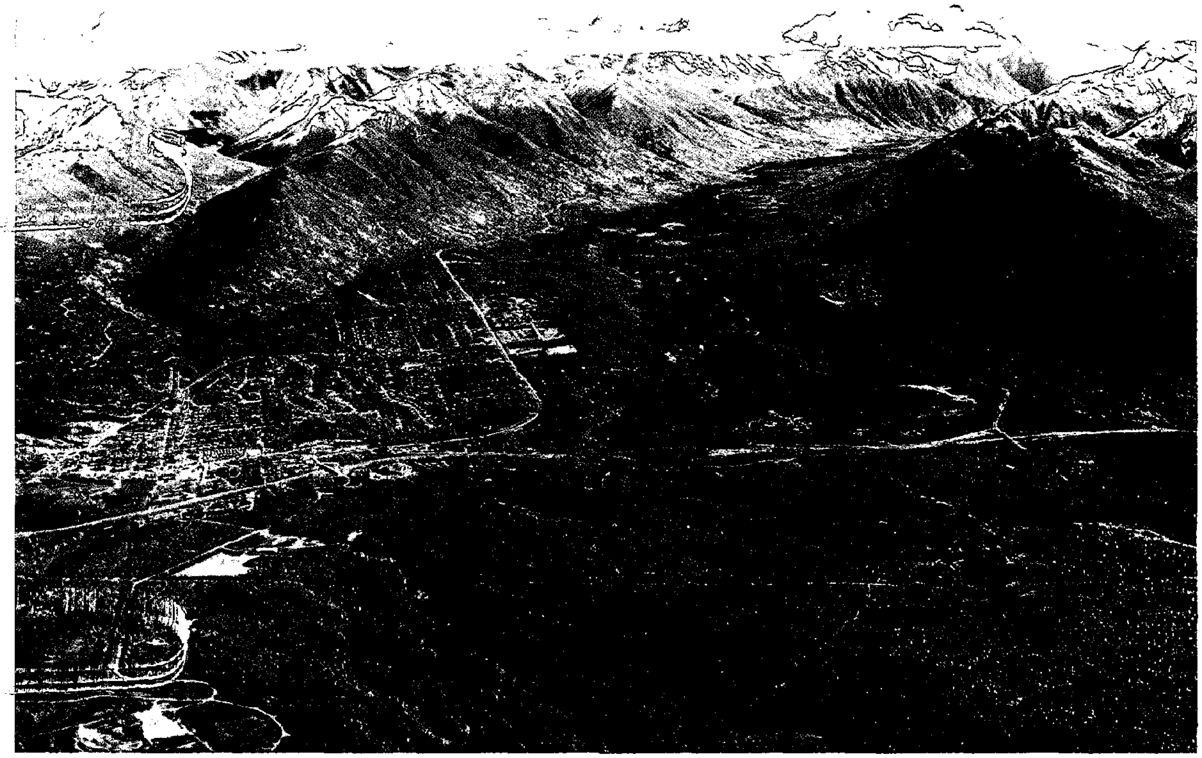
TASK 5 EKLUTNA LAKE ALTERNATIVE WATER SOURCE EVALUATION

Appendix

V

Eagle River Water Resource Study



Municipality of Anchorage
Water and Sewer Utilities

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CH2M HILL

December 1981

Alaska Department of Community and Regional Affairs

TASK 5
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SOURCE EVALUATION

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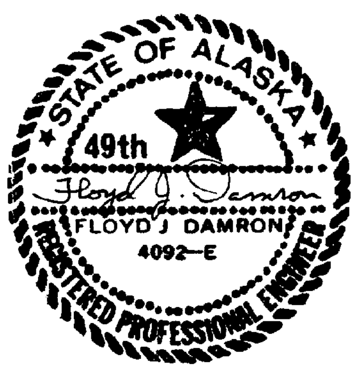

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PREFACE

To pursue the recommendations for further study that were prescribed in the Metropolitan Anchorage Urban Study, completed by the U.S. Corps of Engineers in 1979, the Municipality of Anchorage engaged CH2M HILL to conduct the Eagle River Water Resource Study. The purpose of the study is to investigate the potential sources of water supply from the Eagle River Valley. The original scope of the study comprised of four tasks:

Task 1	Well Drilling Program
Task 2	Preliminary Damsite Investigation
Task 3	Flour Water Treatment Study
Task 4	Transmission Main Design

Task 5, Eklutna Lake Alternative Water Source Evaluation, was added to the scope of this project after the completion of the first four tasks.

The report for each task is bound separately and is an appendix to the summary of the entire study. This Appendix V is the report for Task 5.

ACKNOWLEDGMENTS

We wish to express our appreciation to the following people:

- The Anchorage Water and Sewer Utilities staff for their contributions at the weekly meetings, updating of task scopes, and overall administrative assistance

- The U.S. Department of Energy, Alaska Power Administration, personnel for their valuable assistance, particularly in making available the reports and unpublished data on the Eklutna hydroelectric project, and for their cooperation during our field work

SUMMARY AND CONCLUSIONS

The purpose of the Eagle River Water Resource Study was to investigate the potential of the Eagle River Valley to provide 70 million gallons per day (mgd) of water to meet the metropolitan Anchorage area's increasing demands. Expansion of existing sources and development of new sources within the Anchorage Bowl are also needed to help meet these demands.

The results of the four tasks of the study indicated that the only possible source from the Eagle River Valley would be surface water impounded by a dam and reservoir on the Eagle River. A fifth task was added to identify one or more alternative water supply projects on or near Eklutna Lake, to screen these alternatives, to compare them with the proposed Eagle River dam and reservoir project (Appendix II, Preliminary Damsite Investigation), and to make recommendations.

Eklutna Lake is a high-altitude glacially formed lake 30 miles northeast of downtown Anchorage and 16 miles northeast of the Eagle River. The annual inflow to Eklutna Lake averages over 200 mgd and the average elevation of the lake is above 845 feet. Essentially all of this flow and head is used by the Eklutna hydroelectric project, which began operation in 1955. Prior to the development of the project, the lake waters flowed down the 10-mile-long Eklutna River to the Knik Arm of Cook Inlet.

Any water supply project drawing on Eklutna Lake must take into consideration this 30-MW project, which generates an average of 155 kWh per year. Diversion of Eklutna Lake water upstream of the turbines would reduce the hydroelectric energy output. Any municipal water supply project that diverts the water below the turbines would require large amounts of pumping energy because the tailrace water is near sea level.

The hydroelectric project has several key elements that were considered in identifying alternative water diversion points in this report: a 9-foot-diameter, 4-1/2-mile-long concrete-lined tunnel; a tailrace channel near sea level; and a dam with a 30-inch by 30-inch gate at elevation 852 feet and an uncontrolled spillway at elevation 871 feet. There is also a 1,395-foot penstock between the tunnel and the power plant. However, it was not considered in any of the supply development alternatives because tapping the penstock could seriously affect downstream hydraulics.

ALTERNATIVES

Three conceptual project alternatives were developed using various points of diversion, treatment plant locations, pump stations, and pipeline routes. All the pipeline routes that were considered would join the proposed pipeline (Appendix IV, Transmission Main Design) from the Eagle River to the existing Municipal Water Treatment Plant near Ship Creek. The Eklutna alternatives would require about 22 more miles of pipeline than would the Eagle River diversion. The Eklutna River watershed below Eklutna Lake was considered as a supplemental water source in developing these alternatives. This would reduce the project impact on the existing hydroelectric facility or reduce pumping energy requirements, depending on which alternative configuration were used. Each alternative could meet the projected demand of the Anchorage area that cannot be met by local sources. However, the sources within the Anchorage Bowl would have to be developed in order to meet intermediate or peak demands.

Alternative 1: Tailrace and River Diversion

This alternative draws water from the hydroelectric project tailrace and from the Eklutna River at a point near the Old Glenn Highway bridge. Early in the life of the project, a large percentage of the summer demand would be provided by the river flows. Later, as demands increased and during periods of low flow in the river, more water would be pumped from the tailrace. Tailrace and river water would be treated near the village of Eklutna and pumped to Anchorage through a 54- to 48-inch pipeline. Treated water would be available to communities along the line.

Alternative 2: Tunnel Diversion

In this alternative, water would be diverted from the pressurized hydroelectric tunnel at the adit near the surge tank. This would divert water upstream of the turbines. All of the ultimate 70-mgd demand would be provided from this location. The water would be treated at a high-altitude treatment plant and would flow by gravity to Anchorage through a 60- to 48-inch pipeline. Communities along the pipeline would take water through pressure-reducing valves.

Alternative 3: Eklutna Lake and River Diversion

This alternative would take water directly from Eklutna Lake and the Eklutna River. Except for the Eklutna Lake dam, none of the existing hydroelectric project facilities would be affected. Early in the life of the project, a large percentage of the increasing demand would be provided by the river flows. Much of the winter low flows in the river would be required for minimum streamflow maintenance downstream of the diversion structure near the Old Glenn Highway. To meet demands not met by the river, water would be diverted into the river by opening the 30-inch by 30-inch gate in the existing Eklutna Lake dam. When the lake level is too low, the lake water would be pumped to the gate by a low-head pump station. The lake water would flow down the river to the diversion structure near Old Glenn Highway. The lake and river water would be treated near the village of Eklutna and pumped to Anchorage through a 54- to 48-inch pipeline. Treated water would be available to communities along the pipeline. As demand approaches 70 mgd, more lake water would be diverted, which decreases the amount of water available for power generation.

COMPARISON OF EKLUTNA ALTERNATIVES WITH THE EAGLE RIVER PROJECT

Water Treatment

The water quality of Eklutna Lake is similar to that of the Eagle River, though less turbid. Bench-scale testing indicates that treatment processes, as for the Eagle River water, would consist of flocculation with alum, sedimentation, filtration, and disinfection. These processes should make Eklutna Lake water an excellent source of potable water. A year of treatment pilot plant testing, at a 1-mgd minimum, should be conducted to verify the adequacy and effectiveness of the selected treatment systems.

Energy Impacts

The energy impacts of the Eklutna alternatives and of the Eagle River dam and reservoir project are shown in the following table.

