurelia labriata	Moon jellyfish
Cyanea capillata	Sea blubber
Phylum Brachipoda	
Class Articulata	
Terebratalia transversa	Lamp shell
Phylum Annelida	
Class Polychaeta	
Nereis vexillosa	Clam worm
Serpula vermicularis	Calcareous tube worm
Phylum Echiurida	
Echiurus echiurus alaskensis	Echiuroid worm
Phylum Arthropoda	
Class Crustacea	
Balanus glandula	Barnacle
Tylos sp.	Isopod
Elassochirus tenuimanus	Thin handed hermit crab
Pagurus hirsutiuculus	Hairy hermit crab
Hemigrapsis nudus	Purple shore crab
Hemigrapsis oregonensis	Common mud flat crab
Oregonia gracilis	Decorator crab
Chionoecetes bairdi	Tanner crab
Paralithodes camtschatica	King crab
Pandalus borealis	Pink shrimp
Pandalopsis dispar	Sidestripe shrimp
Phylum Mollusca	
Class Amphineura	
Tonicella lineata	Lined chiton

TABLE 7. (cont.)

Class Pelecypoda	
Chlamys hastata hericia	Pink scallop
Chlamys rebida	Hind's scallop
Mytilus edulis	Purple mussel
Pododesmus macrochisma	Jingle shell
Saxidomus giganteus	Butter clam
Protothaca staminea	Pacific littleneck clam
Clinocardium nuttallii	Cockle
Class Gastropoda	
Acmaea sp.	Limpet
Calliostoma ligatum	Blue top snail
Hermissenda crassicornis	Opalescent nudibranch
Littorina sp.	Periwinkle
Archidoris montereyensis	Nudibranch
Archidoris odhneri	Nudibranch
Melibe leonina	Hooded nudibranch
Phylum Echinodermata	
Class Asteroidea	
Dermasterias imbricata	Leather star
Mediaster aequalis	Vermillion star
Pycnopodia helianthoides	Sunflower star
Pisaster ochraceus	Ochre star
Class Ophiuroidea	
Ophiopholis sp.	Brittle star
Class Holothuroidea	
Parastichopus californicus	Red sea cucumber
Leptosynapta clarki	Burrowing sea cucumber
Class Echinoidea	
Strongylocentrotus droebachiensis	Green sea urchin
Strongylocentrotus franciscanus	Giant red urchin

TABLE 8. Fishes known to occur in the Green Lake drainage 1/, Silver Bay and adjacent waters, Baranof Island, Alaska.

Common Name	Scientific Name
Family Salmonidae	
Pink salmon	Oncorhynchus gorbuscha
Chum salmon	Oncorhynchus keta
Coho salmon	Oncorhynchus kisutch
Cutthroat trout	Salmo clarki
Rainbow trout	Salmo gairdneri
Brook trout	Salvelinus fontinalis
Dolly Varden	Salvelinus malma
Family Osmeridae	
Eulachon	Thaleichthys pacificus
Family Gadidae	
Pacific cod	Gadus macrocephalus
Pacific tomcod	Microgadus proximus
Walleye pollock	Theragra chalcogramma
Family Scorpaenidae	
Rougheye rockfish	Sebastes aleutianus
Pacific ocean perch	Sebastes alutus
Brown rockfish	Sebastes auriculatus
Yellowtail rockfish	Sebastes flavidus
Quillback rockfish	Sebastes maliger
Black rockfish	Sebastes melanops
Yelloweye rockfish	Sebastes ruberrimus
Bocaccio	Sebastes paucispinus
Family Hexagrammidae	
Whitespotted greenling	Hexagrammos stelleri
Family Cottidae	
Padded sculpin	Artedius fenestralis
Pacific staghorn sculpin	Leptocottus armatus
Great sculpin	Myoxocephalus polycanthocephalus
Family Bathymasteridae	
Searcher	Bathymaster signatus
Family Stichaeidae	
Pacific snakeblenny	Lumpenus sagitta
Family Pholididae	
Saddleback gunnel	Pholis ornata

TABLE 8. (cont.)

Family Pleuronectidae	
Arrowtooth flounder	*Atheresthes stomias*
Rex sole	*Glyptocephalus zachirus*
Flathead sole	*Hippoglossoides elassodon*
Rock sole	*Lepidopsetta bilineata*
Yellowfin sole	*Limanda aspera*
Slender sole	*Lyopsetta exilis*
Arctic flounder	*Liopsetta glacialis*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*

1/ Green Lake and the Vodopad River contain no natural resident or anadromous fish populations due to the presence of an impassable falls on the Vodopad River at tidewater. An introduced population of brook trout has been established in Green Lake by stocking.

APPENDIX II

Table 1. Hydrogen Ion Concentration, pH, of Green Lake, 1974 1/

	West Basin		East Basin	
Depth (m)	5/18	8/22	5/18	8/22
1	7.0	-	6.9	6.7
3	7.0	6.7	6.9	6.6
5	7.0	6.7	6.9	6.7
10	7.0	6.7	6.9	6.7
14	6.9	6.7	6.9	6.7
16	6.9	6.7	6.9	6.9

1/ Data provided by the Alaska Department of Fish and Game

Table 2. Water quality and nutrient analysis of Green Lake, 1974 2/

Parameter Measured	Date May 18, 1974	August 22, 1974
Depth (m)	0.6	0.3
	7.9	4.9
Diss. Oxygen (mg/l)	12.4	12.0
	12.6	12.1
pH	6.9	6.5
	6.9	6.7
Phosphate (mg/l)	0.01	0.00
	0.01	0.00
Diss. Potassium (mg/l)	0.8	0.5
	0.6	0.4
Diss. Calcium (mg/l)	28	16
	28	17
Diss. Silica (mg/l)	2.6	1.5
	2.5	1.5
Diss. Sodium (mg/l)	19	26
	19	14
Diss. Sulfate (mg/l)	3.9	2.6
	4.8	2.8
Turbidity (JTU)	0	0
	0	0
Vanadium (µg/l)	5.9	ND 1/
	5.2	ND
Temp. (^{o}C.)	6.0	8.0
	5.0	7.0
Zinc (µg/l)	230	ND
	90	ND
Alkalinity ($CaCO_3$) (mg/l)	14	ND
	14	ND
Aluminum (µg/l)	100	ND
	100	ND

Table 2. (cont.)

Bicarbonate (HCO_3) (mg/l)	13	10
	16	10
Boron (µg/l)	110	3
	120	4
Diss. Calcium (mg/l)	5.9	3.5
	5.7	3.6
CO_2 (mg/l)	3.4	ND
	3.4	ND
Total Organic Carbon (mg/l)	1.6	ND
	2.0	ND
Diss. Chloride (mg/l)	3.0	1.7
	3.4	1.5
Cobalt (mg/l)	50	ND
	50	ND
Color	7	2
	8	2
Conductivity (micro-ohms)	49	31
	47	29
Copper (µg/l)	10	10
	100	10
Fluoride (mg/l)	0	0
	0	0
Total Hardness (mg/l)	17	9
	16	11
Non-Carbonate Hardness	3	1
	2	1
Diss. Iron (µg/l)	80	21
	80	40
Diss. Magnesium (mg/l)	0.5	0.0
	0.5	0.4

Table 2. (cont.)

Diss. Manganese (mg/l)	10 0	0 0
Molybdenum (μg/l)	1 0	ND ND
Nitrogen, NH_4 (mg/l)	0.02 0.06	0.02 0.02
as N	0.20 0.24	0.07 0.09
as NO_3	0.89 1.10	0.31 0.40
Total Organic N	0.02 0.00	0.02 0.00
NO_2+NO_3	0.16 0.18	0.03 0.07

1/ ND = Not determined

2/ Data provided by the Alaska Department of Fish and Game

Table 3. Plankton composition, density (organisms per square meter of surface area) and weight (milligrams per square meter), Green Lake, May 15 - Deptember 17, 1974 1/

Date	5/15	5/29	6/12	7/5	7/17	7/30	8/19	9/17
Depth of tow (m)	15	13	13	13	13	13	13	13
Rotatoria								
<u>Keratella</u>	1528	509	1528	2037	2037	5484	0	130888
<u>Kellicottia</u>	2037	0	1528	509	1018	3056	16806	1528
<u>Polyarthra</u>	0	0	0	0	0	1018	0	16297
<u>Conochilus</u>	0	0	0	0	0	0	0	1018
<u>Filinia</u>	0	0	0	0	0	0	0	3565
Cladocera								
<u>Bosmina</u>	1018	0	1018	0	0	0	1018	509
<u>Holopedium</u>	0	0	0	0	0	0	1018	0
Copepoda								
Cyclopoida	0	0	0	0	0	509	509	0
Calanoida	1018	2546	509	0	0	0	0	0
Nauplii	0	509	1018	0	0	509	1508	0
Miscellaneous								
<u>Coelospherium</u>	509	0	15788	0	0	509	0	1018
<u>Tabellaria</u>	3565	0	0	0	0	0	0	0
<u>Fragellaria</u>	0	0	1018	1528	2546	0	1528	2037
Dry Weight	80.5	56.5	22.4	10.2	11.2	28.0	19.4	36.7
Organic Weight	66.2	48.9	14.3	8.6	5.1	19.4	15.3	26.5
Ash Weight	14.3	7.6	8.1	1.5	6.1	8.6	4.1	10.2

1/ Data provided by the Alaska Department of Fish and Game

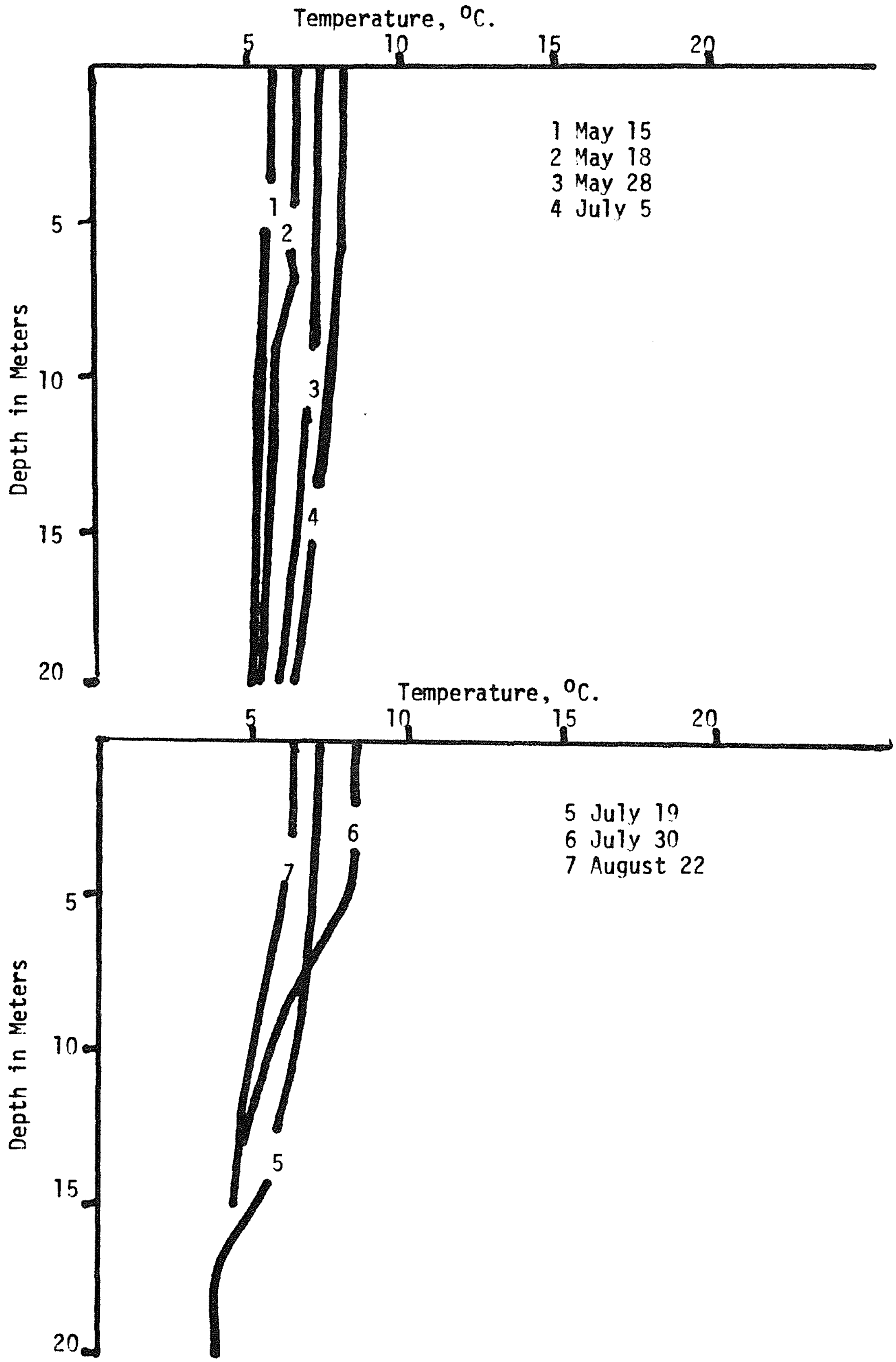


Figure 1. Thermal profile, Green Lake, May 15 - August 22, 1974 from data provided by the Alaska Department of Fish and Game

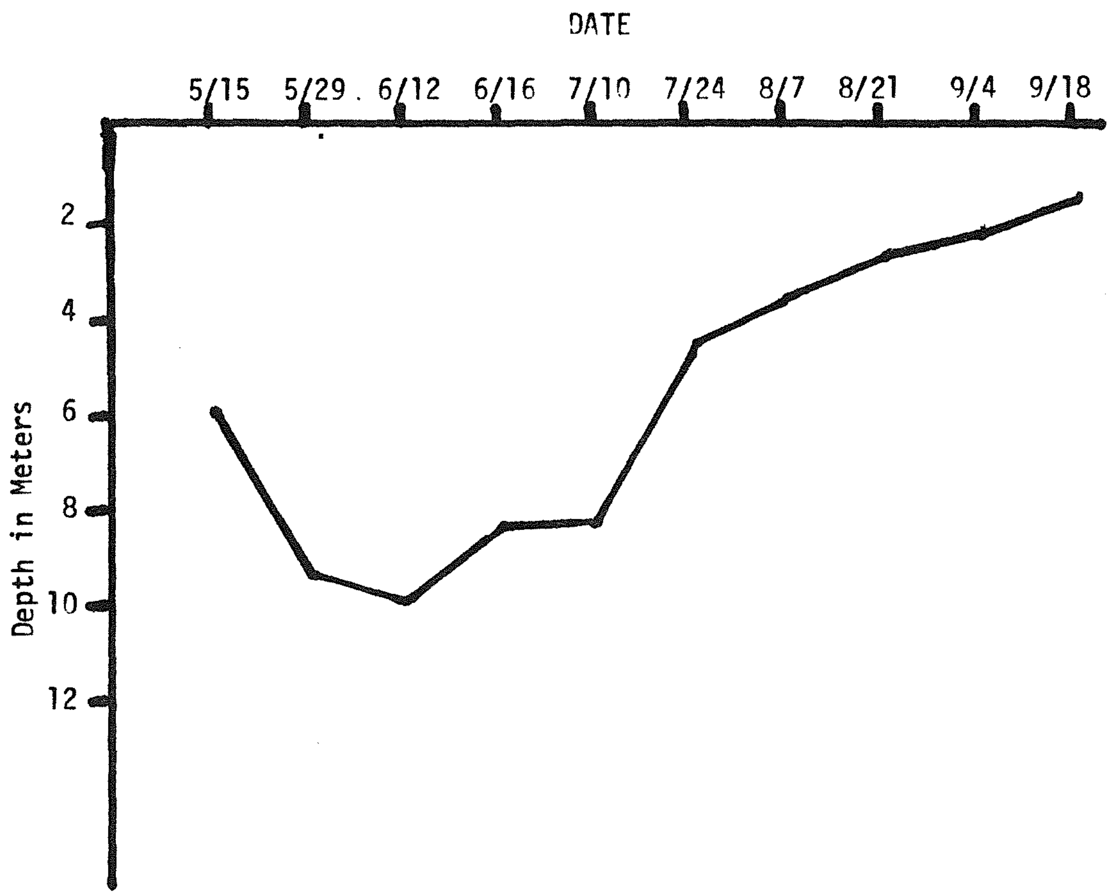


Figure 2. Secchi disc visibility, Green Lake, 1974, from data provided by the Alaska Department of Fish and Game

APPENDIX III

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Environmental Assessment Division
Juneau, Alaska

Estuarine Investigations in Silver Bay
Baranof Island, Alaska
June 8 and 9, 1977

Introduction

To meet future energy needs of Sitka, Alaska, a hydroelectric project is planned at Green Lake on the Vodopad River near its confluence with Silver Bay. The project site is ten miles southeast of Sitka (Fig. 1). An access road from an existing highway at Herring Cove will be built along Silver Bay. Some excess spoil material will be pushed into Silver Bay during road construction.

Purpose

The purpose of this study was to determine the types of estuarine habitat in Silver Bay adjacent to the proposed access road. Relative habitat types were assessed to estimate the relative impacts that deposited spoil material would have on the local ecology of the area.

Materials and Methods

Biologist-divers, using SCUBA, investigated estuarine habitat at six sites in Silver Bay from Bear Cove to the mouth of the Vodopad River (Fig. 2). The U.S. Forest Service, Chatham Area, provided a Boston whaler for transportation.

At each site, a transect line marked in 5-m (meter) intervals was placed perpendicular to shore. Because of excessive depths, some transects were shorter than others, allowing the biologist-divers to avoid decompression dives. Bottom types and plant and animal species were noted along the transect. Bottom slopes were measured with a protractor and leveling device. All information was recorded on underwater paper.