ANNUAL ENERGY AND CAPACITY IMPACTS[a]

	Eklutna Alternative 1	Eklutna Alternative 2	Eklutna Alternative 3	Eagle River
Total Energy Impact (MWh)				
14 mgd	11,869	12,150	15,671	6,850
45 mgd	49,496	43,900	68,945	23,400
70 mgd	88,003	67,737	121,680	38,808
Total Capacity Impact (kW)				
14 mgd	1,500	150	1,490	1,150
45 mgd	6,500	500	5,720	3,500
70 mgd	12,025	775	10,005	6,175
Annual Cost of Impacts (x $1,000)				
14 mgd	1,136	1,056	1,464	676
45 mgd	4,754	3,838	6,383	2,278
70 mgd	8,486	5,922	11,257	3,221

[a]Without additional sources developed in the Anchorage Bowl, 14 mgd is needed by 1985, 45 mgd is needed by 2000, and 70 mgd is needed by the year 2012. (Metropolitan Anchorage Urban Study, Volume 2, Water Supply. U.S. Army Corps of Engineers. 1979.) Development of Anchorage Bowl water sources will delay the need for these volumes of water from a source outside of the Anchorage Bowl.

These impacts include the replacement energy for lost hydroelectric generation, energy for pumping and treatment, and capacity to provide the needed energy. The tunnel diversion, Alternative 2, requires much less energy than the other alternatives, but uses much more than the Eagle River project. The cost of pumping and replacement energy is assumed to be 8.66¢ per kWh, the expected cost (1981 dollars) of new thermal generation.

Costs

The capital costs for the four projects (1981 dollars) are:

Alternative 1 (Tailrace and River): $149 million
Alternative 2 (Tunnel Tap): $151 million
Alternative 3 (Lake and River): $131 million
Eagle River Dam and Reservoir: $122 million

The Eagle River project costs are not complete nor directly comparable to the costs of the Eklutna alternatives. Substantial capital cost items that have not yet been determined for the Eagle River project are reservoir land acquisition, old Eagle River dump water quality impact mitigation, fish facilities and habitat impact mitigation, and other special environmental considerations. These costs could range over many millions of dollars. In addition, certain features of the Eagle River project were analyzed in more detail than the Eklutna alternatives. Therefore, confidence limits for the Eklutna project cost estimates are broader than for the Eagle River project.

The following table compares annual project costs for the least costly Eklutna alternative (Alternative 2) with those for the Eagle River project. It can be seen that total annual costs are quite comparable.

TOTAL ANNUAL COST FOR CAPITAL,
OPERATION AND MAINTENANCE (1981 DOLLARS)

Project	1985 (13.5 mgd)	2012 (70 mgd)
Eklutna Alternative 2		
Minus 20% Confidence Limit	$11 million	$16 million
Plus 20% Confidence Limit	17 million	25 million
Eagle River Dam and Reservoir		
Minus Undetermined Items	11 million	16 million
Plus $30 Million Capital Cost for Undetermined Items	14 million	18 million

Environmental

The principal environmental concerns for the Eklutna alternatives are:

- The management of the pipeline right-of-way
- Loss of wildlife habitat
- Fishery impacts (in the lower Eklutna River)
- Water quality effects of human activity
- Recreational use of watershed
- Operation of a thermal power plant for replacement or pumping energy production

The environmental concerns relating to natural resources are less for the three Eklutna alternatives than for a dam and reservoir at Eagle River. Potential fisheries impacts are less, and potential impacts on wildlife are much less. While there might be slightly greater fisheries impacts from Eklutna Alternatives 1 and 3 than from Alternative 2, they are not expected to be large.

The impacts on water quality and the potential effects of water quality on human health are much less with the Eklutna options than with Eagle River, particularly in regard to sediment and sludge disposal. The old Eagle River dump also poses potential water quality problems for the Eagle River dam project.

Visual impacts are not a problem at Eklutna compared with the impacts of the proposed reservoir on the Eagle River. Projects in either watershed would encourage development in the Eagle River-Eklutna area because they would provide water to this area. The Eklutna alternatives would require less right-of-way and land acquisition than the Eagle River project. Eklutna Alternative 3 requires a shorter pipeline than Alternatives 1 and 2.

CONCLUSIONS AND RECOMMENDATIONS

The costs for both the Eagle River project and the Eklutna alternatives would probably be comparable with the addition of the undetermined capital costs to the Eagle River project costs, but the development of a water supply project at Eklutna would have considerably less environmental impact. Potential delays of the Eagle River project for land acquisition, environmental studies, and old Eagle River dump mitigation lead to the conclusion that construction of the Eklutna project can begin sooner. Additionally, inflation effects of such delays could severely raise final construction costs of the Eagle River project.

All three Eklutna alternatives appear feasible, and none incurs cost, scheduling, construction, and environmental problems of the magnitude that the Eagle River dam and reservoir project must address. Alternative 1, tailrace and river diversion, would incur energy costs for pumping; however, it does not significantly impact the operation of the Eklutna hydroelectric project, whose energy losses would have to be reconciled. Further, it could be implemented sooner than the other alternatives. It is recommended, therefore, that Eklutna Alternative 1 be pursued as part of the solution to the Municipality of Anchorage's projected water needs through the year 2025.

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Chapter 1
INTRODUCTION

BACKGROUND

The population and, thus, the water supply needs of the metropolitan Anchorage area are rapidly growing. Presently, water to Anchorage is principally supplied by surface water from Ship Creek and by groundwater wells in the Anchorage Bowl. However, if present growth trends continue, these sources will not meet future needs.

In 1974 the United States Congress authorized the U.S. Army Corps of Engineers to perform the Metropolitan Anchorage Urban Study (MAUS), which was completed in 1979. The purpose of MAUS was "to evaluate the adequacy of the developed water supply in the metropolitan Anchorage area, to determine future water demands, to assess sources for water supply development, and to formulate water supply plans to meet the increased future demand" (U.S. Army Corps of Engineers, 1979). The MAUS study area comprised the Anchorage Bowl and the area northeast to the town of Eklutna (Figure 1-1).

The projected future water demand increases, determined in the MAUS, are shown in Figure 1-2. It is expected that by the year 2025 an additional 81.5 million gallons per day (mgd) of water will be needed to meet the increased demands in the area.

The MAUS report identified many potential sources of supply: Eagle River Valley groundwater; Anchorage Bowl groundwater; and surface water from Campbell Creek, Ship Creek, Eagle River, and Eklutna Lake. Two plans were recommended by MAUS for future study. Plan IV, which ranked first environmentally and socially, included a combination of supply from Ship Creek, Anchorage Bowl groundwater, and Eklutna Lake. Plan VI, which ranked first on an economic basis, included an increased supply from Ship Creek, winter diversion from Eagle River, further development of Anchorage Bowl groundwater, and exploration for Eagle River Valley groundwater.

To increase the existing water supply sources within the Anchorage Bowl, the Municipality recently constructed a 36-inch supply main to its water treatment plant from the military diversion facility on Ship Creek. Other developments are expected to include new wells to increase groundwater supply and expansion of the Municipal Water Treatment Plant facilities. However, rapidly growing demands in Anchorage require development of a new source outside the Anchorage Bowl within the next 10 years. Demands in the Eagle River-Chugiak-Eklutna area, northeast of Anchorage, require development of a new source now.

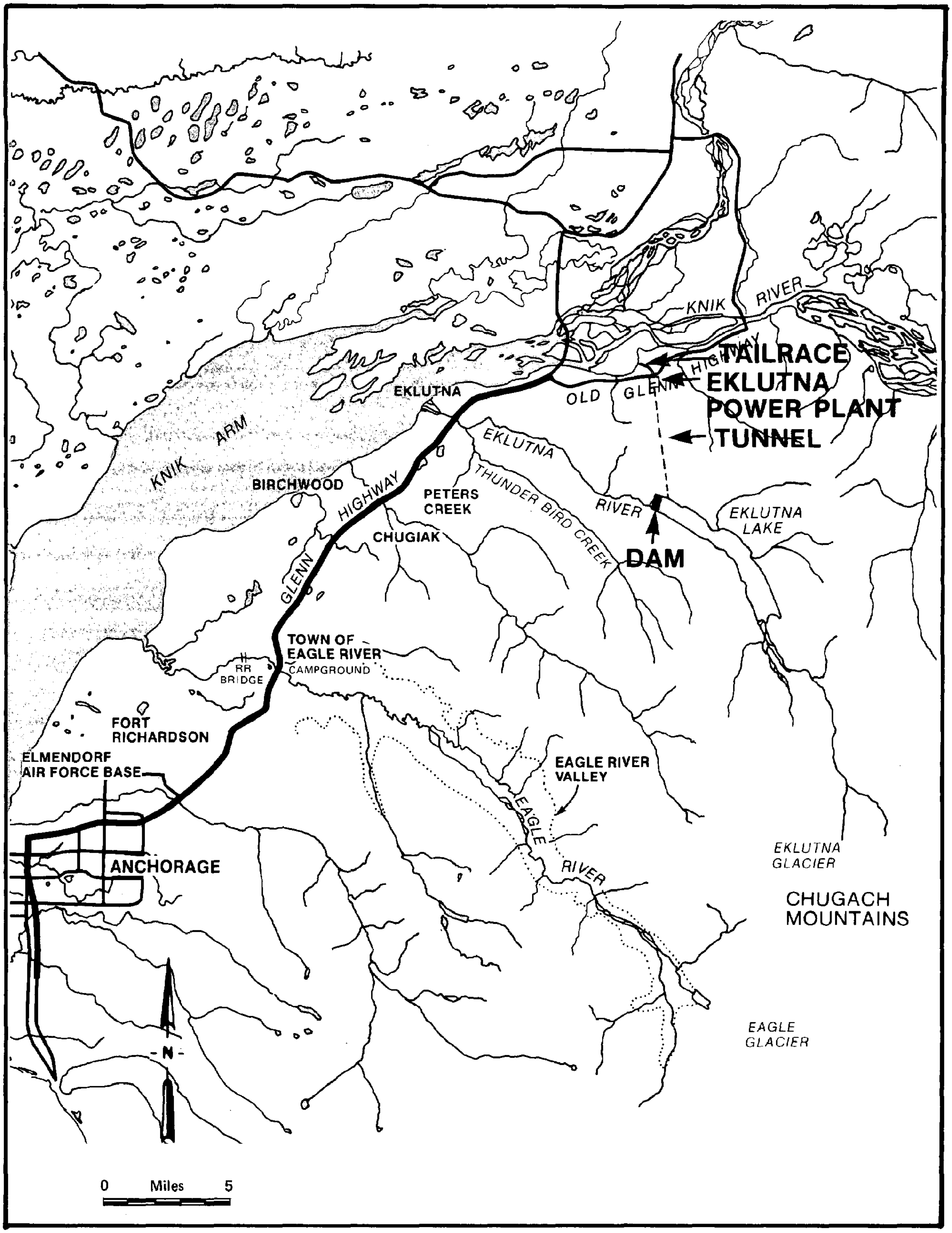
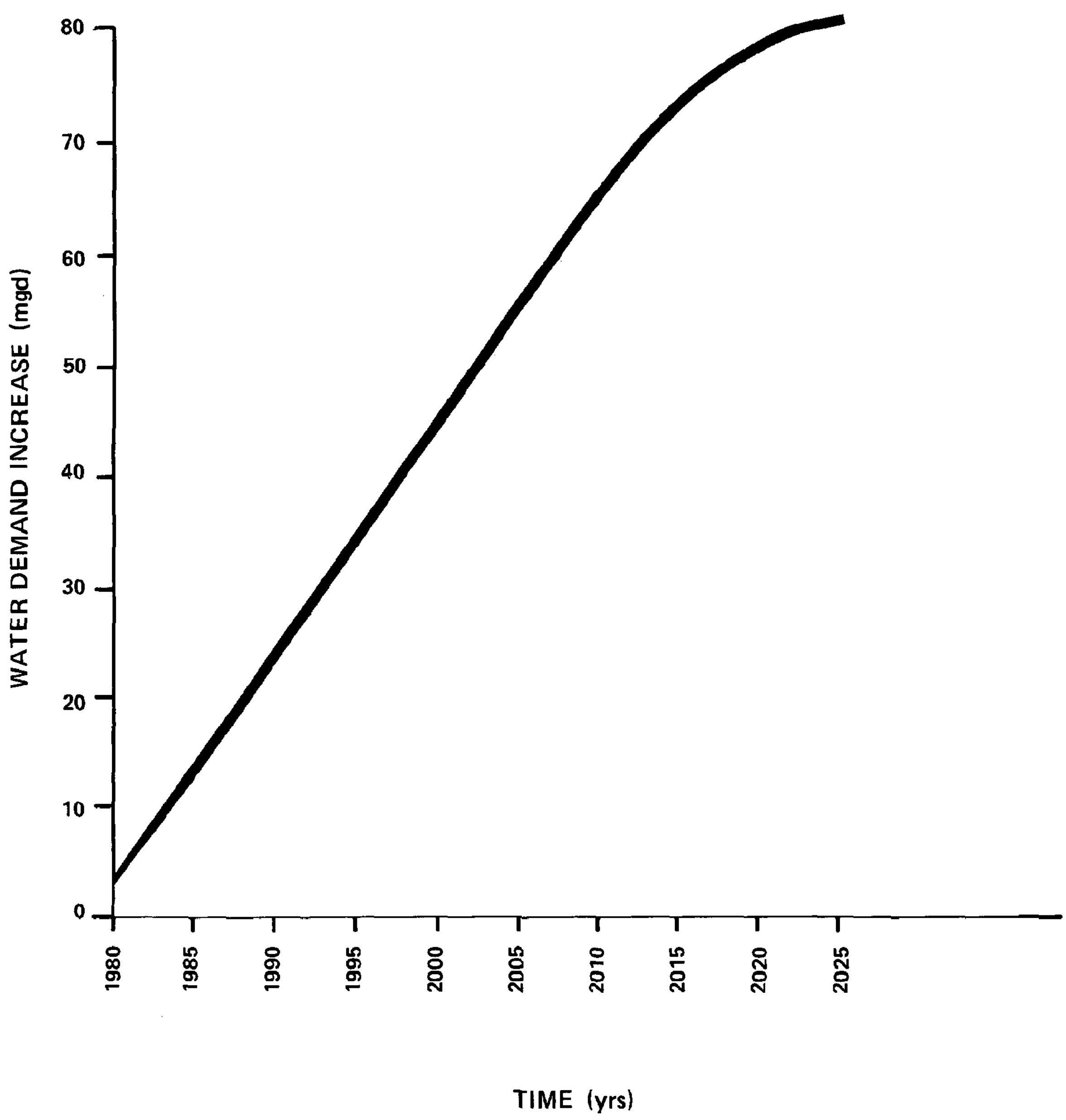