Results

Bottom profiles (Appendices 1-4) of each site depict slope, substrate, and life zones. At all sites the mid and upper intertidal zones are

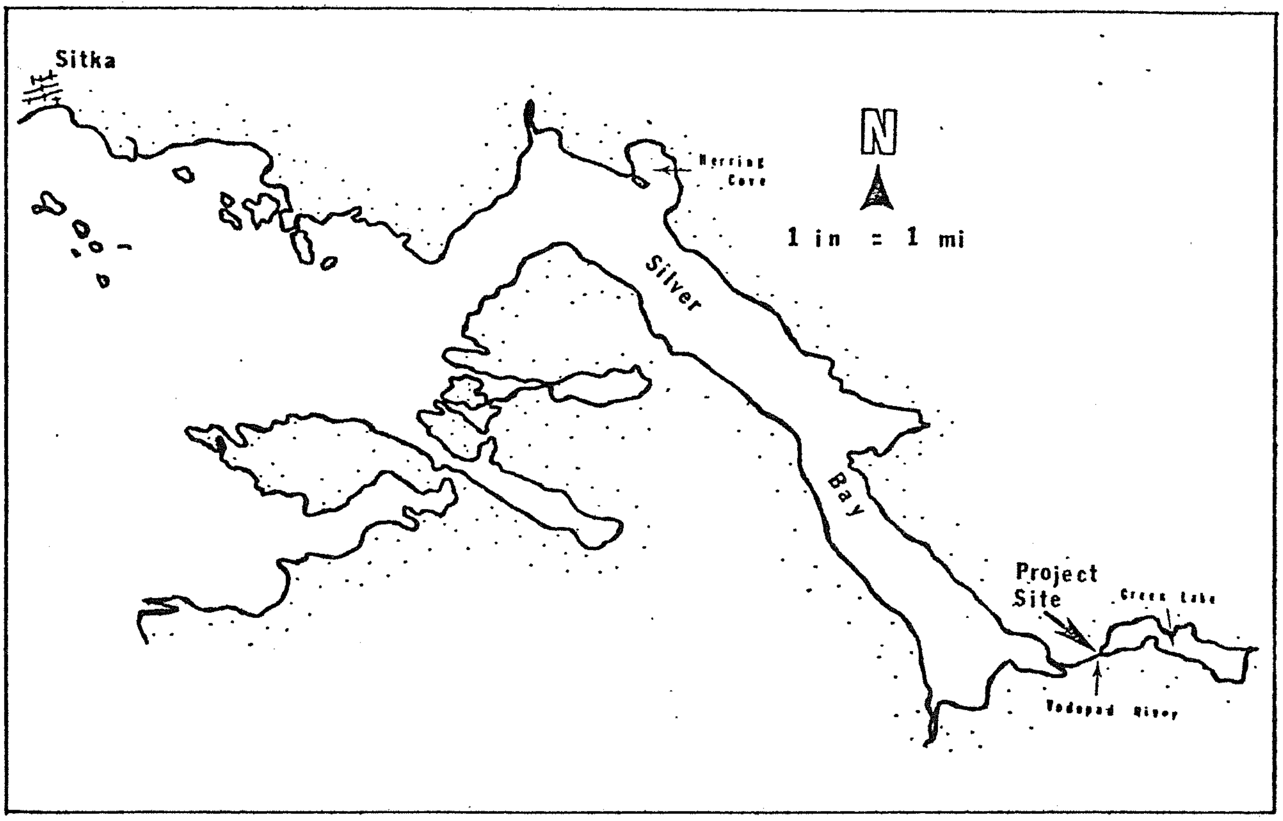


Figure 1. General location map of Green Lake hydroelectric project site.

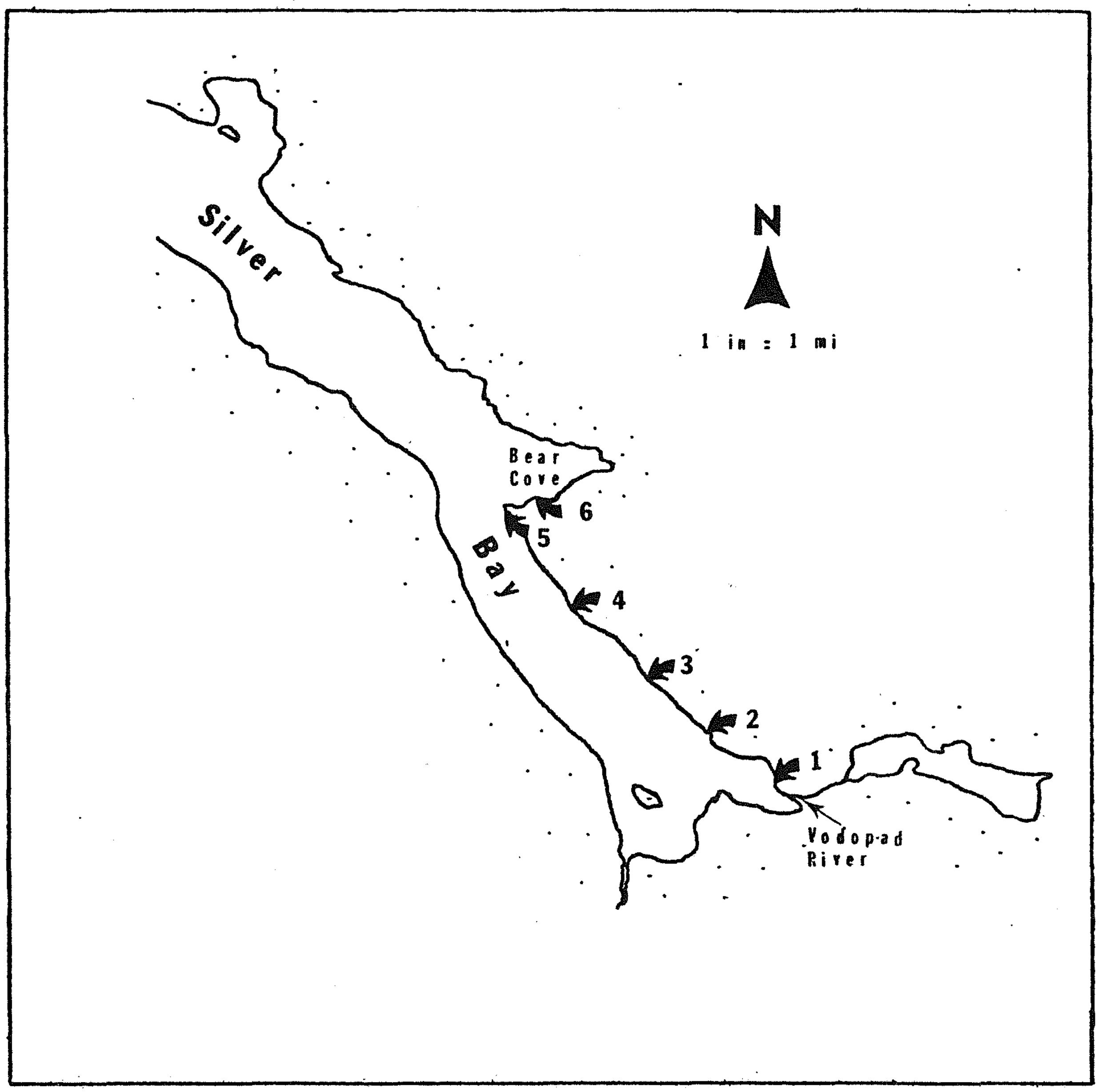


Figure 2. Locations of sites in Silver Bay investigated with SCUBA in conjunction with the proposed Green Lake Hydroelectric Project access road.

rocky, nearly vertical, and relatively unproductive except for some attached species, e.g., barnacles (Balanus sp.) and mussels (Mytilis edulis). Various algal species and assorted animals are numerous in the lower intertidal and upper subtidal zones. Various rockfishes (yellowtail, Sebastes flavidus; black, S. melanops; and quillback, S. maliger), the searcher (Bathymaster signatus) and the kelp greenling (Hexagrammos decagrammus) inhabit all sites. Plant and animal species noted at each site are listed in Appendix 5.

Site 1; 6/8/77, 1426-1449 hours - The bottom drops along slopes as steep as 49 degrees to a depth of 28 m where slopes are more moderate. Bedrock composes the substrate from high tide line to a depth of about 28 m, but changes to silt and crushed shells at greater depths at a horizontal distance of 20 m from shore.

A dense 15-m wide band of brown algae (Agarum cribrosum) began about 10 m from shore. Scallops (Chlamys sp.) are numerous at all depths.

Site 2; 6/8/77, 1528-1556 hours - The bottom drops moderately from shore along an initial slope of 30 degrees and then levels off into a flat trough before rising sharply to form an underwater reef about 20 m from shore. Beyond the reef, the bottom continues to drop along slopes of 31-38 degrees into deeper water. The top of the reef was 4 m deep at the time of the survey (low tide was +0.2 m at 1359 hours.). The bottom is bedrock from shore to a distance of 10 m, changing to silt and crushed shells up to where the reef starts, which again is bedrock. Beyond the reef the bottom is silt and crushed shells. A dense 5-m wide band of A. cribrosum began 5 m from shore. This alga also occurs on the reef. Scallops were noted along the entire transect.

Site 3; 6/9/77, 1041-1110 hours - The bottom drops uniformly along a slope of about 31 degrees along the transect. For the first 10 m from shore the bottom is composed of large rocks. Further out, the bottom is composed of silt, gravel, crushed shells, and some bark, except for some large cobbles about 20 m from shore. A sparse 20-m wide band of A. cribrosum and Laminaria sp. began about 8 m from shore.

Site 4; 6/9/77, 1145-1202 hours - The bottom drops sharply along an 80 degree slope to a depth of about 18 m, which occurs about 7 m from shore and then drops along a slope of about 40 degrees along the remainder of the transect. Associated with the steep slope is a bottom of bedrock, which changes abruptly into silt, large rock, crushed shells, and some bark. A. cribrosum began in a 5-m wide band about 5 m from shore.

Site 5; 6/9/77, 1248-1300 hours - The bottom drops sharply along slopes up to 80 degrees to a depth of 10 m, about 5 m from shore. The bottom then drops along slopes of 25-32 degrees for a distance of 10 m. About 16 m from shore the bottom drops very steeply into deep water. A dense 20-m wide band of A. cribrosum and Laminaria sp. occurs along the rock wall.

Site 6; 6/9/77, 1320-1328 hours - The bottom drops gently along slopes of 18-26 degrees along the entire transect. The bottom is composed of large rocks to a distance of 10 m from shore and then changes abruptly to silt and crushed shells to a distance of 35 m and beyond. A. cribrosum and Laminaria sp. occur in a dense 15-m wide band to a distance of about 20 m from shore.

Discussion

Except for sites 3 and 6, all sites have a bedrock bottom near shore. Sites 3 and 6 have large rocks near shore and, hence, all sites have solid substrate to provide firm stable habitat for attached plant and animal species. Sites 2, 4, and 5 drop steeply from shore, which would cause introduced material to settle in deeper waters offshore. The submerged ridge that forms a trough at site 2 is not usually found in sheltered bays in southeast Alaska. Excess spoil material deposited here will remain in the trough.

It can be expected that introduced rock debris will smother any attached life forms. Introduced rock on top of natural rock habitat should be repopulated by the same attached life forms that presently populate the area. Infauna on soft bottoms, however, may not come back if smothered by rock debris. Hence, a change in the local ecosystem may occur at soft bottom sites due to the change in habitat.

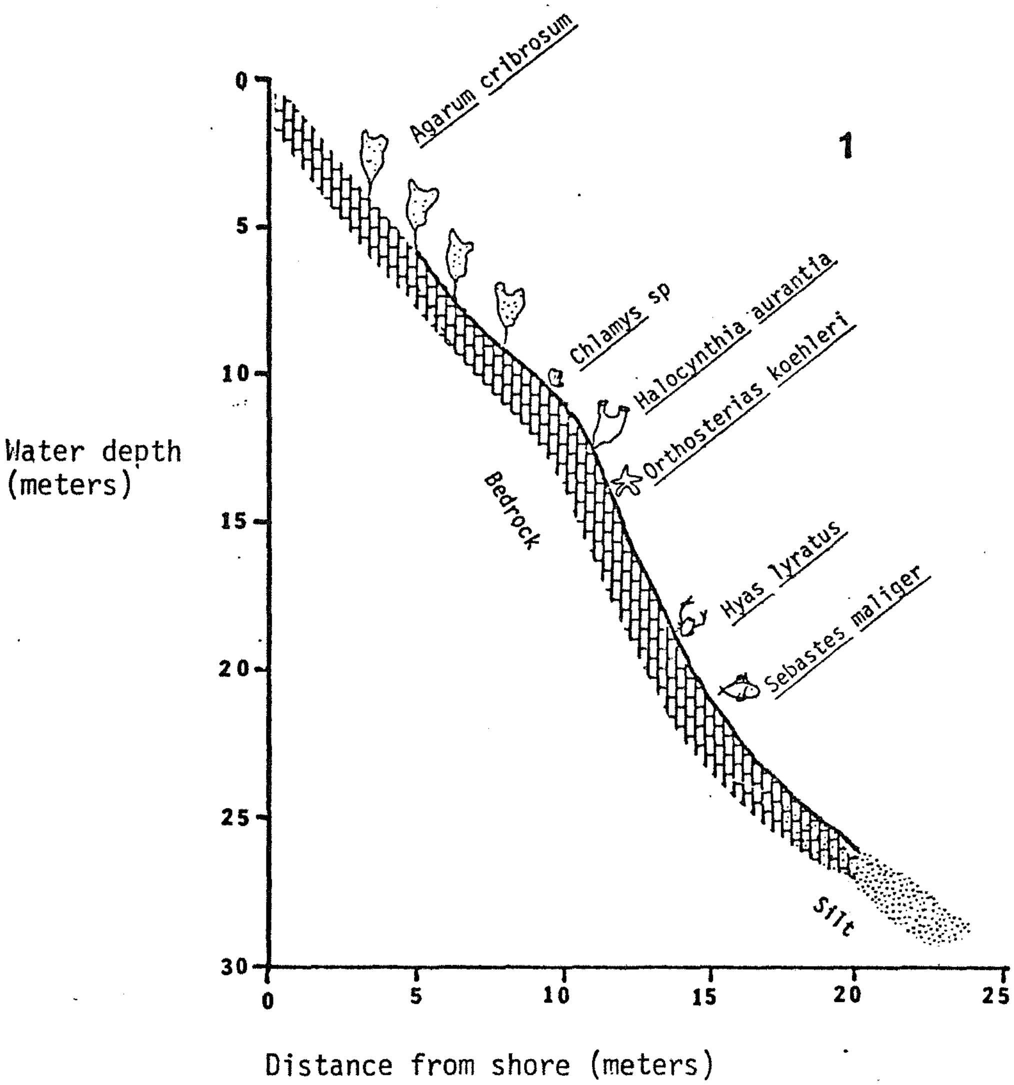
Habitat in deep water was not investigated and effects of rock debris settling there are not estimated in this report.

Acknowledgments

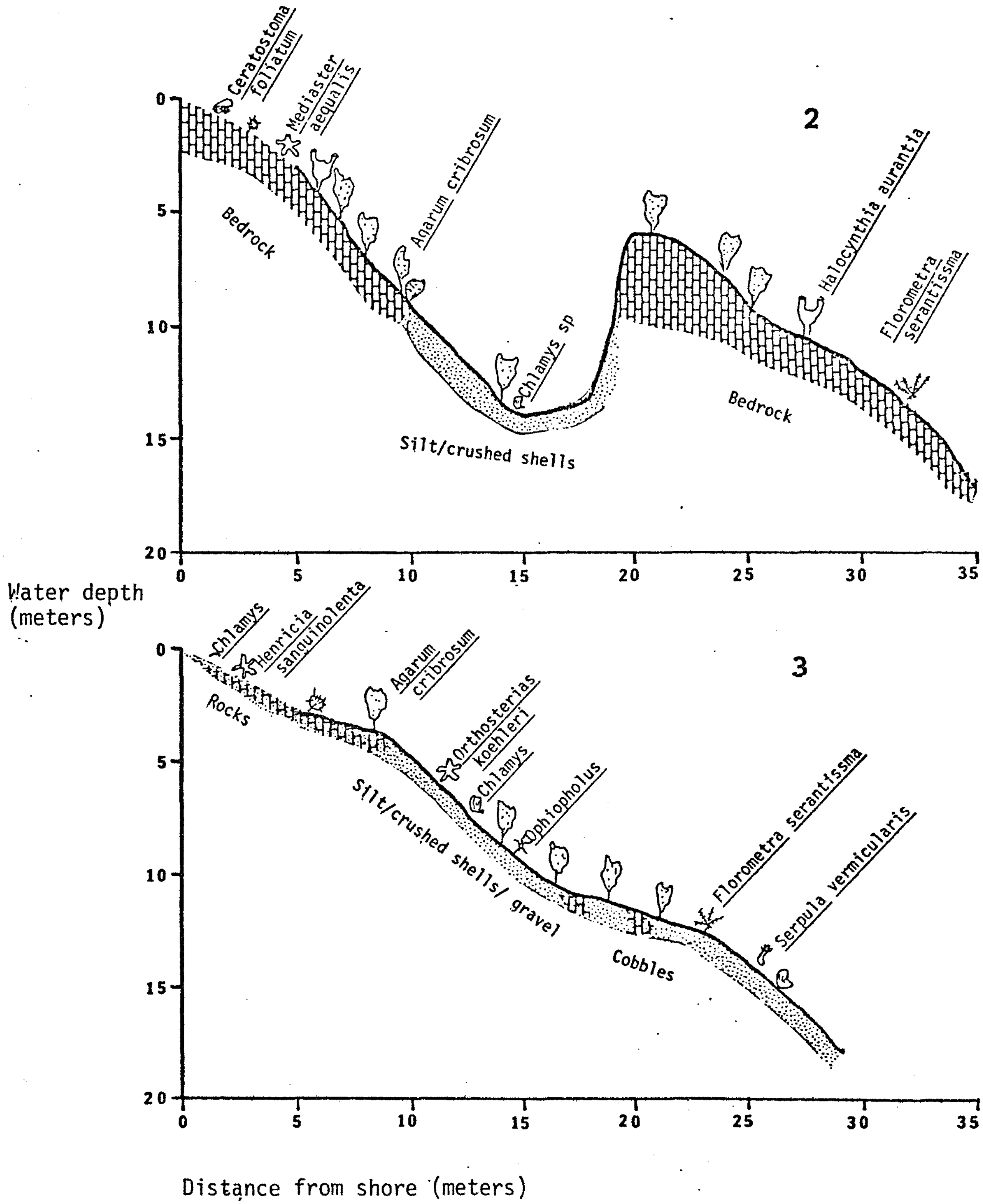
Rick Reed, Alaska Department of Fish and Game, was a principal investigator during the subtidal surveys.