Figure 1-1
Vicinity Map



NOTE: Increase Based on 1977 Total Demand.

SOURCE: U.S. Corps of Engineers. 1979.

Figure 1-2
Projected Water Demand Increase 1980-2025

As a result of the MAUS findings, the Municipality decided to investigate potential sources outside the Anchorage Bowl that could supply 70 mgd of water. Based on the MAUS population projection, this diversion would satisfy the demands of the entire study area through the year 2012. The increases in water supply capacity that are expected to be developed within the Anchorage Bowl will delay the need for the full 70-mgd capacity of the new water source outside the Bowl until approximately the year 2020 or longer.

To investigate possible sources of water supply outside the Anchorage Bowl, the Municipality engaged CH2M HILL to conduct the Eagle River Water Resource Study. This original scope of the study comprised four separate tasks to investigate the Eagle River Valley (Figure 1-1) as a potential source of municipal and industrial water supply:

- Task 1, a well drilling program to study the feasibility of developing the Eagle River Valley as a groundwater source
- Task 2, a preliminary damsite investigation to determine the feasibility of developing the Eagle River as a surface water source
- Task 3 was a study to determine if glacial rock flour in the Eagle River water could be easily removed
- Task 4, a preliminary design of a pipeline to transport groundwater or surface water from the Eagle River Valley to Anchorage

Each task was conducted independently.

The results of the first four tasks clearly indicate that a substantial dam and reservoir are required to develop the Eagle River as a water source. Before committing itself to this dam and reservoir project, the Municipality of Anchorage increased the study scope to include Task 5. The purpose of Task 5 is to analyze the capability of Eklutna Lake (Figure 1-1) to supply the 70 mgd of water to the area.

The report of each task appears as an appendix to the Executive Summary of the entire study. This Appendix V is the report for Task 5, Eklutna Lake Alternative Water Source Evaluation.

PURPOSE AND SCOPE

The purpose of Task 5 is to identify one or more alternative water supply projects on or near Eklutna Lake, to screen these alternatives, to compare them with the proposed Eagle River dam and reservoir project (Appendix II, Preliminary Damsite Investigation), and to make recommendations. Each alternative should be able to provide a safe water supply to meet the projected future needs of the Anchorage area. This study is to consider the proposed Eagle River dam and reservoir as the only other feasible source to meet the future demands. Impacts of the project on the existing hydroelectric facility, such as reduced energy production and operational changes, also must be considered.

This appendix contains discussions of the following:

- o Eklutna watershed
- o Existing hydroelectric project
- o Supply alternatives
- o Analysis of Eklutna Lake water as a potential potable water source
- o Cost, power, and energy considerations of the proposed alternatives and a comparison with the proposed Eagle River dam project
- o Environmental concerns for each alternative as compared to the proposed Eagle River dam project
- o Conclusions and recommendations

Three alternatives were identified and analyzed. The conceptual layout of each alternative, the costs and associated impacts of each alternative, and recommendations for required future studies are presented to aid the Municipality of Anchorage in its comparison of Eklutna Lake with the Eagle River as major water supply sources.

Each alternative was developed to provide a 70-mgd water supply to serve the MAUS study area: Anchorage, Eagle River, Chugiak, Eklutna, Peters Creek, and Birchwood.

However, prior to design of any Eklutna or Eagle River water supply facility, the MAUS demand projections should be updated. Current Municipality projections indicate that there are immediate needs to expand existing Anchorage Bowl sources. Each alternative has elements that could be constructed in stages to accommodate changing demands.

The capital, operation, and maintenance costs were evaluated for each alternative. Particular emphasis was placed on the analysis of energy requirements and of impacts on the existing Eklutna hydroelectric facility. Energy requirements for any of the alternatives and replacement energy for lost hydroelectric energy are assumed to come from a new source of energy at a cost substantially higher than Eklutna energy costs.

SITE DESCRIPTION

Eklutna Lake is a high-altitude glacially formed lake. Eklutna Glacier now terminates several miles upstream of the lake. The lake is 30 miles northeast of downtown Anchorage and 16 miles northeast of Eagle River (Figure 1-1). It varies in elevation about 50 feet annually, with an average elevation of 845 feet above mean sea level. The waters of Eklutna Lake are turbid with glacial rock flour and have historically flowed down the 10-mile-long Eklutna River to the Knik Arm of Cook Inlet. In 1955 diversion of the lake water began for a hydroelectric project. This diversion substantially reduces the Eklutna River flows.

The 30-MW Eklutna hydroelectric project diverts an average of about 300 cubic feet per second (cfs) of water through a tunnel under Goat Mountain to a powerhouse at the upper end of Knik Arm. The major project features are an earth and rockfill dam with an uncontrolled spillway crest at an elevation of 871 feet, a 640-square-foot screened intake, a 23,550-foot-long tunnel, a 1,395-foot-long penstock, and a powerhouse containing two Francis-type turbines, 15 MW each. The turbines extract about 800 feet of head from the lake water and normally control the lake. The average annual energy production is 155 million kWh, and total generation through August 1981 is over 4 billion kWh. The only major project shutdown occurred after the 1964 earthquake.

LIMITATIONS

This report has been prepared for the use of the Anchorage Water and Sewer Utilities for specific application to the Eagle River Water Resource Study, Eklutna Lake Alternative Water Source Evaluation, in accordance with generally accepted engineering practice. No other warranty, expressed or implied, is made. In the event of any changes to the conditions considered under this study, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and the conclusions or recommendations are modified or verified in writing by CH2M HILL.

The majority of the data used for this study was supplied by various Federal and state agencies. Alaska Power Administration (APA) operation records and construction drawings of the Eklutna hydroelectric facilities were used for most of the alternatives analysis. Except for water quality and treatability tests, no new field data were collected during this study.

The conceptual alternatives presented in this report are believed to be workable, but the concepts are not refined enough for incorporation into a final design. Additional investigations will be required prior to final design of any of the alternatives.

Chapter 2
EKLUTNA WATERSHED

To evaluate Eklutna Lake as a water supply source for the Anchorage area, three drainage basins within the Eklutna watershed were studied (Figure 2-1): (1) Eklutna Lake, (2) Upper Eklutna River below Eklutna Lake and above the old Anchorage Light and Power diversion dam (the location of the old dam is shown on Figure 5-1), and (3) Lower Eklutna River below the upper river basin, near the Old Glenn Highway bridge. The physical and hydrologic characteristics of each basin and of the entire Eklutna watershed are summarized in this chapter.

DESCRIPTION

The Eklutna watershed lies northeast of Anchorage and is about 26 miles away at its nearest point. The basin extends from Eklutna Glacier, high in the Chugach Mountains, to the Knik Arm of Cook Inlet, approximately 27 miles northwest of the glacier. The three basins within the study area drain to a single point on the river approximately 1/2 mile upstream of the Old Glenn Highway. The total area of the watershed is about 168 square miles. Eklutna Lake and its drainage area comprise close to 119 square miles, 71 percent of the total area. The Upper Eklutna River basin drains almost 19 square miles, and the Lower Eklutna River basin drains about 30 square miles.