Submitted by:	Approved by:
Ronald J. Berg 24 June 77	Duane Petersen 6/24/77
Ronald J. Berg Date	Duane L. Petersen Date
Fishery Biologist	Field Supervisor

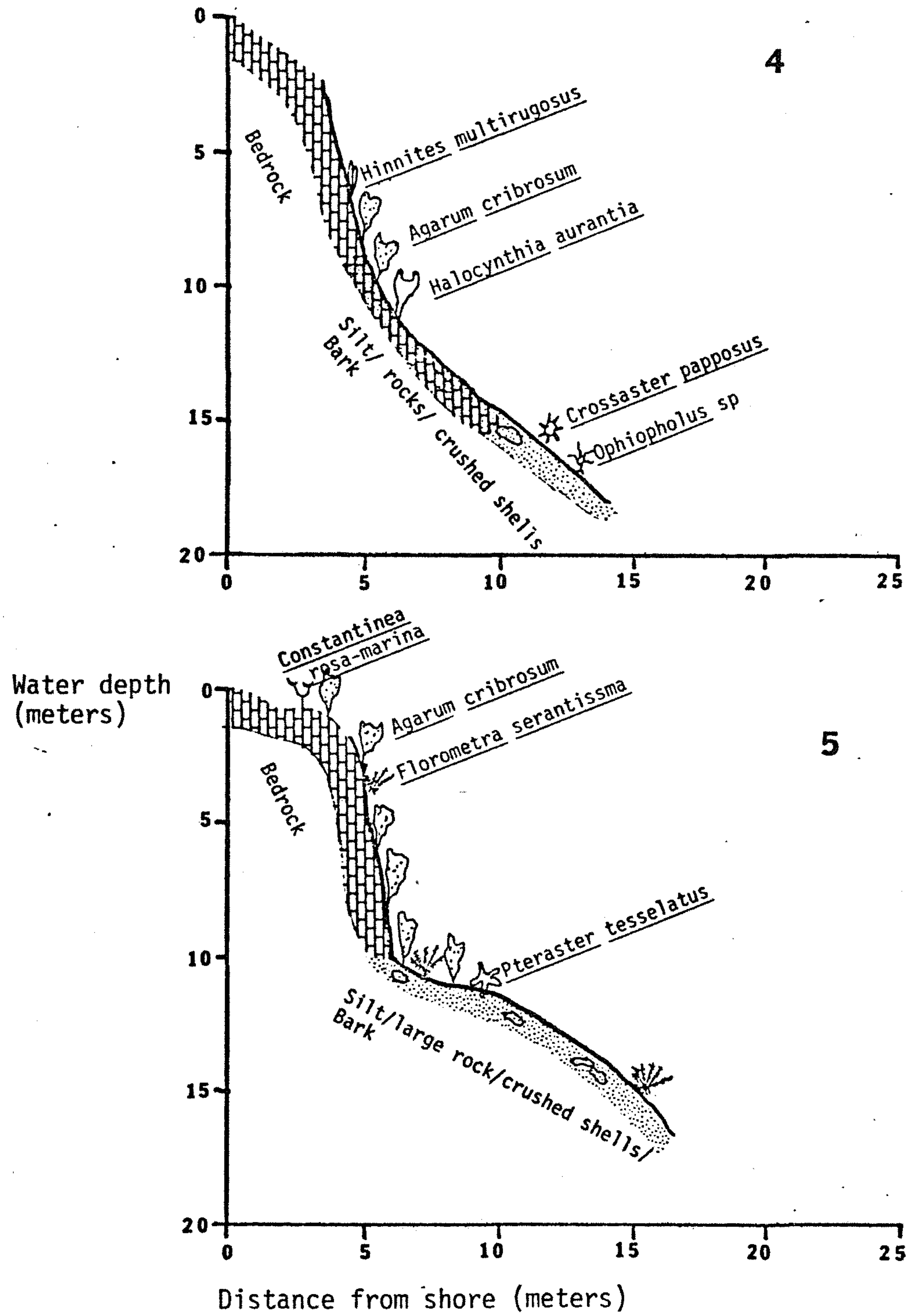
Appendix 1. Habitat zones at Site 1 in Silver Bay.



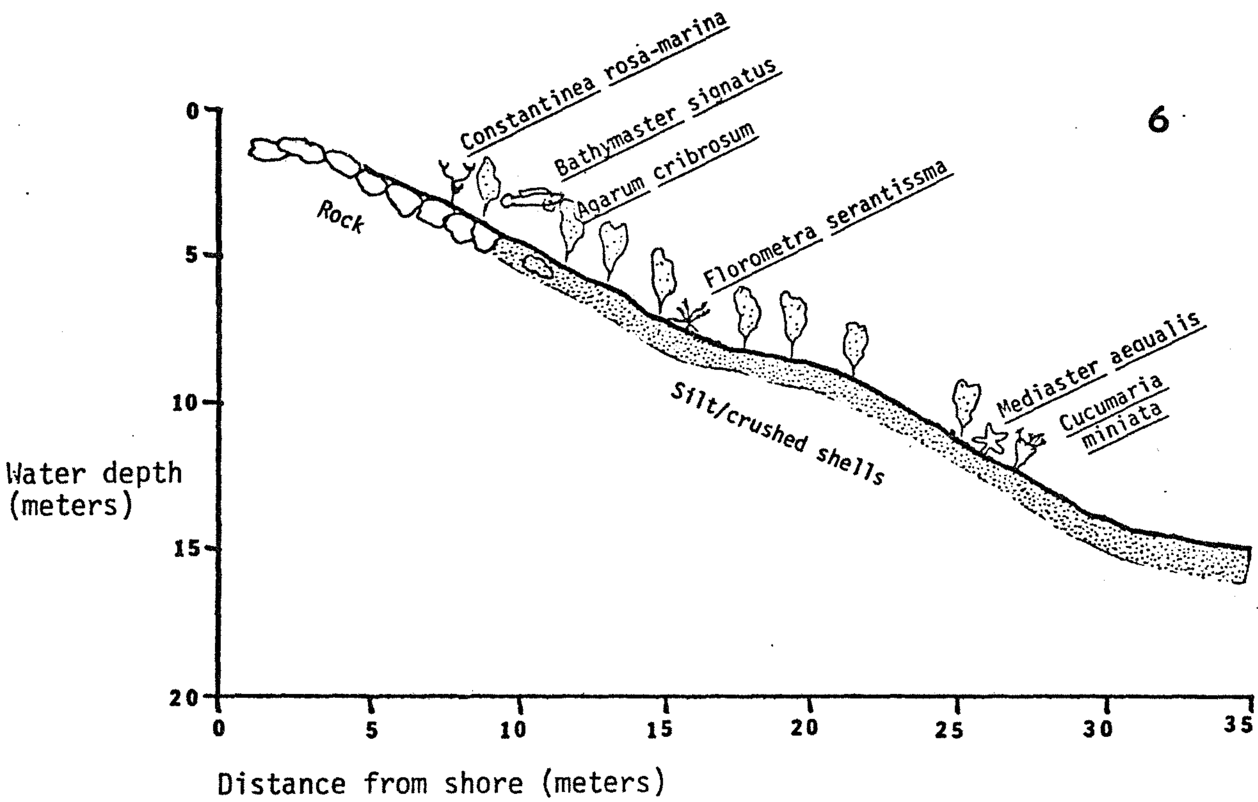
Appendix 2. Habitat zones at Sites 2 & 3 in Silver Bay.



Appendix 3. Habitat zones at Sites 3 & 4 in Silver Bay.



Appendix 4. Habitat zones at Site 6 in Silver Bay.



Appendix 5 - Plant and animal species observed at the study sites.

	Sites					
	1	2	3	4	5	6
PLANTS						
Fucus distichus	x	x	x	x	x	x
Agarum cribrosum	x	x	x	x	x	x
Laminaria sp.	x	x	x	x	x	x
Rhodymenia palmata	x	x		x		
Ralfsia sp.		x		x	x	
Corallinaceae		x	x			
Lithothamnion sp.	x	x	x	x	x	x
Callophyllis pinnata				x		
Constantinea rosa-marina				x	x	x
Membranoptera sp.				x		
ANIMALS						
Porifera (sponges)	x	x	x	x	x	x
Cnidaria (Anemones)						
Metridium senile, White plumed anemone	x	x	x	x	x	x
Hydrozoans		x				
Entoprocta						
Membranipora serilanella, Encrusting bryozoan	x	x	x	x	x	x
Bryozoa, Moss animals						
Microporina borealis					x	
Echinodermata (starfish, sea urchins)						
Orthosterias koehleri	x		x		x	x
Henricia leviuscula			x			
Evasterias troschelli, Mottled star				x		
Mediaster aequalis, Equal arm star		x				x
Ophiopholus sp., Brittle star			x	x		
Florometra serantissma, Crinoid		x	x	x	x	x
Crossaster papposus, Rose star				x		
Pteraster tesselatus, Cushion star				x	x	
Dermasterias imbricata, Leather star		x		x	x	
Pycnopodia helianthoides, Sun star			x	x		
Strongylocentrotus droebachiensis, Green sea urchin		x	x			
S. franciscanus		x				
Stichopus californicus, Sea cucumber	x					x
Cucumaria miniata, Burrowing cucumber						x
Mollusca (Clams, nudibranchs)						
Acmea, sp., limpet	x	x	x	x	x	x
A. mitra, limpet					x	

	Sites					
	1	2	3	4	5	6
Tonicella lineata, Lined chiton	x	x	x	x	x	x
Trichotropis cancellata	x	x				
Ceratostoma foliatum		x				
Littorina sitkana					x	
Macoma irus		x			x	
Archidoris odhneri, nudibranch			x	x		
Chlamys sp., scallop	x	x	x	x	x	x
Calliostoma caniculatum, snail	x	x	x	x	x	x
Margarites pupillus, snail				x	x	x
Hinnites multirugosus,				x		
Annelida						
Eudistylia polymorpha, Plume worm				x	x	
Serpula vermicularis, Tube worm	x	x	x	x	x	x
Arthropoda (shrimp, crabs)						
Oregonia gracilis, Decorator crab				x		
Hyas lyratus, Lyre crab	x					
Balanus sp., Horse barnacle	x	x	x	x	x	x
Chordata, Tunicates						
Corella sp.	x	x	x			
Halocynthia aurantia	x	x	x	x		
H. igaboja	x	x		x	x	
Ascidiopsis sp.			x			
Cnemidocarpa joannae Broadbase sea squirt						x
Chordata, Fishes						
Bathymaster signatus	x	x	x	x		x
Sebastes maliger	x					x
S. flavidus					x	
Hexagrammos decagrammus	x			x		

Appendix W - 11

Archeological Investigation

by

Robert E. Ackerman, Ph.D.

ARCHEOLOGICAL SURVEY OF PROPOSED ACCESS ROAD AND DAM IMPOUNDMENT AREA: SILVER BAY - GREEN LAKE REGION, BARANOF ISLAND, ALASKA

FOR

R. W. BECK AND ASSOCIATES,INC.
SEATTLE, WASHINGTON

BY

ROBERT E. ACKERMAN
LABORATORY OF ANTHROPOLOGY
WASHINGTON STATE UNIVERSITY

JUNE 28, 1977

WASHINGTON STATE UNIVERSITY
PULLMAN, WASHINGTON 99163

DEPARTMENT OF ANTHROPOLOGY
Office: (509) 335-8556

LABORATORY OF ANTHROPOLOGY
Office: (509) 335-4587

July 12, 1977

R. W. Beck and Associates, Inc.
200 Tower Building
Seattle, Washington 98101

Attention: Mr. Donald Melnick

Gentlemen:

Enclosed is the final report of our archeological survey of the proposed Silver Bay - Green Lake hydroelectric project area near Sitka, Alaska (your project No. WW-1521-HG2-NC).

The data represents the compilation of our field investigations (archeological survey and informant interviewing) as well as correspondence relative to this project. The report contains a section by section evaluation of the access road area along the eastern shore of Silver Bay and the Green Lake impoundment area. During our investigations, June 6-12, 1977, we did not find evidence of significant archeological data that would be affected by your proposed hydroelectric project.

Yours sincerely,

Robert E. Ackerman

Robert E. Ackerman
Professor

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FIGURES

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INTRODUCTION

In compliance with the Historic Sites Act of 1935 (PL 74-292), Reservoir Salvage Act of 1960 (PL 86-523), Historic Preservation Act of 1966 (PL 89-665), National Environmental Policy Act of 1966 (PL 91-190), Executive Order 11593 of 1971, and the Archeological and Historic Preservation Act of 1974 (PL 93-291) as set forth in 36CFR66, 36CFR800, and 40CFR1500, R. W. Beck and Associates, Inc. (Seattle, Washington) in consultation with Dr. Gerald Clark, Regional Archeologist of the U. S. Forest Service (Region 10, Alaska), contacted Robert E. Ackerman, Department of Anthropology, Washington State University, to propose that an archeological survey be conducted over an area ten miles southeast of Sitka, Baranof Island, Southeastern Alaska, that will be impacted by a proposed hydroelectric project.

The Green Lake hydroelectric development (see Figs. 1 and 2) involves the impoundment of Green Lake and part of the Vodopad River valley by the establishment of a 230 foot high concrete arch dam. The water level in Green Lake now at 230 feet above sea level will be raised to a maximum of 390 feet. A 1900 foot long power tunnel will extend from the dam site to a power house located to the north of the Green Lake outlet on Silver Bay. An access road of 6.58 miles will lead from the power house to a connector road built by Alaska Lumber and Pulp Company at Herring Cove (road follows north shore of Silver Bay). An eight mile long 69 KV transmission line will parallel the access road and the existing road in Herring Cove until its hookup with the existing transmission lines at the Blue Lake project powerhouse at Sawmill Cove. Temporary roads will be built in the damsite area, along the north shore of Green Lake and into the Vodopod River valley where concrete aggregate material is to be obtained. Since the slopes of the north shore of Silver Bay are steep, considerable blasting will be required to establish a cliff side road bed. The data relative to the project appeared in (1) "City and Borough of Sitka, Alaska. Green Lake Project. Brochure of Preliminary Project Data, compiled for Briefing of Concerned Governmental Agencies March 7, 1977 by R. W. Beck and Associates, Inc." and (2) Memorandum to David Hoopes, environmental consultant May 23, 1977, by R. W. Beck and Associates ,Inc.

In response to the request for a statement of archeological procedures, a document entitled "Silver Bay - Green Lake Archeological Survey" was submitted to R. W. Beck and Associates ,Inc. by this investigator on May 22, 1977. The document contained the results of a preliminary literature search involving ethnography, history, geology, vegetation, soils, and a search of state and federal registers of national monuments, as well as the Sealaska historic site survey of 1975. Potential archeological site areas based upon map analysis were noted, archeological procedures indicated and a time schedule advanced. This survey prospectus was favorably reviewed by R. W. Beck and Associates , Inc. in Seattle (principally Donald R. Melnick, Principal Civil Engineer and Donald E. Bowes , Executive Engineer). A contract of agreement was drawn with the survey to be accomplished June 6-12, 1977 (File No: WW-1521-HG2-MC 3007).

As required by federal law a permit to survey and test for archeological sites on lands under the management of the U. S. Forest Service was sought (with the assistance of R. W. Beck and Associates). Dr. Gerald Clark, regional archeologist, U. S. Forest Service, Juneau, very graciously worked out the details of the memorandum of agreement (No. 01-103, see Appendix 1). A copy of the "Silver Bay - Green Lake Archeological

Survey" proposal that was sent to R. W. Beck and Associates, Inc. served as a projected work plan as requested by the Forest Service.

Dr. Peter Mehringer, Jr. of the Laboratory of Anthropology agreed to work with me on this survey. His assistance under rather strenuous field conditions is most gratefully acknowledged.

On June 6, Dr. Mehringer and I met with Mr. Donald Melnick and Mr. Donald E. Bowes of R. W. Beck and Associates, Inc. in their Seattle office. Details of the hydroelectric project were discussed. Additional information relative to mining claims, an earlier waterpower proposal by Edgecombe Exploration Company, Inc. (1970), geological investigations by Converse, Davis, Dixon, Associates, Inc., Green Lake construction access road report by Steen and Matlock, Inc., and aerial photographs and enlarged topographic sheets of the project area were given to us. This information proved to be most useful in the field. Following the briefing session, Dr. Mehringer and I left for Sitka, Alaska, and arrived there that afternoon.

Lodging arrangements for the evening of June 6 and 7 were provided by the U. S. Forest Service, Chatham Area, Tongass National Forest. We are particularly indebted to Mr. George Reynolds of the Chatham Area, U. S. Forest Service, for his assistance. The remainder of our stay in Sitka was at commercial lodgings.

We travelled to the Silver Bay - Green Lake survey area by float plane (Eagle Air, Inc.). Prior to our arrival, Davis-Swanson Surveys of Sitka advised against the use of a boat along the steep shoreline. We readily concurred after our first day in the field.

BACKGROUND STUDIES

Ethnography

Prior to European contact the region of the Western Coast of Baranof Island was claimed by Tlingit clan groups. Silver Bay, for example, was the territory of the Sitka Kiksadi Tlingit who had use rights to the resources of the region. The report by Goldschmidt and Haas lists a smoke house on the Green Lake outlet that belonged to the Kiksadi (1946:108). At present, the Silver Bay - Green Lake area in the ethnographic period (last 200 years) seems to have been used as a seasonal hunting/fishing area with no indication of major settlements. This does not preclude a different pattern in the more remote past.