The topography of the area is very rugged, with elevations ranging from near sea level to over 8,000 feet, with many peaks over 7,000 feet. The upper end of the watershed contains several glaciers, including Eklutna Glacier. These glaciers constitute over 6 square miles of the study area. Eklutna Glacier, the largest, is a typical alpine glacier, almost 7 miles long. Downstream of Eklutna Glacier, the watershed consists of a steep-sided, trough-like glaciated valley, with widths varying from 2 miles at elevation 4,800 feet to about 400 feet at elevation 1,000 feet. Eklutna Lake covers most of this valley.

At the upper end of Eklutna Lake, a stream from Eklutna Glacier forms a large delta. Several other streams draining the Chugach Mountains also empty into Eklutna Lake. Near the lower end of the lake, an intake structure and tunnel divert water from Eklutna Lake through Goat Mountain to the Eklutna hydroelectric power plant. The Eklutna hydroelectric facility regulates the lake surface elevation, which varies from about 825 to 870 feet on an annual basis. Lake depth averages about 200 feet. At the extreme lower end of the lake, glacial drift forms a natural barrier to most of the lake outflow. An outlet stream passes through this drift and into the Eklutna River. The Eklutna hydroelectric project dam blocks this stream and regulates the elevation of the lake.

Below the dam, the Eklutna River flows through a deep gorge cut through glacial drift and, in places, bedrock. The depth of this gorge varies between 50 feet and 500 feet before the river converges with Thunderbird Creek. Approximately 1 mile upstream of the convergence with Thunderbird Creek, the flow of Eklutna River is partially blocked by an old diversion dam, built around 1930. This dam was used to divert water for power generation by Anchorage Light and Power (AL&P), but now the area behind the dam is full of sediment, and water flows over the dam. Downstream of the confluence, the slope of the Eklutna River lessens and the river leaves the gorge area. As the river passes beneath the Old Glenn Highway, its floodplain begins to widen until, at its mouth, a large delta is formed.

Thunderbird Creek's headwaters originate high in the Chugach Mountains. It, too, flows through a deep gorge on its way to confluence with the Eklutna River. Just above the confluence point, the creek passes over a waterfall.

CLIMATE

The climate of the Eklutna area is very similar to that of the Eagle River. Both temperature and precipitation are moderate because of the climatic barrier formed by the Chugach Mountains. Approximately 6 years of climatic information, beginning in 1941, was recorded at the old diversion dam on the Eklutna River. Precipitation and temperature were recorded at Eklutna Lake between 1947 and 1976. Currently, the nearest weather station to the Eklutna area is at the Eklutna hydroelectric facility, where climatic information has been gathered since 1952.

The annual temperature in the lower reaches of the Eklutna watershed averages about 33 degrees F, with the daily high temperatures averaging around 54 degrees F. Temperatures in the upper parts of the basin are considerably lower, as evidenced by the glaciers and the length of time snow is present in the basin.

Precipitation in the Eklutna area is estimated to be slightly higher than in Anchorage. The average annual precipitation at the Eklutna hydroelectric facility, based on 15 years of record, is just over 19 inches per year. In the upper part of the watershed, precipitation is much higher because of the proximity of the Prince William Sound area.

HYDROLOGY

Hydrologic data for the Eklutna Lake watershed have been gathered by various agencies. AL&P made estimates of runoff at the old diversion dam between 1929 and 1949. Fragmentary records of the storage change at Eklutna Lake were kept between 1942 and 1949. The USGS measured discharge at the outlet of Eklutna Lake between 1946 and 1962. It also gaged Eklutna Lake heights

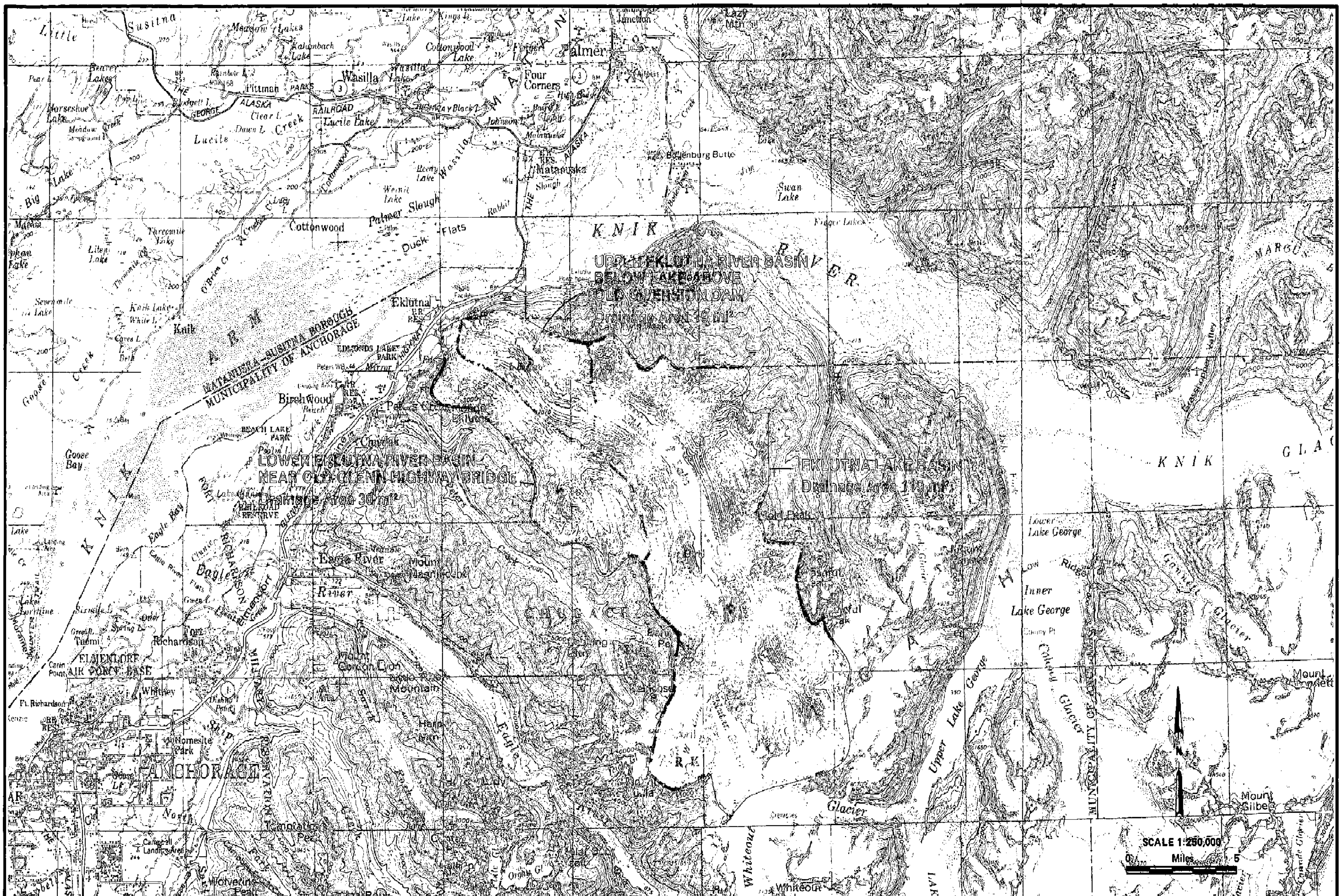


Figure 2-1
Eklutna Drainage Areas

during part of this period. The most complete hydrologic records are kept by the various Federal agencies in charge of the Eklutna Lake hydroelectric project. These extend from 1947 through the present. The records are of estimates of the inflow to Eklutna Lake, outflow of Eklutna Lake through the power plant, lake elevation records, and estimates of spill over the dam.

Eklutna Lake Basin

The hydroelectric project's estimation of inflow to Eklutna Lake (Table 2-1) is based on project records of changes in the lake level, the flow through the power plant, spill over the dam, and any flow through the dam.

Table 2-2 shows the outflow of Eklutna Lake by month between 1966 and 1980. The spill over the dam at the outlet of the lake is estimated by a weir equation based on the lake elevation. Leakage through the dam is based on visual inspection when the lake elevation measurements are made. When there is no spill from the lake or leakage through the dam, the water passing through the power plant constitutes the total outflow of Eklutna Lake. Flow passing through the power plant is recorded daily. The water used by each turbine is determined from turbine performance curves.

Lake levels are normally measured on a weekly basis unless the lake is higher than the spillway, at which time daily measurements are made. Table 2-3 is a tabulation of the average monthly lake levels measured by staff at the hydroelectric facility.

Upper Eklutna River Basin

A relationship between Eklutna Lake outflow and the Upper Eklutna River basin inflow was derived by the Anchorage Public Utilities for water years 1940 through 1949. It was estimated that approximately 11 percent of the flow at the AL&P dam entered the Eklutna River from the Upper Eklutna River drainage area. Table 2-4 shows 10 years of estimated inflows to the area between Eklutna Lake and the AL&P dam. These flow values are derived from discharge records of Eklutna Lake and also of the old diversion dam for water years 1947, 1948, and 1949. Storage records of Eklutna Lake also were kept for these years. From the lake storage and the discharge measurements, the natural inflow between the lake and the diversion dam was computed. The inflows for water years 1940 through 1946 were calculated on the basis of the average monthly percentage of runoff derived from the 1947 through 1949 records.