History

The Russian Period

From the beginning, contact between the Tlingit Indians and the Russians was marked by suspicion and hostility. The destruction of the Russian Post in 1802 at Old Sitka by the Tlingit was followed by the establishment of a more permanent settlement in Sitka harbor in 1804. Various local industries were established by the Russian American Company in an effort to make the colony self-sufficient. Stands of timber behind Sitka were felled to provide the lumber for dwellings and ships. The Russian sawmill built in 1860 near the entrance to Silver Bay (where the Sitka Pulp Mill is now located) provided both lumber and sawdust for the later ice industry. A saltery, flour mill, and a small fort were built on the north shore of Redoubt Bay in 1827 (Hilson 1974). The curative powers of the baths at Hot Springs Bay were realized early in the history of the Russian colony (Zagoskin 1967).

Other records such as Tikhmenev's Historical Surveys of the Russian American Company and its Activities to the Present Day (translated by R. A. Pierce) and R. A. Pierce's translation of Russian American Company Charters provides insights into Russian settlement patterns as does Svetlana Fedorova's The Russian Population in Alaska and California (late 18th century to 1867).

Thus far no information regarding Russian activity in the Silver Bay - Green Lake area other than the 1860 sawmill has been noted.

The American Period

The mineral resources of Southeastern Alaska attracted American prospectors soon after the Alaska purchase. In Sitka, the first gold strike came in 1871 with the discovery of a gold bearing quartz ledge on the Indian River. The find excited considerable interest but did not prove to be of commercial value. In 1872 three miners discovered the quartz ledge known as the Lower Ledge. Later in that same year, Nicholas Hayley discovered the Stewart Ledge which was renamed the Cache Mine. A ten stamp mill was built in 1879 at this location but the ore proved to be of too low a grade to continue operations. Several other claims were staked and some lode mining attempted. Three claims on the north shore of Silver Bay are: Baranof Queen Prospect, Henrietta Prospect, and Silver Bay Prospect (Knopf 1912: fig. 4).

Knopf reports that since 1880 none of the properties at Silver Bay have been put on a productive basis (1912:8). Discoveries in the Juneau area (1880-81) and at Klag Bay to the north of Sitka in 1905 continued the gold fever, but the Silver Bay excitement does not appear to have been rekindled.

Besides the tramways for the mines, the shaft cuts, and the dump areas, there were wagon roads cut to bring in machinery and supplies to the mines. These routes appear to be to the west and south of the project area.

Cabins or camps are noted on the Sitka and Port Alexander quadrangles at the head of Silver Bay, one of which is in the project area with a trail leading to Green Lake.

Geology

The coastal area of the Sitka district on the west coast of Baranof Island is made up of Mesozoic age rock consisting of graywacke, slate, conglomerates, andesitic lavas, and tuffs (Knopf 1912: plate 1). Further inland Paleozoic limestones, cherts, schists, phyllites, and greenstone lavas, and tuffs dominate. Intrusive granites form the central spine of Baranof Island (Knopf 1912: plate 1).

The conglomerate and conglomeratic graywacke contains pebbles of chert, slate, schist, andesite, and felsite, all potential lithic materials for making the stone artifacts of the prehistoric period. Source areas are thus readily available with specific workshop locations undoubtably rare to non-existant. With pebbles the source of raw flaking material, such worked pebbles will be good site indicators.

Within the Silver Bay - Green Lake area, as elsewhere in Southeastern Alaska, the relief is rugged and mountainous. Bear Mountain and Cross Mountain at 4005 and 3976 feet descend steeply to the shoreline of Silver Bay. Vodopad river valley is a broad glacial valley with a small interior catchment basin, Green Lake. The Vodopad River courses across a rather flat valley bottom approximately 300 feet above sea level. Green Lake, according to hydrographic data, lies at 230 feet above sea level with a surface area of 173 acres.

Vegetation

The local vegetation is dominated by the climax forest species of western and mountain hemlock (Tsuga heterophylla, T. mertensiana), lodgepole pine (Pinus contorta), and Sitka spruce (Picea sitchensis). Yellow cedar (Chamaecyparis nootkatensis) is found in better drained locations while the black spruce (Picea mariana) is more tolerant of wet, poorly drained muskeg conditions. Deciduous trees like the Sitka and red alder (Alnus sinuata, A. rubra), Oregon crab apple (Malus diversifolia), and Sitka mountain ash (Sorbus sitchensis) are present. The shrub, sweetgale (Myrica gale) occurs in the tidal flat or bog areas near the coast.

As part of the forest edge or understory, blueberry (Vaccinium alaskaense, V. caespitosum, V. ovalifolium, V. parifolium, V. uliginosum, V. vitis-idaea), Pacific red elder (Sambucus callicarpa), currants (Ribes bracteosum, R. laxiflorum), Nootka rose (Rosa nutkana),western thimbleberry (Rubus parviflorus),salmonberry (Rubus spectabilis),and devilsclub (Oplopanax horridus).

Crowberry (Empetrum nigrim) is found in more alpine conditions with heath vegetation on the coast. In wet conditions, sphagnum moss, saxifrage, skunk cabbage (Lysichitum americanum) as well as a myriad of flowering, bog plants are to be found.

Pioneer plants such as nettles (Urtica lyalli), cowparsnip (Heracleum lanatum), and wild celery (Angelica) are good indicators of historic site disturbance as are Oregon crabapple and salmonberry.

Soils

Soils are highly variable depending on the substrate, slope, drainage, vegetation cover and elevation. Forest podsols are dominant on drained slopes with bog to muskeg development in poorly drained areas. Glacial outwash and alluvium cover valley bottoms.

FIELD STUDIES

Historical and Ethnographic Research

As stated in the survey proposal of May 22, 1977, research in the Silver Bay - Green Lake area would include historical and ethnographic investigation as well as the archeological survey work. This was accordingly accomplished. Correspondence from Mr. Robert De Armond (May 26, 1977, see Appendix 2) provided historical background data and leads for further investigation in Sitka. We followed De Armond's suggestion and met with Mr. William R. Hanlon, a retired miner in Sitka on June 10. (See Appendix 3 for notes taken on this and following interviews). Mr. Hanlon talked about mining activities of the 1930's and gave us the names of individuals who had constructed cabins in the project area. The same morning we also requested information regarding land use permits on Forest Service lands from the Chatham district office. Mr. Norman Schoonover was most helpful in providing us with that information (see Appendix 2). The following morning, June 11, we contacted Mr. James Davis, manager of the Sitka Chamber of Commerce for information on the native settlement/land use in Silver Bay-Green Lake area. Mr. Davis indicated that the older informants who would have known about native land use were deceased, but recommended that we talk to Mr. Glenn Morgan, manager of the Edgecombe Exploration Company, Inc. as he was a long-time resident of the area. Mrs. Charlotte Morgan was contacted immediately following my conversation with Mr. Davis. As the Morgans were about to leave to go to Goddard Hot Springs, Mrs. Morgan's comments were necessarily brief. I indicated that I would like the opportunity to discuss with Mr. Morgan aspects of the history of Silver Bay.

Not satisfied with my ethnographic coverage, I called the Sheldon Jackson Museum to locate members of the Sitka Historical Society who could help me in my quest. I was given the names of Mrs. Isabel Miller and Mrs. Luella Smith. Later in the morning, we met Mrs. Miller at the Centennial Building. She contacted Mrs. Ellen Lang, Superintendent of the Sitka National Monument by telephone for me. Mrs. Lang kindly provided me with the information I was seeking, that the location of an aboriginal camp on the lake side of the outlet to Green Lake was highly unlikely given the fact that the camp was supposedly on a sockeye stream (see Appendix 3 for notes on Mrs. Lang's telephone conversation).

Sunday morning, June 12, Mr. Glenn Morgan stopped by the Potlatch House where we were staying. His conversation about the Silver Bay area covered both mining and hunting experiences. He noted that no one had discussed the proposed project with him or had inquired regarding his intensive, local knowledge. We were fortunate to have had the opportunity to talk with Mr. Morgan.

Archeological Investigations

Tuesday, June 7 marked the beginning of the archeological survey. The first step was to familiarize ourselves with the terrain to be surveyed by flying along the north shore of Silver Bay and over Green Lake and the Vodopad River valley. The topographic relief is rugged. Both Medvezhie Lake valley and Silver Bay lie on extensive faults with steeply sloping side walls. The Green Lake - Vodopad River valley is broad, having been sculptured by Pleistocene and Holocene glaciation. The geological research by Converse, Davis, Dixon Associates, Inc. (1974, 1977) indicate a tectonic instability and numerous recent slides on many of the slopes are indicated by barren scree or a thin covering of forest duff.

Forest vegetation covers all of the area to be surveyed with stands of western hemlock, Sitka spruce and yellow cedar below 2400 feet. In the seasonally flooded valley bottoms alder and willow with thickets of salmonberry dominate the landscape. Muskeg is found in poorly drained valley bottoms or on upland areas.

Silver Bay Section

Herring Cove

The proposed access road is to begin in the southeast corner of Herring Cove (station 00+00, see Fig. 3). It will join the existing ALP road that extends as far south as the barrow pit at the foot of an extensive slide (Fig. 3:1). To the north and west of the barrow pit is a flat, composed of alluvium and reworked beach gravels which has subsequently been filled in and levelled by ALP for a log dump (Fig. 3:2). The cove is partly filled with log rafts (Fig. 4).

As the transmission line will follow the existing ALP road northwest to Sawmill Cove, we also surveyed areas that were still relatively undisturbed by the highway construction. The ALP road is bounded for the most part by almost vertical cliffs of green schist (Fig. 4). This imposing face is broken in a few areas by lower slopes. In the northwest corner of the cove (Fig. 3:3) we came upon the remains of a stone chimney standing isolated amidst a stand of salmonberry bushes and red elder berry (Fig. 5). Scattered about the chimney were the following:

> Christmas tree light bulb, gas jet burner for cook stove, wood stove, kerosene stove, bedsprings, frying pan, wash boiler, industrial type light reflectors, galvanized pipe, water pump parts, and a Rainier pull tab beer can (this last item a more recent addition).

About 20 meters to the north and west was a narrow wooden walkway that once served as a bridge over a small stream. The location of the chimney coincides with the position of the cabin cluster noted for Herring Cove in Sitka (A4) Quadrangle based upon aerial photographs of 1948. The aerial photographs produced by H. G. Chickering for ALP in May 1957 also reveal existing cabins in this area (stereo pair ALP7:37A, nos. 7 and 8).

Location:

Section: T.56S.,R.64E., S.3

57°2'45"N.Lat, 135°12'30" W. Long.

UTM (Zone 1, Alaska Coordinate system) E 2,378,734.375, N1,907,718.750

Mr. Schoonover reports (see also Appendix 2) that the cabin where only a chimney now stands was built in 1933 by Jack Calvin (see also Hanlon's statement). Calvin obtained a special use permit for the area on March 16, 1927 (year not clear in Schoonover's note). He sold the cabin in 1935. There were apparently then two or more owners (one perhaps Bill Marquat as noted by Hanlon). The cabin burned down in 1964 (approximate date).

No other data are available for the adjacent cabins noted on the Sitka Quadrangle map. Hanlon mentions a cabin built by the ex-marine Marsh. It may have been in this area rather than at the barrow pit area.

Below the road is a modern cabin last owned by Gilbert Engman whose permit was issued October 12, 1967 and terminated March 21, 1973. Schoonover further notes that the previous permit holder was Edwin M. Halverson who had the cabin as far back as 1958. The cabin appears to be built on road bed fill next to the water.

No other cultural features were noted in the Herring Cove area. The survey was not carried into Sawmill Cove as Euro-American activity there had destroyed any trace of aboriginal occupation. The "farm" and the ALP pulp mill destroyed any meager evidence of the earlier Russian sawmill (see Appendix 2 - George A. Hall correspondence of June 13, 1977). Prehistoric occupation is ruled out by the high vertical cliffs fronting the shoreline in this section of the road.

Herring Cove Accessment

The earliest cabin ruin in location 3 of Herring Cove (Fig. 3) dates to 1933 according to Forest Service records. Mr. Hanlon's recollections are also somewhere in the 30's and 40's for the cabins. The cabin along the beach is modern. Since the remains are less than 50 years of age they are not subject to national register nomination unless there is particular local significance attached to the area (36CFR60.6). There is no indication that the sites would meet National Register criteria. No significance can be attached to the scattered bits of this occupation which has already been heavily impacted by the ALP road.

Recommendations - Since the cabin ruins are in a low area and it is probable that transmission tower bases would be located higher to clear the cliff areas along the road, it is unlikely that this modern site area will be impacted. It can be easily avoided in the transmission line planning.

Shoreline-Herring Cove to Bear Cove

Station 00+00 - 20+00

Starting at Station 00+00 on the proposed access road area (Fig. 3) we walked over a raised bench. This feature does not appear to be an elevated beach but rather a feature of slope activity, i. e., a talus foot.

Testing encountered rock a scant distance below the forest organic mat. As we moved along the slope towards Station 20+00 we saw that the slope was continuous (no evidence of interrupted uplift or sea still stands resulting in terraces) and approximately 45° - 60°. The southern shoreline of Herring Cove in unstable with numerous examples of slides (Converse, et al 1977: plate 6). The beach is abrupt with no suitable landing for watercraft. No evidence of sites in this section.

Station 20+00 - 100+00

Along this section of the access road area we encountered some benches on the slope. Our tests revealed evidence of buried organic horizons separated by colluvium. This indicates repeated slides and slope instability. Such slide areas were numerous. The slope (Fig. 6) was steep with little to no shoreline flats. The heavy forest cover did not mask the fact that the unstable slope was unsuitable for prehistoric or historic settlement. We did not find any evidence of human occupation.

Station 100+00 - 130+00

This section appeared on the Sitka (A-4) quadrangle to have some potential, as it was associated with two streams and was relatively flat compared to the previous section surveyed (Figs. 3 and 8). We found the surface to be very uneven (as if it were the toe of a talus slope) with a great deal of tree throw. The uprooted crown roots were searched for artifactual material but with negative results. The area did not look as good on the ground as on the map. Plate 5 in Converse et al (1977) indicates talus at triangulation point DENEB with an alluvial fan at the shoreline. A slide was similarly noted between Stations 110+00 and 120+00. Again, the instability of the slope is reflected in the relatively recent surface features. There was no evidence of cultural features in the area other than past timber cutting.

Station 130+00 - 160+00

We found this section to be extremely steep with cliffs along the shoreline (Fig. 7). In all of our cliffside scrambles we did not locate any archeological features. Such an area can be safely ruled out of consideration for human site use.

Bear Cove

Station 160+00 - 170+00

The head of the cove is an outwash valley formed by the cascading stream flowing from Medvezhie Lake (Figs. 7 and 8). Logs from previous rafts lie in haphazard positions on the tidal flats. Back of the tidal flats a thicket of alder, willow, and salmonberry bushes covers the gravels of the stream delta. In this thicket (Fig. 8:1) we came upon the leaning remains of a privy (Fig. 9) constructed of tongue and groove boards. Fifty-five feet to the south in a thicket of salmonberry bushes (Fig. 10) we encountered a five gallon Blazo can, tin cans for coffee and vegetables, glass jars (catsup, pickles/relish), parts of a single metal bed frame, stove pipe protective collar, and a section of floor or side wall made of tongue and groove boards. There was no indication of a foundation for a cabin. The site is located in:

Section: T. 56 S., R. 65 E., S. 18

57° 54" N. Lat., 135° 8' 45" W. Long.

UTM (zone 1, Alaska coordinate system E 2,390,937.5, N 1,895,843.75)

Evaluation: The site is modern and of little cultural significance. An overflow channel active during spring run off cuts through the site area. No further testing is recommended. A cabin was probably constructed here due to the presence of the well made privy, but little evidence is left to mark the dwelling. A cabin is also shown on Sitka (A4) quad further up the valley. Field checking and study of the ALP 1957 aerial photographs failed to reveal it. The location given in Sitka (A4) quad for a cabin is highly improbable given the nature of the valley bottom which seasonally is flooded during the spring melt of the snow pack in the mountains.

As the site is between the shore and the road crossing the valley at 170+77.53 (Steen and Matlock 1977:plate 4),it undoubtably will be impacted. Considering the age of the site and the fact that the few items of modern junk do not constitute a significant contribution to knowledge it is recommended that no effort be made to avoid the site nor further archeological work be done there.

Stream Valley to Medvezhie Lake

Since alternate section 2 of the access road goes almost to Medvezhie Lake it was necessary to survey the stream valley. We soon found that the steep V notched valley (fault zone) with a cover of alder and salmonberry in the bottom (disturbance vegetation) and hemlock and spruce on the valley slopes was unsuitable for site use. The granitic rock slide on the north face was impressive with house sized boulders. No cultural evidence was noted.

Station 170+00 - 190+00

Between station 170+00 and 190+00 we noted a small bench approximately 250 feet from the shore (Fig. 8). The face of the bench had subangular cobbles showing with only a thin organic layer over sand, pebbles and cobbles. While the bench looked very much like a terrace the angularity of the rock indicated that it was not water rolled. It apparently represents morainal material from the Medvezhie Lake area (Converse et al 1977:

plate 5). Several tests were made and uprooted tree root crowns checked but no evidence of artifactual material was found.

Considerable logging has been done in the area and undoubtably represents the post World War II logging mentioned by Mr. Hanlon. Skid trails are evident in the forest.

The relatively low elevation of the south shore of Bear Cove between stations 170+00 and 190+00 should have been ideal for a village location but only if the area were stable. The age of the alluvial deposit derived from up valley sediments is unknown but does not appear to be old as forest soil development is insignificant. This may be the reason for the apparent lack of occupation.

Shoreline - Bear Cove to Green Lake Outlet

Station 190+00 - 270+00

Proceeding from the flat on the south side of Bear Cove toward Point Ranus we constantly climbed upward to make our way round the point to Silver Bay (Converse, et al 1974:14). From station 210+00 - 270+00 it was a steep slope from 60 - 80° (Figs. 8 and 11). Nothing in this section was noted that could be regarded as evidence for human occupation.