Table 2-1
INFLOW TO EKLUTNA LAKE

Water Year	Inflow (ac-ft x10^3) Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1947	4.8	4.2	1.6	1.1	0.6	1.4	1.3	5.5	28.9	75.6	55.8	32.5	213.3
1948	14.3	7.3	4.5	3.2	0.8	0.8	0.9	7.3	33.3	59.0	56.7	17.2	205.3
1949	8.0	3.8	6.2	2.0	0.8	0.5	0.7	8.7	31.1	60.5	61.3	41.7	225.3
1950	9.1	6.0	3.6	2.3	0.9	1.1	0.7	3.2	36.4	62.5	70.0	18.8	214.6
1951	5.9	1.5	2.1	1.2	0.4	0.4	1.2	5.4	31.5	85.8	69.2	60.5	265.1
1952	9.1	4.9	2.6	2.4	0.4	0.7	0.3	2.5	23.4	62.4	49.4	20.0	178.1
1953	21.4	9.9	5.3	2.1	1.3	1.0	1.4	12.1	63.1	103.3	78.2	29.7	328.8
1954	13.5	4.8	3.1	1.1	0.2	0.6	0.6	9.5	36.2	63.4	73.4	33.4	239.8
1955	11.7	7.2	5.9	2.2	2.0	2.8	2.6	5.2	22.2	69.5	54.8	23.8	209.9
1956	7.8	3.1	3.2	3.2	2.0	1.5	3.6	8.6	24.5	75.9	63.1	34.2	230.7
1957	7.4	6.3	5.2	1.0	3.2	2.6	2.5	11.5	59.2	79.5	73.1	50.4	301.9
1958	11.9	7.1	4.7	4.1	2.2	1.3	3.0	12.9	52.2	68.8	57.7	13.1	239.0
1959	6.7	5.7	2.7	1.2	1.6	1.1	2.1	12.4	59.0	62.5	60.8	17.6	233.4
1960	9.5	6.0	5.1	1.8	3.2	3.1	-1.7	20.3	46.0	68.3	55.8	27.1	244.5
1961	11.6	5.5	6.3	7.5	3.8	2.0	1.1	12.8	39.7	64.9	62.4	34.9	252.5
1962	12.4	5.6	2.9	2.4	1.8	1.8	3.5	7.6	43.6	69.3	61.9	21.3	234.1
1963	6.9	5.1	3.2	2.9	2.1	1.8	2.6	11.7	25.5	73.5	72.0	30.6	237.9
1964	8.2	3.5	4.3	1.2	1.9	-1.0	4.3	9.0	52.0	61.8	48.1	21.9	215.2
1965	6.9	5.3	0.8	0.3	-3.9	3.8	4.5	5.3	18.5	49.2	53.8	46.1	190.6
1966	11.9	3.7	5.0	1.8	1.8	1.9	2.7	5.9	42.1	68.1	63.2	36.1	244.2
1967	16.0	6.0	3.6	3.3	0.1	3.6	-1.0	9.7	43.7	67.1	76.3	51.9	280.3
1968	46.7	6.6	4.0	7.0	0.9	2.5	1.6	13.4	37.2	67.7	65.2	19.0	271.8
1969	6.5	5.6	2.9	0.6	0.1	1.2	3.2	13.2	46.2	63.9	31.2	16.7	191.3
1970	21.9	6.5	4.6	3.0	1.3	2.8	3.8	7.5	29.9	48.5	45.1	22.0	196.9
1971	5.5	10.1	1.6	2.6	0.7	2.0	1.9	3.4	25.6	70.3	81.0	20.6	225.3
1972	8.9	5.4	1.1	0.6	0.1	2.3	1.9	6.0	21.4	70.1	63.7	34.7	216.2
1973	4.7	5.2	0.1	2.6	1.7	7.4	5.5	3.7	20.6	54.4	44.4	14.8	165.1
1974	5.9	2.9	2.4	1.9	-1.2	5.5	.1	1.8	27.5	50.0	57.4	43.6	197.8
1975	3.2	7.2	4.0	-5.3	1.1	3.1	2.8	13.4	21.3	68.9	53.7	25.8	199.2
1976	8.9	-1.1	4.6	1.1	1.4	5.5	-5.4	10.6	26.2	70.8	49.8	37.2	209.6
1977	12.0	8.6	13.3	0.2	2.3	7.1	8.6	-1.6	50.7	84.6	84.9	37.1	307.8
1978	15.1	7.6	-0.7	6.7	2.2	0.8	1.9	13.9	24.1	59.5	59.7	34.1	224.9
1979	10.9	5.5	5.5	0.9	3.2	7.7	4.1	9.9	29.8	79.5	72.2	37.6	266.8
1980	17.8	7.8	5.8	5.4	3.8	0.3	10.0	14.2	27.9	87.9	61.8	9.9	252.6
1981	7.8	8.2	7.5	19.1	4.7	13.3	-0.8	8.4	57.9	66.6	84.4	9.0	286.1
Monthly Average	11.2	5.7	4.0	2.7	1.4	2.7	2.2	8.7	36.0	68.4	62.0	29.3	234.3

Notes: 1. One acre-foot per month = .0109 mgd = .0168 cfs = 7.54 gpm (30-day month).
2. Negative values represent revisions.

Data Source: Operations records of the Eklutna Hydroelectric Project.

Table 2-2
OUTFLOW OF EKLUTNA LAKE

Water	Outflow[a] (acre-feet)												
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Avg.
1966	13,947	15,650	12,980	14,769	12,807	13,889	13,175	19,426	16,151	16,607	18,217	18,065	15,474
1967	15,494	20,529	18,599	20,328	18,098	23,643	21,570	21,235	18,679	23,725	23,694	20,732[b]	20,527
1968	24,317[b]	13,026	23,972	23,340	21,579	19,544	18,111	19,453	16,674	16,680	20,007	10,046[b]	18,896
1969	22,518[b]	22,618	17,935	19,599	19,131	21,192	16,233	17,241	21,186	22,867	22,179	20,108	20,234
1970	17,946	19,046	20,462	21,016	16,089	18,263	14,898	16,466	21,955	22,416	18,174	14,039	18,398
1971	14,737	19,820	23,355	18,202	12,742	8,978	6,866	13,437	19,624	19,760	19,013	17,629	16,180
1972	23,916	21,480	28,182	28,296	25,073	22,251	8,308	8,022	14,978	19,093	17,380	19,147	19,677
1973	23,040	24,393	22,596	21,571	14,917	15,133	14,017	13,313	11,576	6,860	8,709	10,194	15,527
1974	9,667	15,894	13,134	14,172	13,766	12,531	11,636	16,587	19,199	14,416	16,355	13,092	14,202
1975	14,871	21,394	18,963	22,139	17,469	14,764	12,112	9,683	12,254	18,045	14,915	16,026	16,053
1976	17,990	21,867	21,843	18,876	17,570	14,394	15,293	17,239	12,297	13,300	13,048	13,386	16,425
1977	13,976	12,241	16,824	17,927	17,090	20,771	17,165	27,409	23,040	26,761	30,625[b]	30,231[b]	21,172
1978	27,393[b]	20,897	21,695	25,079	21,057	21,194	22,727	16,512	23,794	25,649	25,849	23,319	22,930
1979	17,268	16,547	15,459	13,280	10,541	21,638	23,268	24,176	19,476	21,873	19,686	18,744	18,496
1980	25,459	21,723	23,581	21,182	16,236	21,159	17,328	31,842	25,884	22,499	32,072	23,602	23,547

[a]Based on actual water used at the power plant.

[b]Lake spilled during these months.

Data Source: Operations records of the Eklutna Hydroelectric Project.

Table 2-3
EKLUTNA LAKE WATER SURFACE LEVELS

Water Year	Elevation (feet) Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Avg.
1955	--	--	--	864.4	860.8	857.8	855.0	852.6	852.5	863.3	869.5	869.5	--
1956	867.8	865.4	861.5	856.3	852.3	848.1	843.9	841.3	842.3	854.5	868.3	868.8	855.9
1957	867.0	863.4	859.1	854.4	849.7	844.4	839.6	836.3	845.8	861.3	869.5	869.4	855.0
1958	868.1	866.7	862.8	857.6	853.6	849.3	844.0	839.3	843.6	856.0	867.2	868.1	856.4
1959	865.0	860.0	855.0	849.8	843.9	838.2	832.8	828.7	833.1	848.8	860.0	867.4	848.6
1960	865.3	861.7	857.0	851.6	846.2	840.3	833.6	828.0	832.1	844.3	858.3	864.0	848.5
1961	863.5	859.3	853.9	848.1	842.9	836.3	828.0	821.0	821.2	831.3	847.0	856.5	842.4
1962	858.4	853.1	846.3	839.3	833.1	825.9	819.5	815.5	815.7	833.3	849.3	858.0	837.3
1963	856.5	853.0	848.6	844.6	839.9	835.4	831.4	828.8	830.1	841.8	856.4	865.8	844.4
1964	864.0	859.3	855.0	851.7	846.5	839.9	835.0	833.0	842.6	857.0	861.4	859.6	850.4
1965	855.5	848.8	842.1	832.6	823.1	*	*	*	814.0	820.5	830.8	840.4	--
1966	847.2	844.2	840.7	837.3	833.3	829.3	825.3	821.5	822.3	835.9	853.6	862.3	837.7
1967	865.2	862.8	858.0	852.9	847.5	841.4	834.0	828.3	829.6	842.3	857.4	869.0	849.0
1968	870.5	867.8	863.8	857.3	850.9	844.6	839.5	834.7	837.0	850.0	864.3	870.5	854.2
1969	869.3	863.9	858.4	853.0	847.4	841.7	835.3	832.9	834.8	848.0	856.3	856.5	849.8
1970	856.9	855.3	850.3	845.3	839.8	835.5	830.8	826.5	826.3	832.0	842.0	847.5	840.7
1971	847.4	873.1	838.5	832.6	827.7	824.0	822.1	819.9	817.1	826.1	847.3	858.4	836.2
1972	856.4	851.8	844.3	835.5	827.0	818.0	812.8	811.2	811.1	820.8	838.2	849.8	831.4
1973	849.4	843.0	836.4	829.5	823.6	819.5	816.4	812.4	811.0	821.7	836.9	844.2	828.7
1974	844.0	842.0	837.7	833.9	829.3	825.4	822.2	820.1	820.9	826.6	840.4	852.9	833.0
1975	857.9	854.6	849.8	844.2	837.0	832.1	827.7	825.6	826.8	837.2	852.8	860.3	842.2
1976	860.9	856.6	850.6	844.7	838.9	832.8	829.3	824.2	822.6	833.6	851.3	857.9	842.0
1977	864.9	863.8	862.9	860.3	854.3	849.8	844.6	838.3	834.3	848.4	869.0	872.4	855.3
1978	869.7	866.0	861.2	855.3	848.4	842.6	836.1	831.0	830.0	835.0	848.5	855.4	848.3
1979	856.2	854.1	850.3	846.6	843.6	839.6	832.2	825.7	823.3	832.9	853.8	864.6	843.6
1980	867.5	864.2	860.3	854.5	850.1	845.5	840.0	833.7	829.7	839.2	858.3	862.7	850.5
1981	865.3	865.3	862.3	860.4	855.5	848.5	839.0	833.7	839.6	853.9	867.4	872.1	855.3
Average 66-80	859.0	857.6	850.9	845.5	839.9	834.8	829.9	825.7	825.1	835.3	851.3	859.0	842.8

*Records incomplete.

Data Source: Operations records of the Eklutna Hydroelectric Project.