Station 270+00 - 280+00

At Point Rasal we came upon a temporary camp (Figs. 11:1, and 12) with numerous broken beer and wine bottles, fragments of an iron wood stove, Copenhagen snuff can lid, an earthernware sherd, pieces of quartzite laid on sawn stumps and two boards which may define an enclosure 1.7 x 1.7 meters. It is also at this point that a cable for a log raft is tied.

Location:

Section: T. 56 S., R. 65 E., S. 19

56° 59' 46" N. Lat., 135° 8' 24" W. Long.

UTM (Zone 1, Alaska coordinate system) E 2,391,548.125, N 1,888,843.75

Evaluation: The area appears to represent a late historic, temporary camp. The quartzite samples suggest mining activity, which may be related to the claim KX 116-11 Baranof Queen (1912). The bottles were all mold formed so the site is well within the 1900's. It would seem that the placement of the quartzite samples on the stumps was also a relatively recent event as there was no moss growing over or around the samples. A recently visited prospect may be nearby.

The thin scatter of 20th century trash is culturally insignificant. No further work needs to be done in the area and no precautions need to be taken to protect the site from impact.

Station 280+00 - 320+00

The shoreline was paralleled until we reached a point south of station 290+00 where the road turns inland and follows the slope just north of an alluvial filled depression (muskeg) (Converse et al 1977: Plate 4). This slope was followed to station 320+00 where we dropped down to view the cabin ruin along the shore.

The cabin ruin , at the head of the trail to Green Lake (Figs. 11:2 and 13) consists of a collapsed jumble of square cut timbers. Mr. Morgan indicated that it had been a three story structure but that most of the timbers had fallen on the shore and been washed away. In front of the cabin is a stone dock built of graywacke with eye bolts anchored in the rock shoreline. A few pieces of metal and fragments of a transfer ware, ironstone (chinaware) plate were found on the beach. Within the cabin area there was a section of a flattened metal drum, a piece of modern looking galvanized pipe, and two shallow wooden boxes. The cabin seems to have been approximately 16 x 20 feet. There is surprisingly little debris about the cabin. Perhaps it has been picked clean by collectors or there never was much debris about.

Mr. De Armond indicates that the cabin had been built on the site of an earlier log cabin occupied by Andrew Dixon, Peter Romanoff and John Sandman (correspondence, Appendix 2). The present cabin ruin occupied by Steve Tuss was said to have been constructed by Andrew Dixon (Glenn Morgan, Appendix 3). The cabin was built in the late 1920's to early 1930's. Steve Tuss was also working mining claims for Nicholas Bolshanin of Sitka (De Armond and Morgan data).

Location:

Section: T. 56 S., R. 65 E., S. 30.

56° 54' 21" N. Lat., 135° 7' 22" W. Long.

UTM (Zone 1, Alaska coordinate system) E.2,395,031.25,
N. 1,886,234.38

Evaluation: Since the road runs north of the cabin ruin and dock, it is unlikely that the site will be impacted. As a point of interest it has little value relative to the history of mining in the area. The cabin is additionally almost completely gone. No further archeological work is recommended. The site can easily be avoided and if possible this is the course of action to be recommended.

Silver Bay - Green Lake Trail

While not exactly of concern in terms of historic cultural values, the scenic value of the trail constructed by the Civilian Conservation Corps in the 1930's to Green Lake should be considered. The access roads will cross this trail at two points. I am unaware of plans that are being considered in terms of the recreational value of the Green Lake dam, but the trail itself is quite spectacular. Preservation of the trail should be considered in the land use plan.

Station 320+00 - 332+66.37.

The access road from Station 320+00 to the powerhouse at 332+66.37 extends along a steep cliff to the powerhouse site which will be in a cliffside cut (Fig. 14). No cultural materials were noted in this section. Habitation on such a slope in the past was not feasible.

Shoreline - Green Lake outlet to Salmon Lake Outlet

Although the head of Silver Bay from the Green Lake outlet was not specified in the project area, I felt that the question of a Kiksadi camp at the head of Silver Bay should be resolved if possible. The location of the former camp on the west shore of Green Lake near the outlet (Goldschmidt and Haas 1946: plate 9) was quite improbable. The shore line is very steep with no area for a camp. Additionally, Goldschmidt and Haas mention that the camp was on a sockeye stream. Salmon cannot get up the falls in the Green Lake outlet. We thus needed to find a more appropriate location. The streams at the head of Silver Bay were checked. West of the buildings associated with the Edgecombe Exploration Company, Inc. operation, there is a fine stream, but not one associated with sockeye (no lake). Further west, beyond Bower Cove is a braided stream channel which flows out of

Salmon Lake. Mr. Morgan informed us that this formerly was filled with runs of sockeye, coho, and dog salmon. On the west bank of the stream, there is suitable location for a camp. This is adjacent to a cabin that has recently been destroyed by a slide (Fig. 11:3).

It would thus appear from the statements of informants and our own investigation that the former Kiksadi camp was on the outlet to Salmon Lake and not on Green Lake. No further investigation was done as we were only interested in checking the probability of the Kiksadi camp outside the project area. We can now safely conclude that the location of a Tlingit fish camp on Green Lake is quite improbable.

Green Lake Section

Powerhouse - Damsite Area

The construction road route (station 320+00 - 340+00) to the dam site was surveyed as well as the work area associated with the building of the dam. The only cultural material noted was the work camp established by Converse, Davis, Dixon and Associates, Inc. during the coring of the Green Lake outlet. This camp on an elevated bench now covered with muskeg vegetation is within the projected work area for the dam.

The trail was followed down to the Green Lake shore and then around the rock face to the outlet of the lake. The area, through which a subsurface power tunnel (going from the dam to the powerhouse) will pass, is extremely precipitous. Use of the area aboriginally or historically is improbable. No cultural material was noted.

Due to the extremely rugged terrain of the powerhouse damsite area, there is little need for concern that cultural values in terms of previous human occupation will be threatened.

North Shore

Since the project plans include the construction of a road to the Vodopad River valley to obtain gravel for the concrete aggregate, we surveyed the shoreline from the trail to Green Lake to the flat on the north central shore (Fig. 16). This was undoubtably the most difficult stretch in our entire survey. The slope is extremely steep and heavily wooded (Fig. 15). The section from the trail head at Green Lake to the north shore flat was too steep for anything but trees to cling to. We did not find any evidence of human site use.

The flat in the central part of the north shore is composed of alluvium carried by three or more streams from the higher slopes. It is frequently covered with a sheet wash of alluvium during peak run offs. The streams carry their load out into the lake forming a shallows between the north shore and the island against the opposite south shore (Converse, et al 1977: plate 4). While the outwash area is pleasant in summer, I am not sure it would be a good spring location. De Armond noted that there was a claim on the north side of the lake worked in 1923 by Andrew Dixon, Peter Romanoff, and John Sandman (Appendix 2). We did not find any evidence of this activity.

From the north flat to the Vodopad River the shoreline rises vertically. We eliminated this area from consideration as it fell into the extremely difficult to impossible category for utilization.

South Shore

The south shore was surveyed from the east side to the island opposite the north flat. The remainder of the shoreline to the outlet was a steep cliff that was too sheer to traverse. The entire south shore is uniformly steep. A headland and the island were considered the best possibilities.

Our survey revealed that the island would have been a fair campsite area, but no evidence of utilization was observed here or elsewhere along the south shore. Mr. Hanlon reported that Robert's tunnel was cut into the south shore of Green Lake. This was undoubtably at a much higher elevation than the level of the dam impoundment. Most shafts to the south were at or above 2000 feet.

Vodopad River Section

Valley Bottom and Slopes

The valley bottom along the Vodopad River and the branch streams associated with it is covered with a tangle of willow, alder, salmonberry bushes and conifers. The alluvial covering does not restrict the course of the streams which meander across the valley, changing their courses over the years. As a habitation zone, the valley bottom is quite undesirable. In our surveys along the edges of the valley at the toe of the slopes we found excellent growths of skunk cabbage, but no evidence of human occupation or land use.

Surveys along the valley walls were equally negative. Benches that appeared on the map to be potentially interesting proved to be covered with muskeg. We made several overflights into the valley to check out areas that we could not reach on foot within the time limits of the proposed survey. We did not see any locations within the impoundment area that would require further investigation.

CONCLUSIONS

The survey from Herring Cove to the head of Silver Bay and then around Green Lake and into the Vodopad River valley was from the archeological standpoint rather unproductive. The Silver Bay section, based upon previous knowledge of land use patterns was earlier evaluated as being the most potentially productive part of the survey in terms of site locations. Although the entire area was covered on foot, the results are meager - three cabin areas at (1) Herring Cove, (2) Bear Cove, and (3) the start of the trail to Green Lake. These had already been noted on existing maps. The fourth site was the camp at Point Rasal. None of the sites have any local significance as judged by an interest in site preservation. Most are historically recent, i. e., less that fifty years old. None represent material that can "offer a significant contribution to knowledge". The admonition to avoid where possible would hold for these sites as today's trash is the future's heritage. If the site areas are to be impacted by the project however it is felt that no further archeological work need be done in these areas as there is no justification for further investigation based upon the recovered data.

The Green Lake - Vodopad region was even more archeologically sterile. Based upon ethnographic data such a region would undoubtably have had little aboriginal impact. Hunting expeditions would have operated from small camps with no visible remains after a few years of forest growth. Most interior camps have been previously found along acknowledged salmon streams. The Green Lake area has been regarded as unproductive in terms of fish and probably would not have been fished in the past. In other words, the infrequent use of the area by native groups would have left little if anything for the archeologist of the present to discover. In more ancient times the valley was strongly influenced by mountain glaciation.

In taking an overview of the entire region, one is struck with the idea that that area has been only recently relieved of the effects of neoglaciation and that the surface instability of many of the slopes and the alluvial washes of the valley bottoms made for a rapidly changing landscape. The landslide that destroyed most of the cabin at the Salmon Lake outlet is only a more recent example of this.

The ethnographic data seem to confirm this - hunting and fishing activity in the Silver Bay area occurred with perhaps the establishment of temporary camps, but not permanent settlement.

Historically, during white occupation, the activity was mining on the higher elevations with the scatter of cabins as a reminder of that presence along the shore. The cabins at Herring Cove and the mobile home of Dorman McGraw at Bower Cove reflect recreational use, a new cultural practice in the history of Silver Bay.

From this survey, we can conclude that the access road, power transmission lines, construction road, damsite, power tunnel, powerhouse, work area, and impoundment area will not threaten significant archeological sites. In fact, there appear to be few sites of even inconsequential archeological value within the entire area. This is not to imply in the final sense that there are no archeologically significant sites in the project area. Our survey has shown, however, that the possibility is extremely limited. In the event that archeological materials are encountered during construction, every effort should be made to salvage the available data by qualified personnel.

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FIGURES

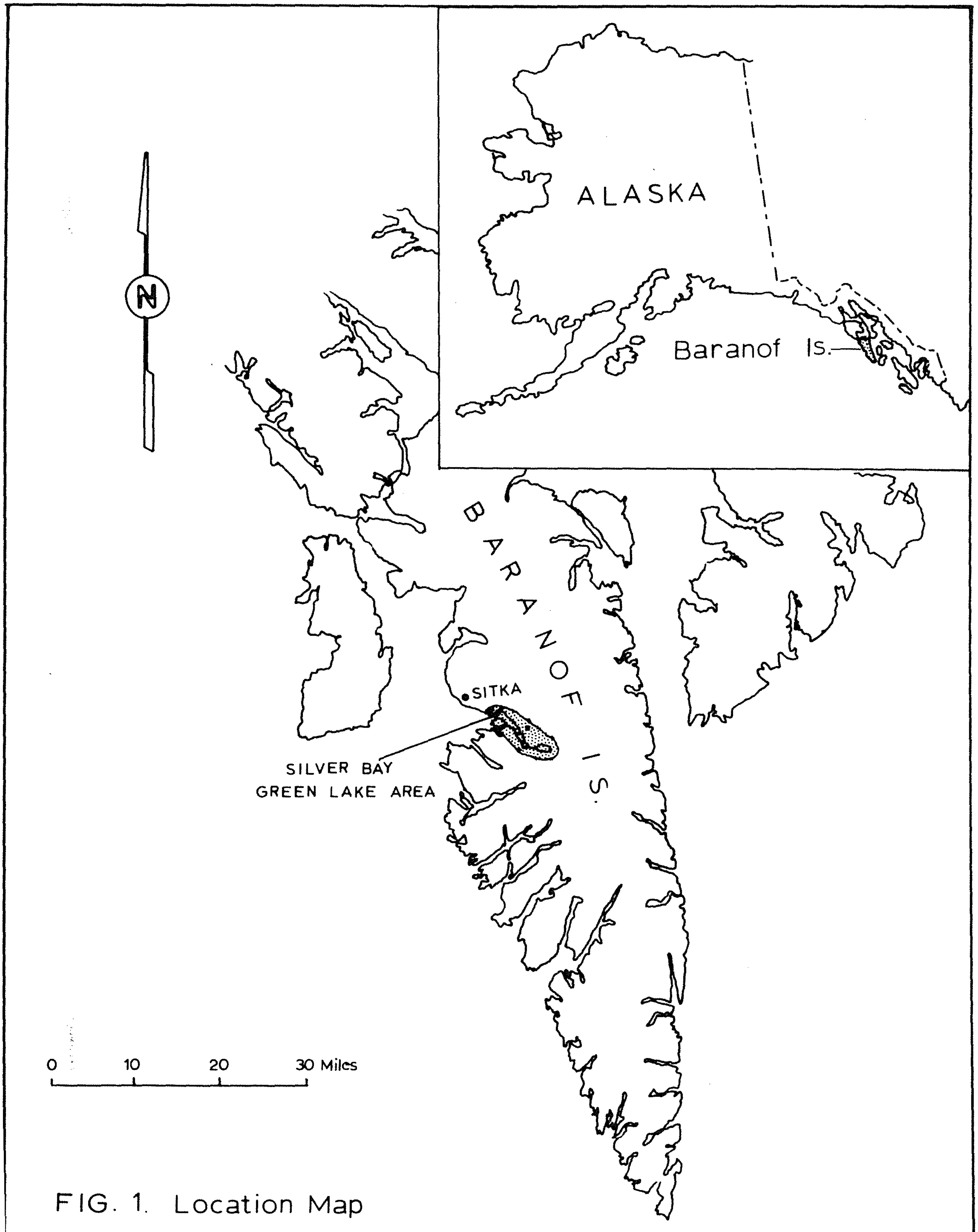

FIG. 1. Location Map

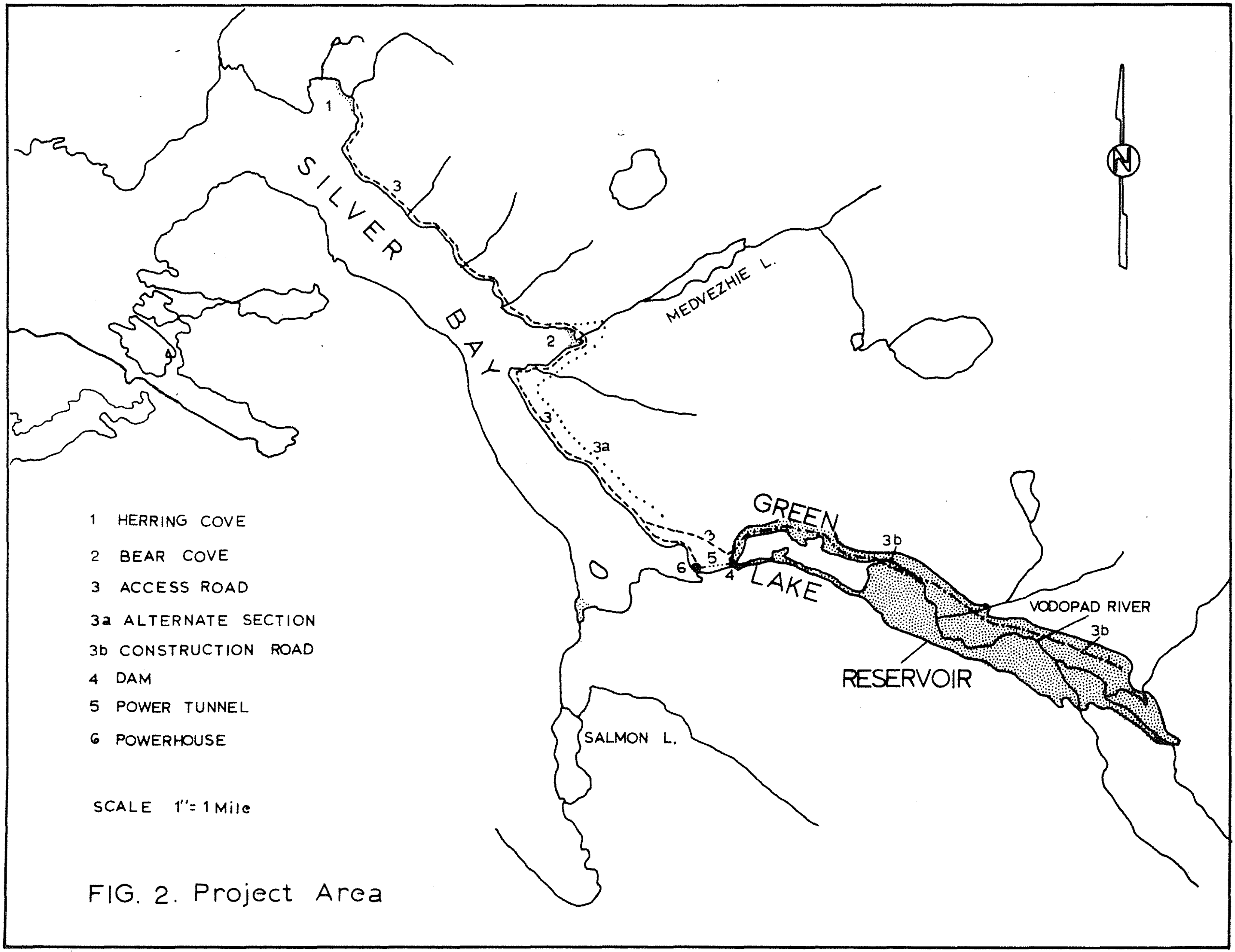

FIG. 2. Project Area

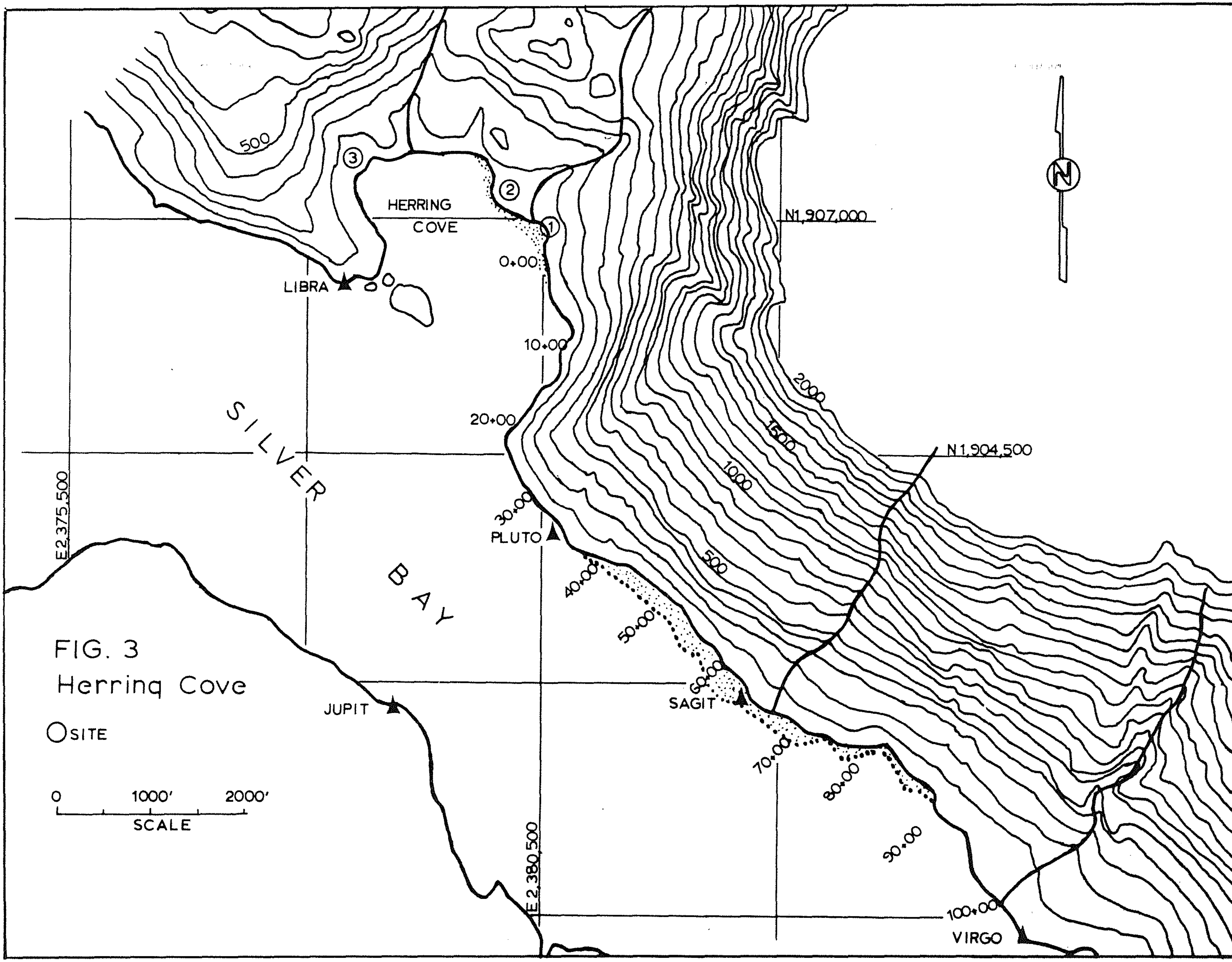

FIG. 3
Herring Cove
O SITE

Fig. 4. Aerial view of Herring Cove from the west

Fig. 5. Cabin ruins (chimney) in location 3, Herring Cove (view to the east)

Fig. 6. Silver Bay north shore (Herring Cove to the left), viewed from the west

Fig. 7. Aerial View of Bear Cove and Medvezhie Lake valley from the west

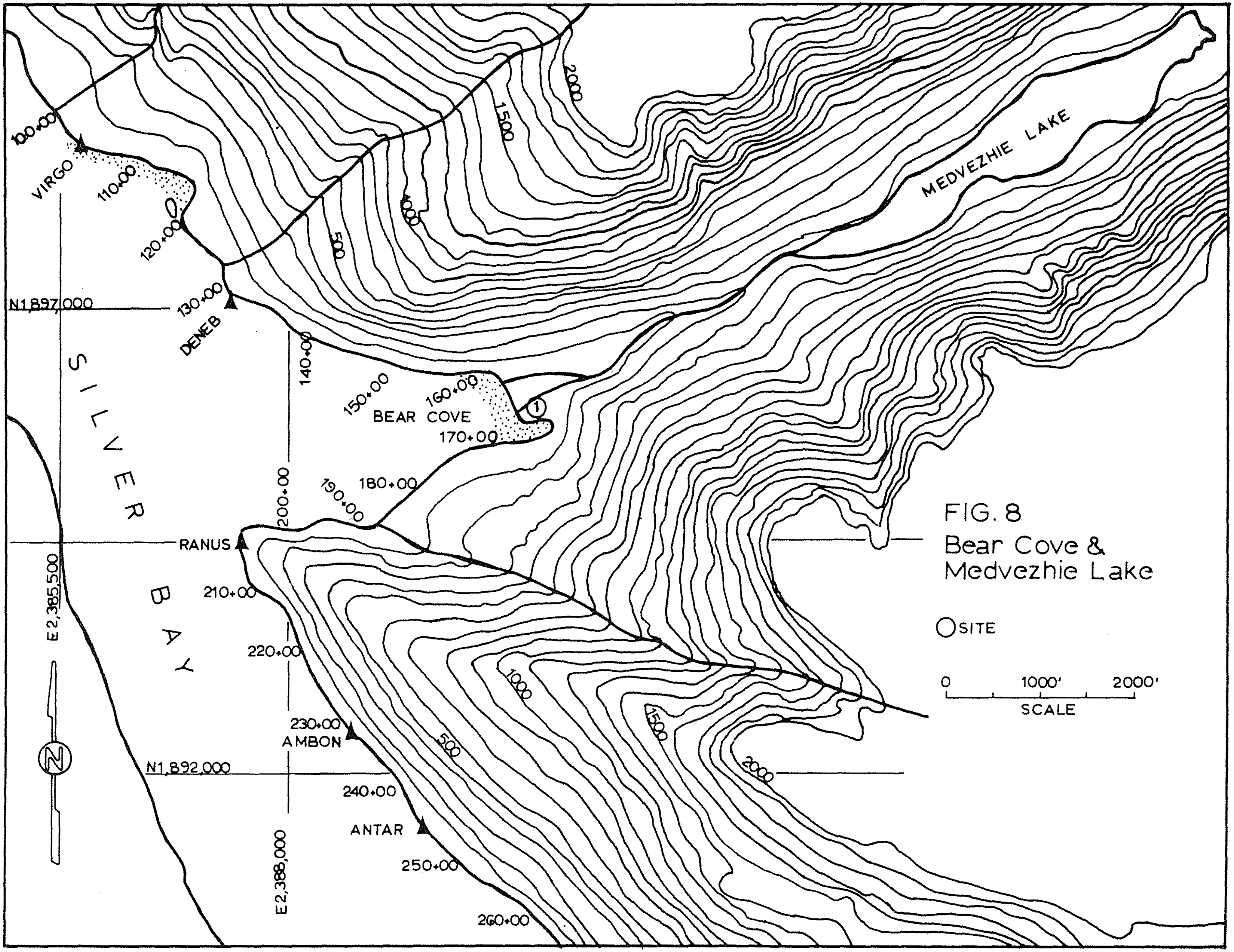

FIG. 8
Bear Cove & Medvezhie Lake

Fig. 9. Privy, location 1, Bear Cove, view from the west

Fig. 10. Site area, location 1, Bear Cove, view from north

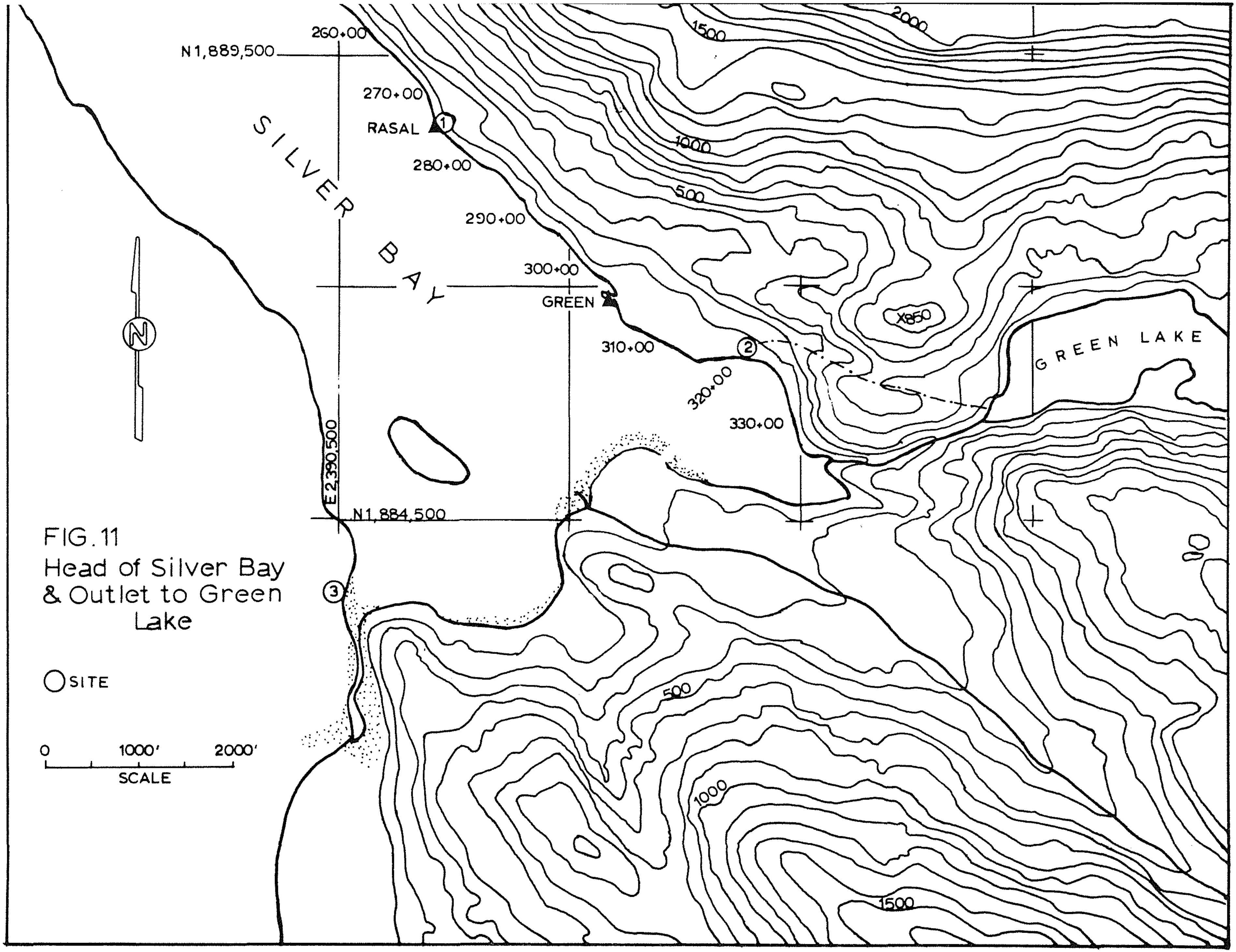

FIG. 11
Head of Silver Bay & Outlet to Green Lake

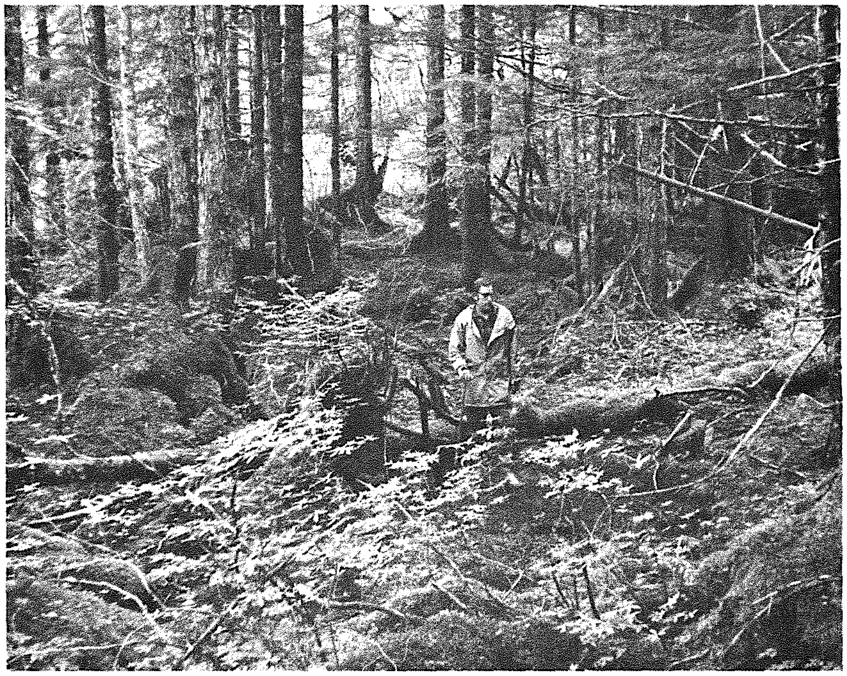

Fig. 12. Temporary camp at Point Rasal, Peter Mehringer standing in main concentration of debris, view to the north

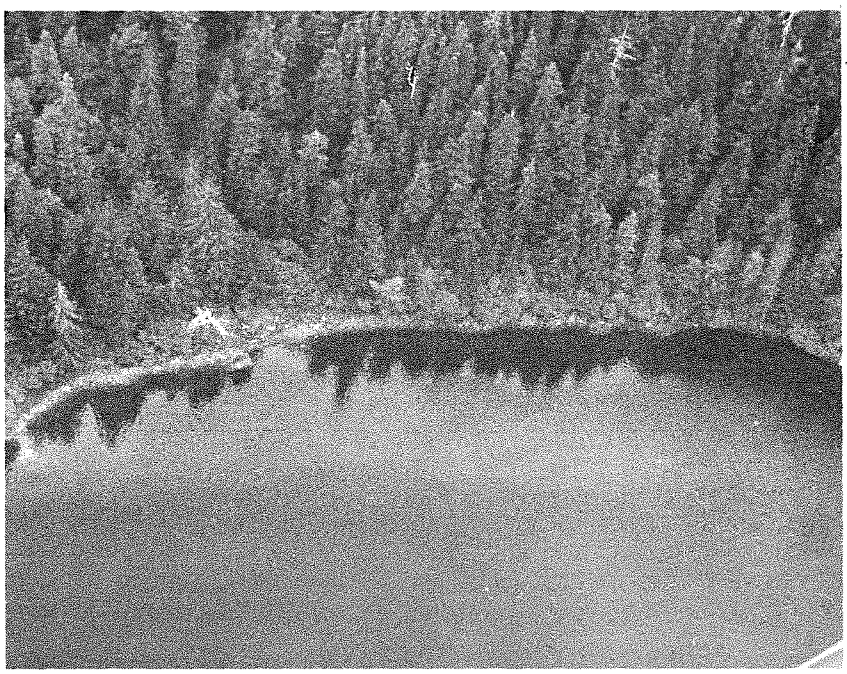

Fig. 13. Cabin Ruin on Silver Bay, north shore, head of trail to Green Lake, view to the east

Fig. 14. Green Lake outlet to Silver Bay, view to the east

Fig. 15. Western part of Green Lake; Silver Bay in background

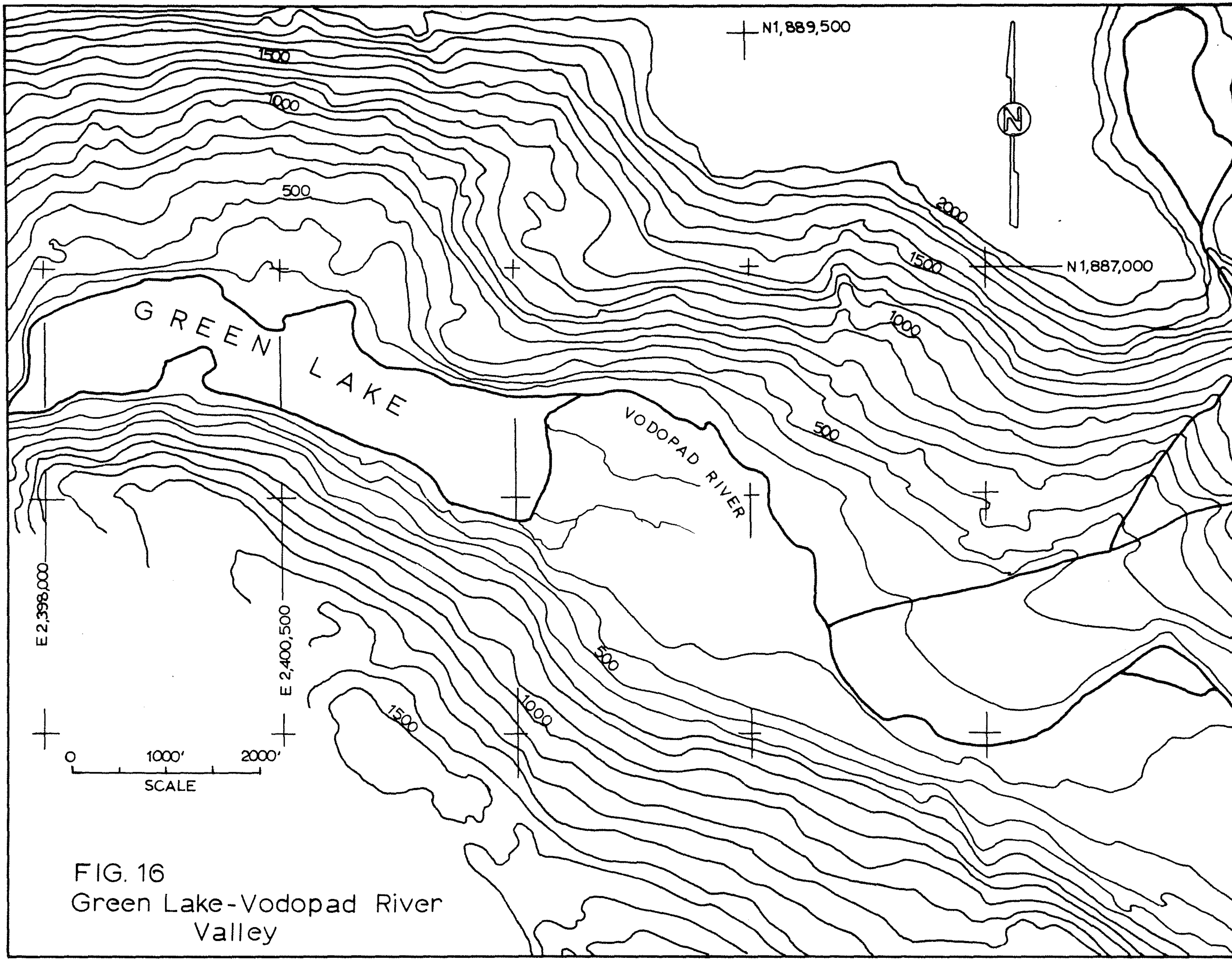

FIG. 16
Green Lake-Vodopad River Valley

APPENDIX 1

MEMORANDUM OF AGREEMENT

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
P.O. Box 1628, Juneau, Alaska 99802

1580 (2300)

JUN 28 1977

Dr. Robert Ackerman
Department of Anthropology
Washington State University
Pullman, Washington 99163

Dear Dr. Ackerman:

Enclosed is a fully executed copy of the Memorandum of Understanding 01-103 relating to your archeological reconnaissance in Silver Bay.