Table 2-4
ANCHORAGE LIGHT AND POWER DAM INFLOW LESS EKLUTNA LAKE OUTFLOW

Water Year	Inflow Less Eklutna Lake Outflow (ac-ft x 10^3) Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1940	10.8	0.6	0.4	1.5	1.5	1.3	0.9	2.0	4.0	3.7	7.3	7.1	41.1
1941	9.7	0.3	0.4	1.5	1.7	0.9	0.6	1.0	6.0	3.4	5.8	2.9	34.2
1942	3.2	0.2	0.6	2.3	1.9	1.0	0.6	6.2	4.4	2.4	2.6	4.3	29.7
1943	7.5	0.2	0.3	1.3	1.0	0.4	0.4	1.3	2.3	1.2	4.5	1.9	22.3
1944	3.5	0.5	0.5	1.7	0.8	0.4	0.5	3.0	6.4	4.2	8.8	3.3	33.6
1945	4.3	0.2	0.3	0.9	0.8	0.3	0.4	2.5	4.7	3.8	6.1	2.3	26.6
1946	5.0	0.1	0.1	0.8	1.0	0.5	0.4	2.7	5.2	4.1	4.3	2.9	27.1
1947	3.0	-1.3	0.2	0.2	0.0	-1.0	0.9	0.6	4.3	1.0	4.2	6.4	16.3
1948	9.0	1.2	1.7	2.0	5.0	3.3	2.2	4.9	5.0	4.9	5.6	0.7	45.5
1949	1.4	0.8	0	4.2	.5	0	0.3	1.2	2.0	3.8	-1.1	2.8	15.9
Average	5.7	0.3	0.4	1.6	1.4	0.7	0.5	2.5	4.4	3.3	4.8	3.2	29.2
Percent Average	238	12	17	68	59	29	22	105	184	135	200	131	100

Data Source: U.S. Bureau of Reclamation, 1950.
Note: Negative values represent revisions.

At present, very little water from Eklutna Lake flows to the Eklutna River above the old diversion dam. For this analysis, annual runoff between Eklutna Lake and the old diversion dam was estimated on the basis of drainage basin size. Monthly flow distribution was also estimated, using a monthly distribution similar to that of Peters Creek. Peters Creek was chosen because it is a fairly small basin with only a few glaciers and is adjacent to the Eklutna watershed, indicating that climatic conditions are similar. A comparison of these monthly flow estimates with the Anchorage Public Utilities records of the 1940's indicates that the annual runoff as predicted by the basin size is fairly accurate. The monthly runoff distribution differs slightly but is considered to be a good representation of actual flows.

Lower Eklutna River Basin

Flows from the Lower Eklutna River drainage basin also were estimated from basin size and the monthly distribution of Peters Creek.

Eklutna River-Thunderbird Creek Monthly Flows

Figure 2-2 shows the predicted average monthly flows for both Thunderbird Creek and the Eklutna River between the lake and the old diversion dam. Also shown is an estimate of the monthly fish flow requirements at the confluence of these basins. The fish flow requirements are based on 30 percent of the average annual flow during the summer months of June through September and on 30 percent of the average winter flow during the months of October through May. The monthly differences between the combined Thunderbird Creek and the Eklutna River streamflows and the required fish flows are estimates of the amount of water that potentially would be available for use by the Municipality of Anchorage. Actual downstream flow requirements should be established prior to diversion.

LAKE ICE

Careful consideration of ice effects on potential intake structures on Eklutna Lake, Eklutna River at the old diversion dam, and on Thunderbird Creek is required. Potential problems include growth of ice on water surfaces, ice jamming in the vicinity of the structures, ice forces, and frazil ice production and accumulation.

Ice growth on lake and reservoir surfaces will decrease the available storage for water supply. Usually 3 feet of ice forms on Eklutna Lake during the winter, but it is estimated that 4 feet or more of ice may develop during colder years (about 12,000 ac-ft of storage). The volume occupied by ice above the old diversion dam or a new diversion dam is not known, but it could be significant.

Ice jamming at the old diversion dam and on Thunderbird Creek could occur during spring breakup if the ice cover on either stream is fairly solid when high spring flows begin. High flows could break up the ice and force it against any structures in the river. The force of these ice flows must be considered in the design of any intake or impoundment structures on the Thunderbird Creek and Eklutna River.

Because both streams are fairly steep, large quantities of frazil ice may regularly form, which could seriously hinder water works. No mention of operational problems resulting from frazil ice can be found in the literature for the old hydroelectric project on Eklutna River, but the Municipal Water Treatment Plant on Ship Creek occasionally receives large quantities of frazil ice. The Municipality is considering the use of waste heat from natural gas energy generation to combat the short but intense periods of frazil ice accumulation at the Ship Creek treatment plant.

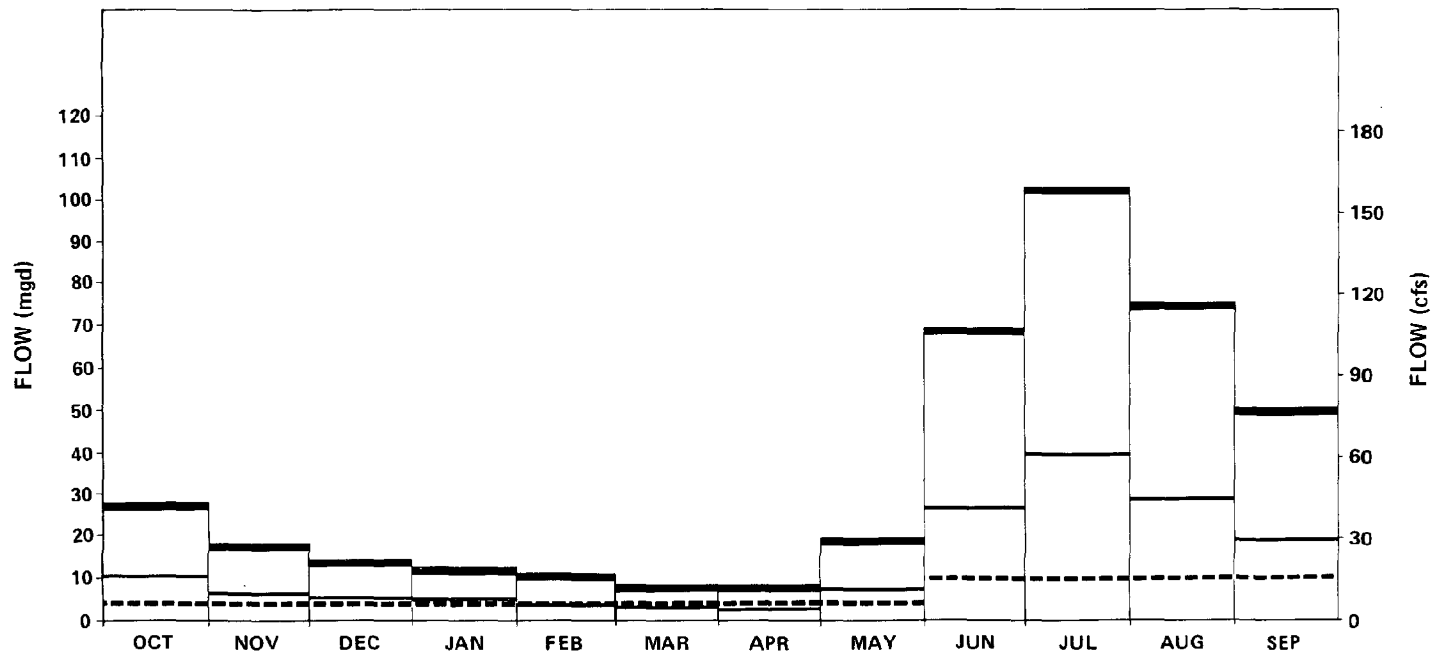
Frazil ice production should be evaluated during design of any structures on Eklutna River or Thunderbird Creek. A winter ice survey similar to that discussed in Appendix II, Preliminary Damsite Investigation, would be invaluable.

SEDIMENTATION

Sedimentation in the Eklutna watershed occurs in both Eklutna Lake and the small lake above the old diversion dam. The sediment is caused mainly by glaciers and by a combination of steep terrain, lightly vegetated areas, and moderate to heavy precipitation in parts of the basin.

Eklutna Glacier, whose toe is about 4-1/2 miles from the upper end of Eklutna Lake, is the main contributor to glacial sediment in the area. A considerable amount of glacial material has been deposited at the upper end of the lake, forming a large delta. A portion of the very fine sediment coming into Eklutna Lake is carried through the lake to both the Eklutna River and the hydroelectric facility. This is evidenced by the turbidity and visual "milkiness" of the water. Sediment moving down the Eklutna River is partially trapped behind the old diversion dam.

Estimates of sediment accumulation in Eklutna Lake and above the old diversion dam were made by Anchorage Public Utilities. These estimates indicate that sediment accumulates above the old diversion dam on Eklutna River at a rate of 1.70 ac-ft per square mile per year. The sedimentation rate at Eklutna Lake has been estimated by the USGS at 10,000 ac-ft per 50-year period. Actual sediment measurements indicate that this estimate is high. The amount of sediment passing through the Eklutna power plant is lower than previously predicted. The rate of sedimentation of Eklutna Lake could have a long-term effect on any diversion project on Eklutna Lake. A program to measure the sedimentation rates should be made to predict more accurately the actual sedimentation rates.



MAXIMUM DIVERSION TO ANCHORAGE (mgd)

OCT	23.7	APR	3.9
NOV	13.6	MAY	15.0
DEC	10.2	JUN	59.3
JAN	8.0	JUL	70.0
FEB	6.3	AUG	64.6
MAR	4.2	SEP	39.4

Figure 2-2
Eklutna River–
Thunderbird Creek Watershed
Available Monthly Flow

LAKE EVAPORATION

The effect of evaporation on the amount of water available at Eklutna Lake is inherent in the hydroelectric facility estimates of lake runoff. Therefore, further study of the evaporation rate at Eklutna is not necessary.

Chapter 3
EXISTING EKLUTNA HYDROELECTRIC FACILITY

HISTORY

The current Eklutna project was built as a single-purpose 30,000-kilowatt-plus project by the United States Bureau of Reclamation to serve the expanding electrical needs of the greater Anchorage, area. The project is operated by the APA. (Figure 1-1 in Chapter 1 shows the relative location of the project and lake with respect to the Anchorage area.) The project went on line in 1955 after a 4-year construction period. Its construction diverted most of the flow from Eklutna Lake through a mountain ridge and directly into Knik Arm (except during infrequent periods of spill) and required the abandonment of the Anchorage Light and Power Company hydroelectric facility on the Eklutna River. Facilities remaining from this abandoned project include the dam (now silted to the crest), the diversion tunnel, the penstock, and the powerhouse. All electrical and mechanical equipment has been removed from the old powerhouse.

EXISTING FACILITIES

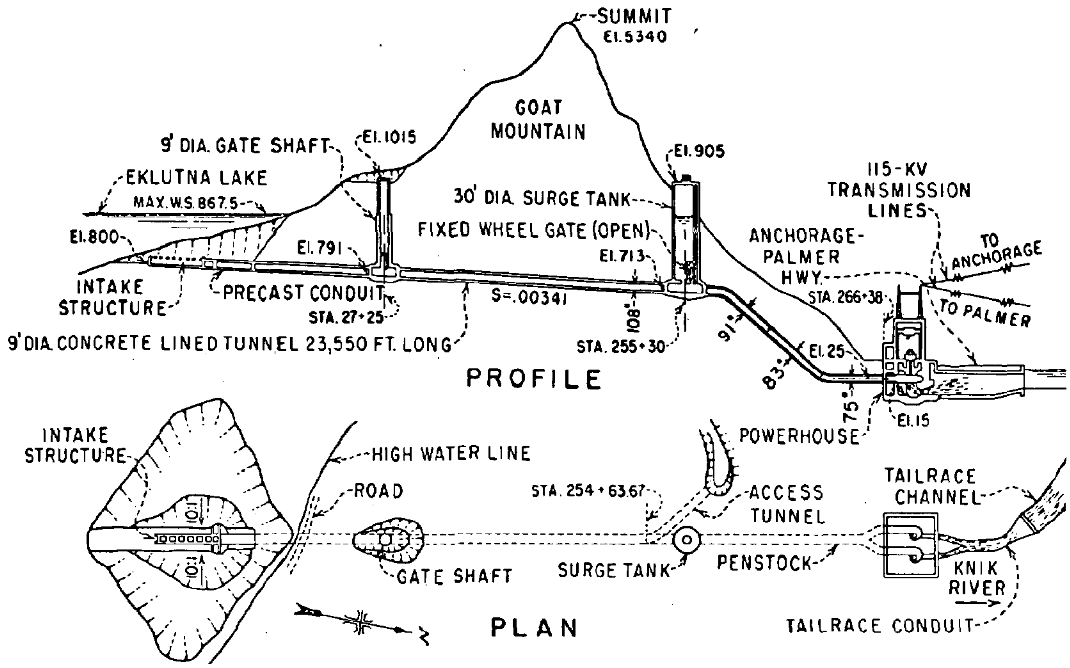
The Eklutna project survived the 1964 earthquake with some damage, but was able to provide power at a reduced capacity until repair work was begun. The project was shut down several weeks during repairs.

The main features of the Eklutna project are the dam, reservoir intake, tunnel, surge tank, penstock, power plant, and tailrace. Figure 3-1 shows the locations of all these features except the dam. Major engineering considerations, including post-earthquake modifications, are as follows:

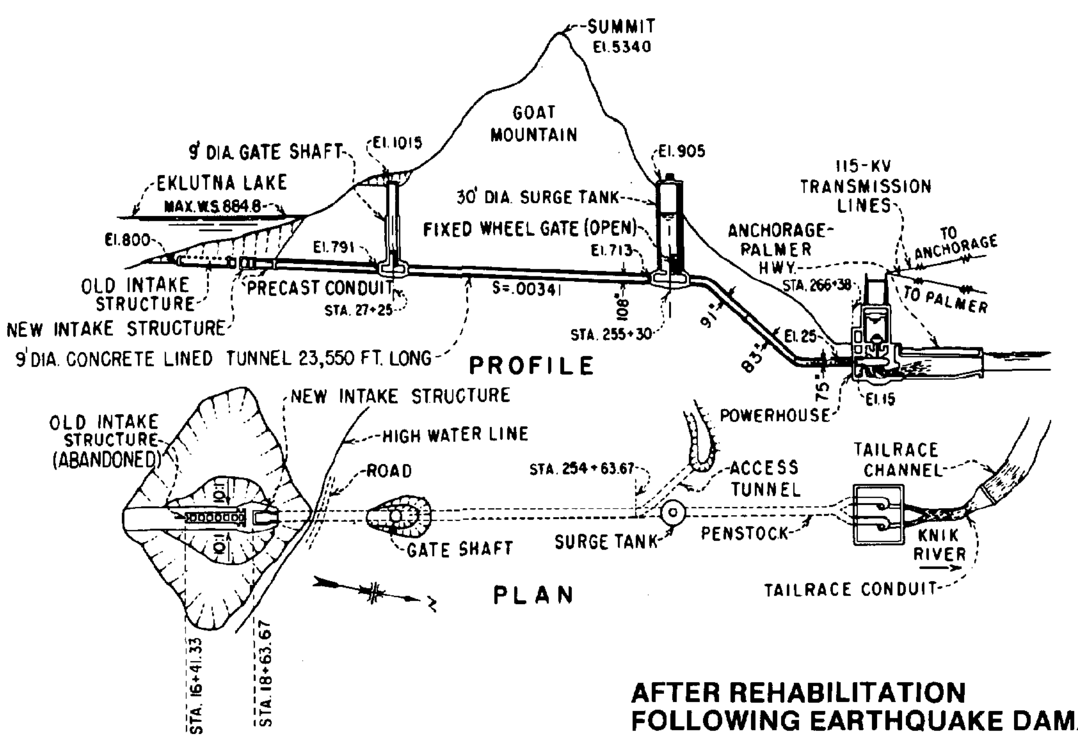
Reservoir (as Modified)

Location: Approximately 10 miles southeast of Eklutna power plant and 30 miles northeast of Anchorage

Reservoir statistics:
- Total live capacity: 213,271 acre-feet
- Active capacity: 174,798 acre-feet
- Present inactive capacity: 38,473 acre-feet
- Surface area (at total capacity): 3,420 acres
- High-water elevation (spillway crest): 871.0 feet
- Length: 7 miles
- Width: 0.7 mile
- Depth: 200 feet



BEFORE 1964 EARTHQUAKE



AFTER REHABILITATION FOLLOWING EARTHQUAKE DAMAGE

SOURCE: U.S. Bureau of Reclamation. 1967.

Figure 3-1
Eklutna Project Features
Schematic Plan and Profile

Dam (as Replaced)

Type: Earth and rock fill
Foundation: Firm glacial till
Slopes: 3-to-1 upstream, 2-to-1 downstream
Slope protection: No special slope protection; rockfill (zone 3) was placed in 3-foot layers on both upstream and downstream faces
Crest length: 815 feet
Crest width: 30 feet
Crest elevation: 891.0 feet
Volume: 85,000 cubic yards

Spillway (as Replaced)

The spillway plan and cross-section are shown in Figure 3-2.
Location: On right bank but almost midway between abutments of dam
Type: An ungated overflow crest with a rectangular reinforced concrete conduit through the dam and a stilling basin energy dissipator
Crest elevation: 871.00 feet
Crest width: 18 feet
Capacity: 3,315 second-feet with reservoir at maximum (surcharge) elevation 884.8

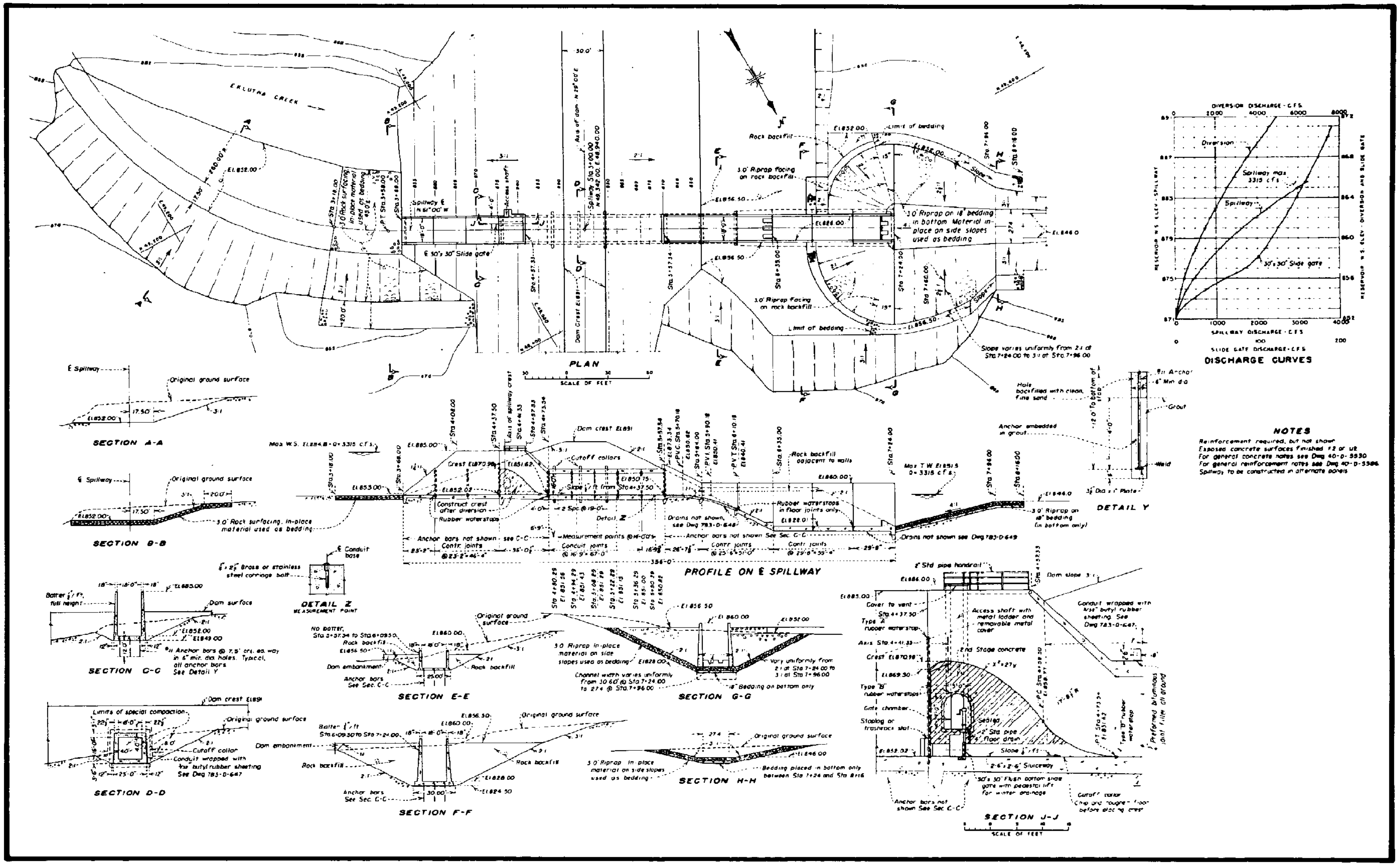
Flood routing curves are shown in Figure 3-3.