We regret the mixup with the Chatham Area office, but fortunately the accomplishment of the reconnaissance apparently was not affected.

Sincerely,

JOHN A. SANDOR
Regional Forester

Enclosure

Agreement No. 01-103

MEMORANDUM OF UNDERSTANDING

between

Laboratory of Anthropology
Washington State University

and

United States Department of Agriculture
Forest Service, Alaska Region

THIS MEMORANDUM OF UNDERSTANDING, made and entered into by and between the Laboratory of Anthropology, Washington State University, hereinafter referred to as the Laboratory, and the United States Department of Agriculture, Forest Service, Alaska Region, hereinafter referred to as the Forest Service, under provisions of the Act of May 15, 1962 (7 U.S.C. 2201).

WITNESSETH:

WHEREAS, the Municipality of Sitka, Alaska, has contracted with R.W. Beck and Associates of Seattle, Washington, to undertake studies pertaining to a proposed hydroelectric project and associated facilties in the vicinity of Silver Bay and Green Lake, southeast of Sitka; and

WHEREAS, the areas of actual and potential impact of the project must be examined for historical and archeological values prior to project impletation and

WHEREAS, R.W. Beck and Associates have negotiated an agreement with the Laboratory for the performance of the required historical and archeological investigation and examination, the Forest Service being unable at present to perform said investigation and examination.

NOW, THEREFORE, in consideration of the above premises, the parties hereto agree as follows:

A. The Laboratory shall:

1. Provide the Forest Service with no less than two (2) copies of the final report submitted to R.W. Beck and Associates.

2. Provide the Forest Service with a catalog of all artifacts or other samples collected in the course of its investigation for the project.

3. Provide the Forest Service with a catalog of all photographs taken of cultural resources encountered.

4. After the completion of the work, restore the lands upon which they have worked to their customary condition, to the satisfaction of the Forest Service.

5. Fully describe the work to be performed under the agreement in a Project Work Plan to be attached as Exhibit I to this agreement. The work plan will outline the aims, purposes, and exact character of the work to be done.

B. The Forest Service shall:

Consider this Memorandum of Understanding as authorization to the Laboratory to conduct historical and archeological investigations on lands administered by the Forest Service which may be actually or potentially impacted by the proposed project.

C. It is mutually agreed and understood by and between the said parties that:

1. No Member of, or Delegate to, Congress or Resident Commissioner shall be admitted to share any part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

2. The United States of America shall not be liable for any damage incident to the performance of work under this agreement. The Laboratory hereby expressly waives any and all claims against the United States if America for compensation for any loss, damage, personal imjury or death occurring in consequence of the performance of this agreement.

3. This agreement shall be effective upon execution by both parties hereto.

4. Either party may terminate the agreement by providing 60 days written notice. Unless terminated by written notice, this agreement will remain in force until June 1, 1978.

IN WITNESS THEREOF, the parties hereto have executed this agreement as of the last date written below.

6/28/77
DATE

Regional Forester
Alaska Region
U.S. Forest Service

[illegible] 15 1977
DATE

Laboratory of Anthropology

APPENDIX 2

CORRESPONDENCE

DE ARMOND
422 CALHOUN AVENUE
JUNEAU, ALASKA 99801
PHONE: 586-3165

May 26, 1977

Robert E. Ackerman
Department of Anthropology
Washington State University
Pullman, Washington 99163

Dear Bob:

Except for some minor mining activity, I do not know that anything has gone on in the Green Lake area.

The study, "Water Powers of Southeast Alaska," issued by the Federal Power Commission and the Forest Service in 1947 mentions both this site and the one at Medvezhie Lake, but the information is more technical than historical.

Mining activity began in the Silver Bay area in the 1870's, but most of it was concentrated on the south and west side of the bay.

In addition to the claims or prospects marked on the map, Fig. 1, which you enclosed, there is a short tunnel just above high tide on the south side of the little bight into which the Vodopad River flows. It was there when I first saw the area, which was probably 1918 or 1919, but I have no idea who drove it.

There was also a claim on the north side of Green Lake, a short distance from the shore of the lake, which was being worked on in 1923 by Andrew Dixon, Peter Romanoff and John Sandman, all of Sitka. They had a round log cabin on the shore of Silver Bay near the present — or proposed - power house site. Later, in the late 1920's or early 1930's, Steve Tuss carried on work there, financed by the late Nicholas Bolshanin of Sitka. Steve built another cabin on the shore, this one of hewed logs.

William Hanlon, who still lives in Sitka - more commonly known as Ikey Hanlon - spent a good deal of time at Silver Bay, on the Haley property and probably knows as much about the area as anyone now living.

The old mining records at Sitka contain many pages of location notices in the 1870's, but it is difficult to place many of them because they did not use geographic names that are now recognizable.

I am sorry to say that Esther Billman died in April - April 2, I believe - at Salem, Oregon.

I do not know James Davis and cannot think of anyone now living in Sitka except Hanlon who might provide any useful information.

So far as I am aware, there were no Indian settlements or houses anywhere on Silver Bay.

Best regards,

Bob

R. N. De Armond

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

Division of Parks
619 Warehouse Dr., Suite 210
Anchorage, Alaska 99501

June 1, 1977

Re: 3100

Professor Robert E. Ackerman
Department of Anthropology
Washington State University
Pullman, Washington 99163

Dear Bob:

This is in reply to your letter dated May 22 informing us of your archaeological survey in the Silver Bay and Green Lake areas near Sitka, in anticipation of a proposed hydroelectric construction project. I enclose a copy of the May 1977 list of sites in the Sitka United States Geological Survey quadrangle which are listed in the Alaska Heritage Resource Survey (AHRS).

You may have learned by now the sad news of the recent death of Ms. Ester Billman. We do understand that James W. Davis has knowledge of cultural resources in the area of your interest. His address is: P.O. Box 1109, Sitka, Alaska 99835.

Sincerely,

GEORGE A. HALL
Acting Director

Bill

By: William S. Hanable, Chief
History & Archaeology

Enclosures

AM:lea

Here is the information on the Herring Cove cabins from records we have.

The cabin above the road where only the chimney remains — This cabin was built in 1933 by Jack Calvin for a residence. His special use permit was issued on 3/16/27. Calvin sold the place in 1935. It had 2 or more subsequent owner but we no longer have the records identifying them. I believe the cabin burned down in 1964.

The cabin below the road was last owned by Gilbert Engman. His permit was issued on 10/2/62 and it was closed 3/21/73. The preceding permittee was Edwin M. Halverson. We no longer have his records but there is evidence that he had the cabin as far back as 1958. There are no records here of earlier occupancy. Calvin says it was built after he left in 1935

N B Schoonover
6/10/77

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

Division of Parks
619 Warehouse Dr., Suite 210
Anchorage, Alaska 99501

June 13, 1977

Re: 0012

Robert E. Ackerman, Professor
Washington State University
Dept. of Anthropology
Pullman, Washington 99163

Dear Bob:

I appreciate having been asked for information on the probability of encountering archaeological data in the Silver and Green Lake area at Sitka. You are correct that the Russian's sawmill, which stood at the entrance of Silver Bay was fairly well destroyed by a "farm" that existed there prior to the Pulp Mill Construction. The Pulp Mill transformed the land even more.

My knowledge of the area suggests that the natives (Kiksadi) moved from Wrangell to Sitka and in some development of the native lore lived at various points along the coast as far westward as Jamestown Bay and then gradually through successive moves to Castle Hill at Sitka. The camps at old Sitka to the North and deeper into Silver Bay were temporary or summer camps. I did not encounter any references to native encampments, villages or other large scale unit uses of this area and deep in Silver Bay. I heard nothing at all about Green Lake. I think the prospect of your finding much material in there is rather limited. There may be evidence of temporary camps although I question this since I believe you will find it was largely a route to somewhere else. I am pleased to see that they are utilizing a professional archaeologist before they undertake a project; this has not been the case in the past. At the time the pulpmill was constructed, there was an offer to do archaeological work at Blue Lake which Paul Schumacker chose to turn down since he arbitrarily determined that there was little probability of evidence. He may have been right, but I would have been much happier if he had done some kind of an analysis.

Sincerely,

George A. Hall
Deputy Director

GAH:lea

APPENDIX 3

INTERVIEW DATA

INTERVIEW DATA

FROM INFORMANTS IN SITKA, JUNE 10 - 12, 1977

1. William R. Hanlon (June 10, 1977)

Mr. Hanlon known as "Iky" or "Mule" Hanlon is a retired miner living in Sitka. He worked for Nicholas Haley and Nicholas Bolshanin in the 1920's and 1930's. His reminiscenses on mining were mainly about claims outside of the project area. Relevant to our investigations are the following:

(1) Herring Cove:

Bill Marquat had a cabin in the area where a stone chimney now stands as the last vestige.

Jack Calvin had a cabin on the east shore, probably destroyed by the ALP log dump construction.

Marsh (ex-marine, W. W. II) had a cabin and small prospect in the southeast corner of Herring Cove. This according to Hanlon's location would be the site of the barrow pit created during the construction of the access road from Sawmill Cove to Herring Cove.

(2) Green Lake

Robert's Tunnel - a shaft sunk near the outlet to Green Lake on the south shore in 1936. It was not clear from Mr. Hanlon's conversation whether this was the same tunnel he then mentioned as being 250 feet long and at the 2600 foot level.

2. Norman Schoonover (June 10, 1077)

Mr. Schoonover is in the planning section of the Chatham district of the Tongass National Forest, U. S. Forest Service. We stopped at the office of the Forest Service to request information regarding the issuance of use permits. Calvin Bird, forest ranger for the Chatham area,suggested in a telephone conversation prior to our arrival in Sitka that we talk to Mr. Clyde Ferguson or Norman Schoonover. We first saw Mr. Ferguson who quickly referred us to Mr. Schoonover. I explained our mission and asked for data on cabins within the project area. Mr. Schoonover said he was not sure how much data was locally available but would make a search for us. He later sent a written copy of his findings to us (see Appendix 2).

3. James Davis (Sitka, June 11, 1977)

Telephone conversation - Mr. Davis is the manager of the Sitka Chamber of Commerce and is an active participant in the Sitka Historical Society. Mr. Davis reported that there were no native informants who could tell me about the aboriginal use of the Silver Bay - Green Lake area. All of the "oldtimers" were gone and with them such information. He recommended that I contact Mr. Glenn Morgan of Sitka as he was a long time resident with considerable experience in mining at the head of Silver Bay.

4. Mrs. Charlotte Morgan (June 11, 1977)

Telephone conversation - I explained to Mrs. Morgan that I was interested in aboriginal settlement in the Silver Bay - Green Lake area and was interested in the statement by Goldschmidt and Haas that a camp was located at the mouth of a good sockeye stream at the head of the bay (1946:108) [on Chart 9 Goldschmidt and Haas have located the former camp at the outlet of Green Lake, on the west shore]. Mrs. Morgan reported that Nicholas Haley in 1864 had Indians working for him in his surface mining activities, spoke Tlingit and knew a fair amount about the native culture. He, according to Mrs. Morgan, never spoke of a smokehouse or camp in the area. She was similarly unacquainted with any fixed aboriginal use area.

5. Mrs. Isabel Miller (June 11, 1977)

Mrs. Miller is one of the members of the Sitka Historical Society that is active in managing the museum in the Centennial Building in Sitka. She indicated that we should contact Mrs. Ellen Lang, Superintendant of the Sitka National Monument for information regarding aboriginal land use in the Silver Bay - Green Lake area. Mrs. Miller kindly located Mrs. Lang for me by telephone and enabled me to get the information that I was seeking.

6. Mrs. Ellen Lang (June 11, 1977)

Telephone conversation - Mrs. Lang is of Tlingit ancestry and considered knowledgeable about local land use. Mrs. Lang indicated that the Tlingit of Sitka had general use rights to the Silver Bay - Green Lake area but that there were no specific settlements there in the past. I asked her about the camp at Green Lake. Mrs. Lang indicated that it was unlikely as there were no salmon in Green Lake, only trout and that the Tlingit made little use of trout. She indicated that the outlet to Salmon Lake would have been a more likely location. Mrs. Lang also noted that the area had been highly disturbed by mining activity over the past hundred years and that the chances of finding any evidence of historic Tlingit occupation of the area would be small. She also provided me with the names of other Tlingit informants: Mr. Bill Peters, Mr. Moses Johnson, and Mr. Bill Bradley (Sitka Camp President, Alaska Native Brotherhood). I was unable to contact these individuals as that evening a potlatch was being held at the ANB hall and we left Sitka the following day.

7. <u>Mr. Glenn Morgan</u> (June 12, 1977)

Mr. Morgan is the manager of the Edgecombe Exploration Company, Inc. Mr. Morgan visited us in response to our call to Mrs. Morgan on June 11. He had been with Mr. Mongin, architectural historian, Office of History and Archeology, at Goddard hot springs the previous day to consider the possibility of nominating the hot springs to the state and national register. Mr. Morgan thus evinced an interest in the cultural values of the Sitka region.

Regarding the possibility of a Tlingit camp at the head of Silver Bay, Mr. Morgan reported that temporary camps were certainly possible in the past, but that he had not heard of any fixed location for such, nor had Nicholas Haley ever mentioned anything like a smokehouse or fish camp for the area. He agreed that if one were to have a camp , the outlet to Salmon Lake would be the likely location. Sockeye, coho, and dog salmon go up this outlet to Salmon Lake and this was a favored fishing location until the fishery was ruined by over netting at the mouth. The cabin on the west bank of the outlet to Salmon Lake was built by Lee Burkhart who received the land title from William Johnson, a relative of Nicholas Haley. The cabin was utilized also by Dorman McGraw until a slide destroyed most of the structure. McGraw then moved a mobile home on floats to Bower Cove (to the immediate east of the Salmon Lake outlet at the head of Silver Bay). McGraw is currently utilizing Bower Cove as a weekend retreat.

Mr. Morgan indicated that Edgecombe Exploration Company, Inc. had 5 ore shoots and 25 claims at the head of Silver Bay - Salmon Lake area. He indicated that he had also thought of using the waterpower potential of Green Lake, but had not done anything with his plan of development.

I commented on the cabin at the head of the trail leading to Green Lake and noted that Robert De Armond wrote that it had been built by Steve Tuss. Mr. Morgan laughed and said that Steve Tuss could not drive a nail straight and that the three story, squared log cabin had been built by Andrew Dixon. Steve Tuss occupied a small room on the third story, the rest of the cabin was open. When the cabin collapsed, much of it fell onto the tidal zone and was washed away. Only a small part of the cabin structure remains.

Mr. Morgan then spoke of the vandalism in the area and the depredations upon his property. Such activity would further reduce once existing evidence of historic occupation. Mr. Morgan was also concerned that we might be raising the question of native claims to the Silver Bay area, but I assured Mr. Morgan that our only interest was the location of an aboriginal camp said to be on a sockeye stream at the head of the bay. I was sure that it could not be at the Green Lake outlet and was interested in proving this point as it would remove any question of specific land use from the project area. Mr. Morgan, relieved that our interest was of a strictly investigative nature, concurred that a camp at the lakeside near the outlet was quite improbable.

Appendix W - 12

Consultants' Vitae

R. W. BECK AND ASSOCIATES

ENGINEERS AND CONSULTANTS

PLANNING
DESIGN
RATES
ANALYSES
EVALUATIONS
MANAGEMENT

200 TOWER BUILDING
SEATTLE, WASHINGTON 98101
TELEPHONE 206-622-5000

SEATTLE, WASHINGTON
DENVER, COLORADO
PHOENIX, ARIZONA
ORLANDO, FLORIDA
COLUMBUS, NEBRASKA
WELLESLEY, MASSACHUSETTS
INDIANAPOLIS, INDIANA

FILE NO.

SUMMARY OF FIRM'S QUALIFICATIONS

GENERAL QUALIFICATIONS

R. W. Beck and Associates provides a complete range of engineering services in planning, feasibility, design, inspection and operation of electrical, civil, structural and mechanical facilities for power and water resources developments. The Firm is staffed to carry a total program from the initial planning for the development of an area through the steps of determining the engineering feasibility of specific projects, providing services on project financing, designing and supervising the construction of projects, and providing continuing analytical services and consultation on the operations of the client.

Since its founding in 1942, R. W. Beck and Associates has gained an outstanding reputation for rendering professional engineering services. The Firm is particularly proud that it has served many of its clients on a continuing basis for more than twenty years. The Firm has completed assignments in nearly every state in the Union and in Afghanistan, Okinawa, Honduras, Singapore, Virgin Islands, Nicaragua, Canada and Thailand. It is a partnership of twenty-one partners.

The general offices of the Firm are located at Seattle, Washington, which is also the headquarters of the Firm's Western Regional Operations. Other offices are maintained at Denver, Colorado; Phoenix, Arizona; Columbus, Nebraska; Orlando, Florida; Boston, Massachusetts, Indianapolis, Indiana; and Minneapolis, Minnesota. The Firm presently maintains a staff of about 400 professional engineers and other specialists dedicated to providing engineering and related services to its clients both within the United States and internationally. The staff includes more than 225 professional engineers of which 65% are registered in one or more states and with other governments. Beck has an HP-3000 computer and a staff of experienced programmers and operators.

EXPERIENCE IN HYDROELECTRIC PROJECTS

R. W. Beck and Associates is especially well qualified in the basic engineering work relating to planning, design and construction of hydroelectric projects and dams.

Typical of those projects for which the Firm has provided engineering services from the initial investigations through design, construction, and operation, are the Sultan and Packwood Projects in Washington. The Sultan Project was designed and an FPC License obtained for Public Utility District No. 1 of Snohomish County and the City of Everett, and the first stage, completed in 1964, supplies the City's 100-mgd water demand as well as providing flood control benefits. Investigations and designs on the second stage for a power installation of 70 MW are now proceeding with a scheduled in-service date of 1984. The 1,800-foot head, 30 MW Packwood Hydroelectric Project in southern Washington, went into operation in 1963. The Firm also provided the full range of services from initial investigation through construction for the Beaver Falls, Ketchikan Lakes, Lake Silvis and Blind Slough hydroelectric projects in Alaska.

In 1967, Beck studied the installation of additional generating capacity of 740 MW in the City of San Francisco's Hetch Hetchy Water Supply System. The studies included the addition of units to the existing power plants, the construction of additional dams, tunnels and power plants on the main Tuolumne River, at the existing Moccasin Plant. An Appraisal Report updating the study of this project was completed in 1976, and an Application was made to the Federal Power Commission for a Preliminary Permit to investigate the 400,000 kW Clavey-Wards Ferry Project in detail.

In 1972 the Firm located and investigated the 2,000 MW Antilon Lake Pumped Storage Project for Chelan County Public Utility District in Washington, and prepared an Interim Feasibility Report and obtained an FPC Preliminary Permit for the project. Feasibility studies, designs and power marketing are progressing with anticipation of the project entering into service in the mid-1980's. The Firm located another 2,000 MW pumped storage project, the Green River Pumped Storage Project in North Carolina, on behalf of Electric Power in the Carolinas (EPIC). An FPC Preliminary Permit was obtained for this 900-foot head project, with a schedule for project completion in the middle 1980's.

Investigations were performed and a feasibility study completed for the 1,100-foot head, 1,000 MW Merrill Lake Pumped Storage Project for Cowlitz County Public Utility District, Washington. A feasibility study has also been completed on a high head pumped storage project, with a capacity of 1,000 MW on the Bull Run River near Portland, Oregon. An investigation was completed in 1972 for the installation of additional units (260 MW) at the Salina Pumped Storage Project in Oklahoma. An 800 MW, 400-foot head pumped storage project was located on the Brazos River in Texas, together with a 50-MW conventional power plant on the same river. An FPC Preliminary Permit to investigate these projects has been obtained and detailed feasibility investigations are in progress. A review was made of the economics and power marketing of the 1,300 MW Boyd County Pumped Storage Project in Nebraska.

Feasibility investigations and preliminary designs have been made on a number of hydroelectric sites in the Pacific Northwest including the Illinois River, the Little White Salmon River and the Wenatchee River. Also in Washington, a possible expansion of the Chelan Power Plant from 48 MW to 288 MW was investigated. A preliminary feasibility report was prepared in 1967 for the 50 MW Cowlitz Falls Project on the Cowlitz River, and an FPC Permit was secured in 1968. A study is now being initiated to appraise the feasibility of this development under current economic conditions. Preliminary designs and feasibility studies have been completed for power installations totalling 43 MW at the existing water supply dams on the Bull Run River for the City of Portland. These studies indicated that such power installations are economically feasible. An analysis was made for the Corps of Engineers of various methods of selective withdrawal from Libby Reservoir in Montana to meet temperature requirements for fish life, and a method was selected and constructed.

State-wide site selection surveys have been made of potential hydroelectric developments in the small to medium range for Washington, Virginia and North Carolina. A similar study for the State of Pennsylvania is in progress.

Investigations, FPC Licensing, and design are also progressing for a number of hydroelectric projects at other locations in Southeast Alaska, ranging up to 25 MW, including the Green Lake Project for Sitka, expansion of the Blind Slough Project at Petersburg, the Thomas Bay and Virginia Lake Projects for the Petersburg-Wrangell area, and Swan Lake Project for Ketchikan.

Feasibility studies were completed for the Black River Hydroelectric Project for the Town of Springfield, Vermont, and an FPC License Application is being prepared for the project. The development comprises six powerhouses with a total installed capacity of 30.3 MW. A report was prepared appraising the feasibility of developing 12 MW on the Missiquoi River for Swanton Village, Vermont, and investigations have commenced on the feasibility of developing about 35 MW on the James River and its tributaries in Virginia. Modifications to the Snowden Plant were studied for the City of Bedford, Virginia.

Feasibility studies were made of installing 62 MW of bulb turbine driven generators at each of the existing Corps of Engineers' Greenup and Cannelton Locks and Dams on the Ohio River. Studies are continuing on the development of 35 MW on the Gunnison River for the City of Delta, Colorado, and an FPC Permit has been applied for. An FPC License Application was recently submitted for the City of Santa Clara, California for the existing hydroelectric development on the Mokelumne River.

Many of these projects contain underground excavations including tunnels with a range of cross-sections and lengths, and for many different geological conditions. The Firm is well experienced in the design and construction inspection of tunnels, particularly the use of more recent innovations such as shotcrete and tunnel machines.

Our transmission design experience includes projects under varying conditions of structural and electric loads for voltages up through 345-kV. Design concepts include single and H-frame prestressed concrete and wood poles, steel poles for single and double circuit construction, and steel towers for single and double circuit construction.

The Firm has been engaged in all facets of substation design for more than fifteen years, with voltages ranging up to 500-kV. During this period, we have been in the forefront of modern design in substations leading to low-profile and semi-low-profile designs utilizing pleasing structural elements. Screen-type fencing, landscaping and other aesthetic treatments are employed.

Staff members and special consultants to the Firm are experienced in a wide range of technical matters related to the air, water and land environments. This experience has been applied to investigations concerning thermal powerplants, reservoirs, hydroelectric plants, transmission facilities, roads, and structures. The Firm has supervised field studies to characterize the environment and ecological systems at proposed project sites, performed analytical studies to project the impact of new facilities on the environment, developed design alternatives to minimize or relieve such impact, and prepared environmental impact statements to accompany applications for facility permits and licenses.

R. W. Beck and Associates has conducted economic and financial feasibility studies which have formed the basis for financing and construction of many hydroelectric and water supply projects throughout the country. Our staff has worked closely with bond counsel and financing agencies and is very well respected in this regard. In all, the Firm has provided assistance for the issuance of more than $3 billion in bonds over the years. In parallel with this we have gained a reputation in the analysis of electric power supply, power marketing and power rates and sales contracts.

JAMES R. DAVIS
President
SCHAEFER J. DIXON
Executive Vice President
SEATTLE
EUGENE R. MCMASTER
Vice President
PASADENA
C. R. MACFADYEN
Vice President
ANAHEIM
THOMAS D. LAKE
Vice President
SAN FRANCISCO
EUGENE A. MILLER
Vice President
LAS VEGAS
ROBERT M. PRIDE
Vice President

Geotechnical Consultants

CONVERSE DAVIS DIXON ASSOCIATES, INC.

100 West Harrison, Seattle, Washington 98119 • (206) 285-5200

GENERAL QUALIFICATIONS

Converse Davis Dixon Associates, Inc. provides a complete range of services in geotechnical engineering. These capabilities include foundation engineering, engineering geology, earthquake engineering, and groundwater geology including all attendant field and laboratory testing services. The firm is organized to provide close, direct consultation of its principals on key assignments, and is staffed to provide sufficient personnel to perform major geotechnical investigations.

The administrative offices of the company are located in Pasadena, California. The firm's consulting offices are maintained in Pasadena, San Francisco, and Anaheim, California, Las Vegas Nevada; and in Seattle, Washington. The firm presently maintains a staff of about 80 total personnel which includes approximately 40 professional engineers and geologists.

Since its founding in 1946, Converse Davis Dixon Associates, Inc. has developed an outstanding reputation in rendering its professional services. Many of its key employees publish technical papers routinely and are active in professional society activities. It has served many of its clients on a continuing basis for decades. The firm has performed investigations in southeast Asia, in Japan and adjoining islands, in South America and Central America, and Africa and the Middle East.

EXPERIENCE IN HYDROELECTRIC AND DAM PROJECTS

Converse Davis Dixon Associates, Inc. has considerable experience in the geotechnical engineering phases of many hydroelectric and dam projects. One of the major services the firm offers is studies leading to the selection of sites for dams. The firm and its personnel have consulted on a total of approximately 80 dam projects throughout the world. All of its key personnel have at one time or another performed work outside the continental United States.

Converse Davis Dixon Associates, Inc. has performed some 20 investigations for R. W. Beck and Associates, Inc. The firm has, therefore, considerable experience in working together. Mr. Williamson and Mr. Dixon, principals of each firm, have worked together over a number of years on prior assignments with several organizations.

Typical of the hydroelectric projects are the Castaic power project near Los Angeles in California, the Green Lake project in Alaska, and the Black River project in Vermont. The latter two of these projects were performed as consultants to R. W. Beck and Associates, Inc. The consulting assignments on these projects typically included geological mapping, site exploration, field and laboratory testing and geotechnical engineering studies providing the basis for preliminary design and cost estimates.

DR. DAVID T. HOOPES - ENVIRONMENTAL CONSULTANT

B.S. in Wildlife Management
University of Alaska
M.S. in Fishery Biology
PhD in Fishery Biology
Iowa State University

American Fisheries Society, American Institute of Fisheries Research Biologists

Dr. Hoopes has had over fifteen years of professional experience related to fishery investigation and study in Alaskan waters. With the National Marine Fisheries Service he has served as project leader for international shellfish problems, and fishery biologist. Dr. Hoopes taught Principles of Ecology at the University of Alaska Juneau-Douglas Community College Campus. He is currently providing consultant services in the field of fisheries and wildlife.

Dr. Hoopes was the writer-editor of the 1971 Southeast Alaska Area Guide, a land and resource management program for the Tongass National Forest, sponsored by the U.S. Forest Service.

In addition Dr. Hoopes has published numerous papers generally concerned with fisheries in Alaska. Some recent publications are:

"Alaska's Fishery Resources - The Dungeness Crab." NMFS Fishery Facts - 6, 1973;
"King and Tanner Crab Research." (With J.F. Karinen and M. H. Pelto) pp. 110-120 in INPFC Annual Report 1970;
"Selection of Spawning Sites by Sockeye Salmon in Small Streams." pp 447-458 Fishery Bulletin 70, 1972;
"Occurrence of Tanner Crabs in the Eastern Bering Sea with Characteristics Intermediate Between c. Bairdi and c. Opilo." (With J. F. Karinen) Shellfisheries Association Vol. 61, 1971.

VITA

ROBERT E. ACKERMAN, Professor of Anthropology
Washington State University

Born: Grand Rapids, Michigan. May 21, 1928

Education:	B.A.	University of Michigan 1950
	M.A.	University of Michigan 1951
	PhD	University of Pennsylvania 1961

Professional Experience:

1973	Professor of Anthropology, Washington State University
1971-72	Acting Chairman, Department of Anthropology, Washington State University
1961-date	Instructor to Professor, Washington State University
1960-61	Instructor in Anthropology, University of Delaware (extension)
1959-61	Fellow in Anthropology, Eastern Pennsylvania Psychiatric Institute, Philadelphia
1957-59	Research Assistant, University Museum, University of Pennsylvania

Membership in Professional Societies:

Arctic Institute of North America (Fellow)
American Anthropological Association (Fellow)
American Association for the Advancement of Science (Fellow)
Society for American Archaeology
Society for Historical Archaeology
American Association of University Professors
Current Anthropology (Associate)
Sigma Xi
Canadian Archaeological Association
Society of Professional Archaeologists

Recent Research and Field Experience:

1976	National Academy of Sciences Senior Scientist Exchange Program with the Soviet Academy of Sciences - 2-1/2 months in Leningrad, Moscow, Novosibirsk, and Irkutsk archaeological research institutes while on professional leave from Washington State University.

VITA (cont.)

Recent Research and Field Experience (cont.)

1975	Archaeological Survey of Loran C Site, Shoal Cove, S.E. Alaska; U.S. Coast Guard
	Archaeological Investigation in Yukon-Kuskokwim Delta; National Science Foundation, U.S. Fish and Wildlife Service, Washington State University
1974	Archaeological Survey of Baranof and Chichagof Islands, S.E. Alaska; U.S. Forest Service, USDA
1973	Archaeological Investigations in the Icy Strait Region, S.E. Alaska; National Science Foundation
1972	Archaeological Survey of Clarence Rhode National Wildlife Range, Bureau of Sports Fisheries and Wildlife, USDI
1971	Archaeological Investigations in the Icy Strait Region, S.E. Alaska; National Science Foundation

Research Interests:

Archaeology and Ethnology of Northern North America, Siberia, and Japan

STEEN & MATLOCK
CONSULTING ENGINEERS

P. O. BOX 4-2665
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THE FIRM

Alaska, with its increasing importance to the nation, faces a growing need for professionals in many disciplines who are familiar with both Alaska's unique conditions and with developments and techniques in the rest of the world. Only a broad knowledge of both can provide the basis on which sound engineering decisions can be made. Also, personal attention to projects by the principals who have this background is essential if the best solution is to be found.

Steen & Matlock, Inc. was formed to provide this service in the Civil Engineering field. The two principals in the firm, with an aggregate of nearly 20 years of responsible experience in Alaska, and over 40 years in other states, are able to offer the mature judgment, broad professional experience and proven technical ability needed to accomplish this objective. The principals' experience has included advance planning, feasibility studies, evaluations, reports and final designs as well as construction management on highways, railroads, bridges, docks and harbor facilities, airports, residential, commercial and industrial buildings, ferry facilities, parking garages, and other related projects.

Geographically, the principals have been involved in projects from the arctic to the tropics, and ranging from the Southwest Pacific to the Eastern Seaboard of the United States.

A prime objective of the firm is to adapt each project in the most compatible manner possible to the environment in which it is located and to the project's intended purpose. This requires a knowledge of subjects outside of the purely technical areas of engineering. For many years both principals have worked closely with federal and state agencies, private associations and people throughout the state on various projects to accomplish this purpose. They have a good working relationship with, and understanding of, the needs in the various areas of Alaska, as well as an intimate knowledge of the terrain, climate, and soil conditions throughout the state.

On the premise that proper management of lands in Alaska is the key to the future well being of the state and its citizens, the principals have continued their active interest and participation in such matters. This, while satisfying a personal interest, also helps in providing a better and more current understanding of the concerns of the people and, thereby, a better capability in providing facilities which best satisfy these concerns.

The firm also has a close working relationship with other engineering firms, as well as with experts in ecological sciences, economics, social sciences, earth sciences, surveying and photogrammetry, and does not hesitate to call on these specialists as needed to supplement in-house expertise.

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KEY PERSONNEL

COSBY E. STEEN
President

Education - Texas A&M University, BSCE 1950
Professional Engineer - Alaska, Texas, Yukon Territory

C. E. Steen has accumulated more than 14 years experience in Alaska, including design and construction supervision of highways, railroads, bridges, docks and harbor facilities, industrial plants and facilities, and commercial buildings and utilities. This work has included supervision of a force of more than 1,600 personnel while he served as Commissioner and Deputy Commissioner of the Alaska Department of Highways.

Prior to his experience in Alaska, C.E. Steen was Project Manager and Chief Estimator for 10 years with a contracting firm operating in Texas, Louisiana, New Mexico, and Oklahoma. Mr. Steen also served as Resident Engineer for the Texas Highway Department. His professional career spans more than 25 years.

Mr. Steen served in the U.S. Air Force during World War II. He is a pilot and flies the company aircraft.

CHARLES S. MATLOCK
Vice-President

Education - University of Texas, BSCE 1943
Professional Engineer - Alaska, Texas, New York

C. S. Matlock has extensive design and construction experience in bridges, port and harbor facilities, buildings and other structures. His professional career exceeds 32 years and has included recognition as a leader in his field, both locally and nationally. During the past 9 years, Mr. Matlock served as Deputy Commissioner of Highways, State Highway Engineer, District Highway Engineer, and Chief Bridge Design Engineer for the Alaska Department of Highways.

Prior to coming to Alaska in 1966, Mr. Matlock was Chief Bridge Engineer for a major consulting engineering firm in New York City and previously had been Supervising Design Engineer (bridges) for the Texas Highway Department. During World War II he served as an officer in charge of building and port construction on Saipan, Mariana Islands for a Naval Construction Battalion.