Intake Structure (as Replaced)

Location: Eklutna Lake bottom
Type: Rectangular reinforced concrete box structure, open and protected by trashracks on its top, front, and two sides
Dimensions: Trashracked portion about 23 feet wide, 20 feet high, and 22 feet long in direction of conduit flow; 42 feet 4 inches in overall length
Elevation of invert: 793.6 feet, which is 77.4 feet below the dam spillway crest
Inlet channel: 100 feet wide, about 720 feet long (original intake structure and portions of original intake conduit remain in inlet channel)

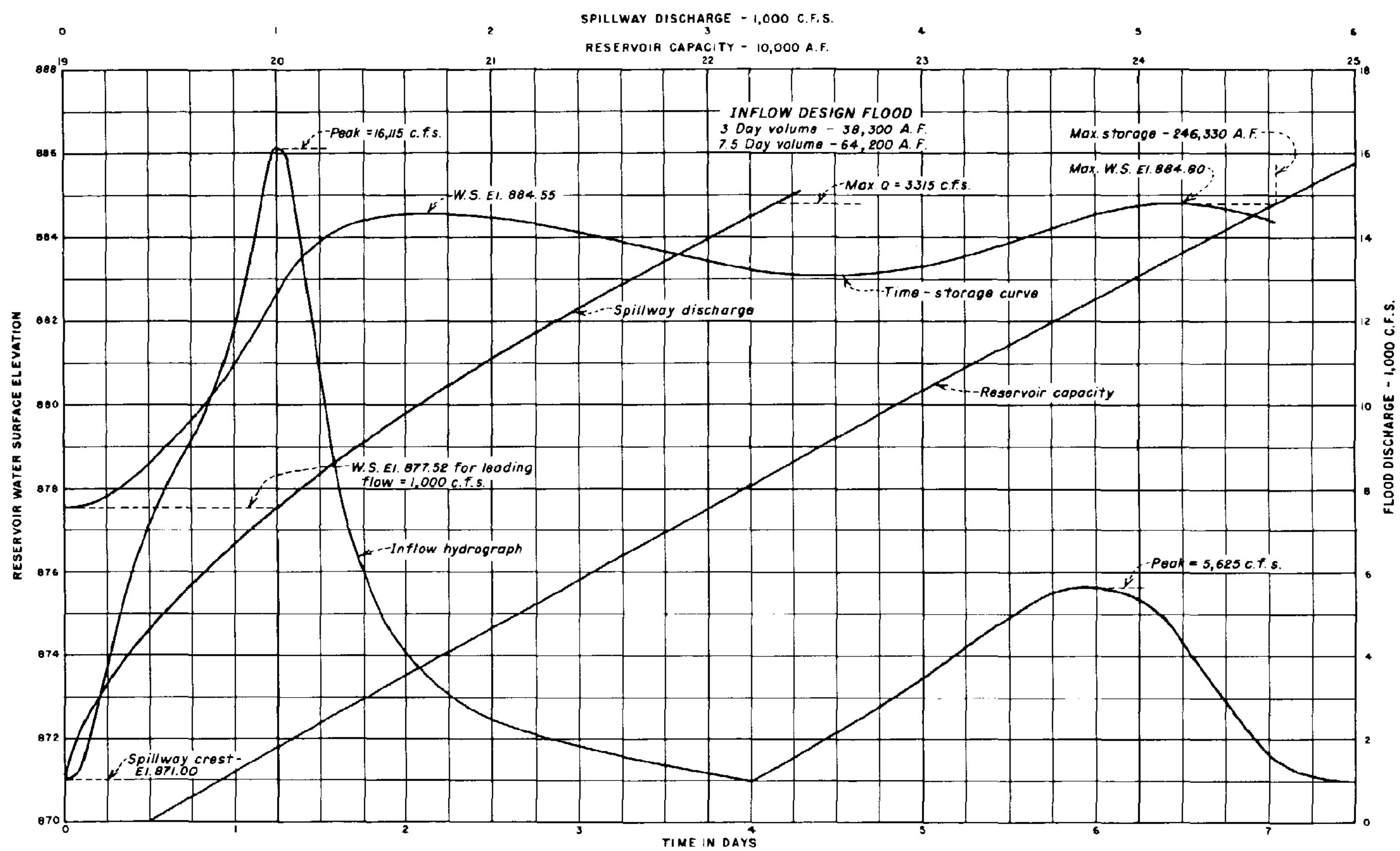
Eklutna Tunnel

Cross-sections of the Eklutna tunnel are shown in Figure 3-4.
Type: Circular, concrete-lined, pressure type
Inside diameter: 9 feet
Length: 23,550 feet
Hydraulic properties:
  Area: 63.62 square feet
  Velocity: 10.06 feet per second
  Capacity: 640 second-feet



SOURCE: U.S. Bureau of Reclamation. 1967.

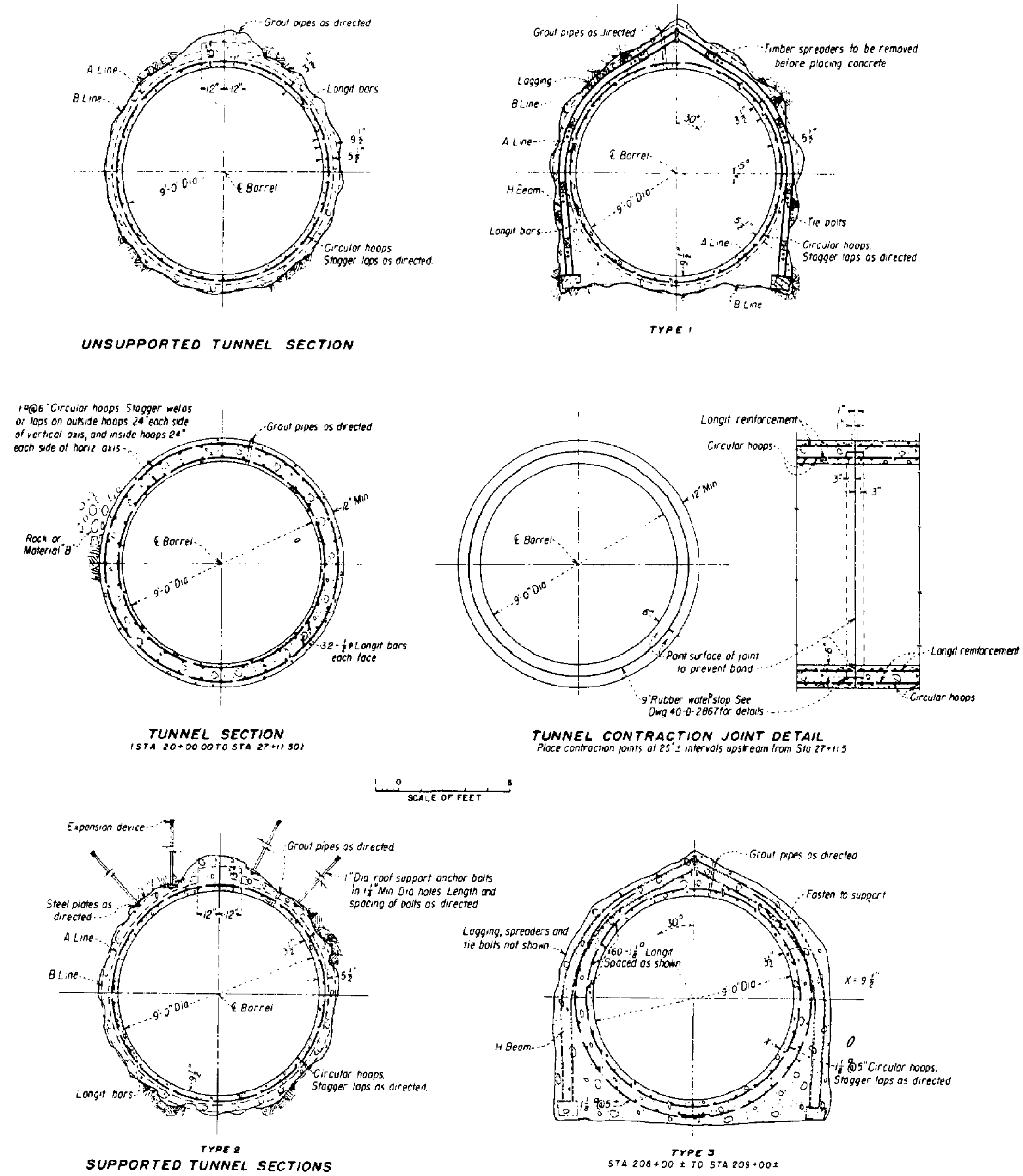
Figure 3-2
Spillway of New Dam General Plan and Sections



NOTE: Reservoir capacity taken from table dated April, 1963.

SOURCE: U.S. Bureau of Reclamation. 1967.

Figure 3-3
New Dam
Spillway Flood
Routing Curves



TUNNEL REINFORCEMENT

FROM STATION	TO STATION	LONGIT.	HOOPS	REMARKS
27+38.5	44+000	30-$\frac{5}{8}$ϕ	1ϕ @ 10"	
44+000	51+000	30-$\frac{5}{8}$ϕ	1ϕ @ 9"	
51+000	190+250	-	-	Unreinforced
190+250	193+250	30-$\frac{5}{8}$ϕ	1$\frac{1}{8}$ϕ @ 8"	
193+250	206+500	-	-	Unreinforced
206+500	208+00±	30-$\frac{5}{8}$ϕ	1$\frac{1}{8}$ϕ @ 8"	
208+00±	209+00±	-	-	See Section Type 3
209+00±	215+000	30-$\frac{5}{8}$ϕ	1$\frac{1}{8}$ϕ @ 8"	
215+000	254+150	30-$\frac{5}{8}$ϕ	1$\frac{1}{8}$ϕ @ 7"	

NOTES

Place all reinforcement so that the centers of bars in the outer layers will be 2½" from face of concrete unless otherwise shown.
Lap all bars 34 diameters at splices
Concrete design based on a compressive strength of 3,000 pounds per square inch

SOURCE: U.S. Bureau of Reclamation. 1967.

Figure 3-4
Pressure Tunnel Sections and Detail Station 20+00 to 255+10

Slope: 0.00341 (80-foot difference in elevation between inlet and the outlet gate at surge tank)
Closure: The details of the tunnel closure near the surge tank are shown in Figure 3-5

Surge Tank

Location: 22,805 feet downstream from bulkhead gate shaft and directly over tunnel
Height above tunnel: 176 feet
Inside diameter: 30 feet
Wall thickness: 18 inches
Type: Restricted orifice

Penstock

Location: Downstream of surge tank
Length: 1,395 feet
Variable diameters: 91-, 83-, and 75-inch outside diameters
Type: Welded and coupled steel pipe encased in concrete
Plate thickness: 5/16 inch for initial section and variable up to 1-1/2 inches at terminal section
Profile: A horizontal run of 30 feet, then descending 864 feet at an angle of 53 degrees, then a horizontal run of 501 feet

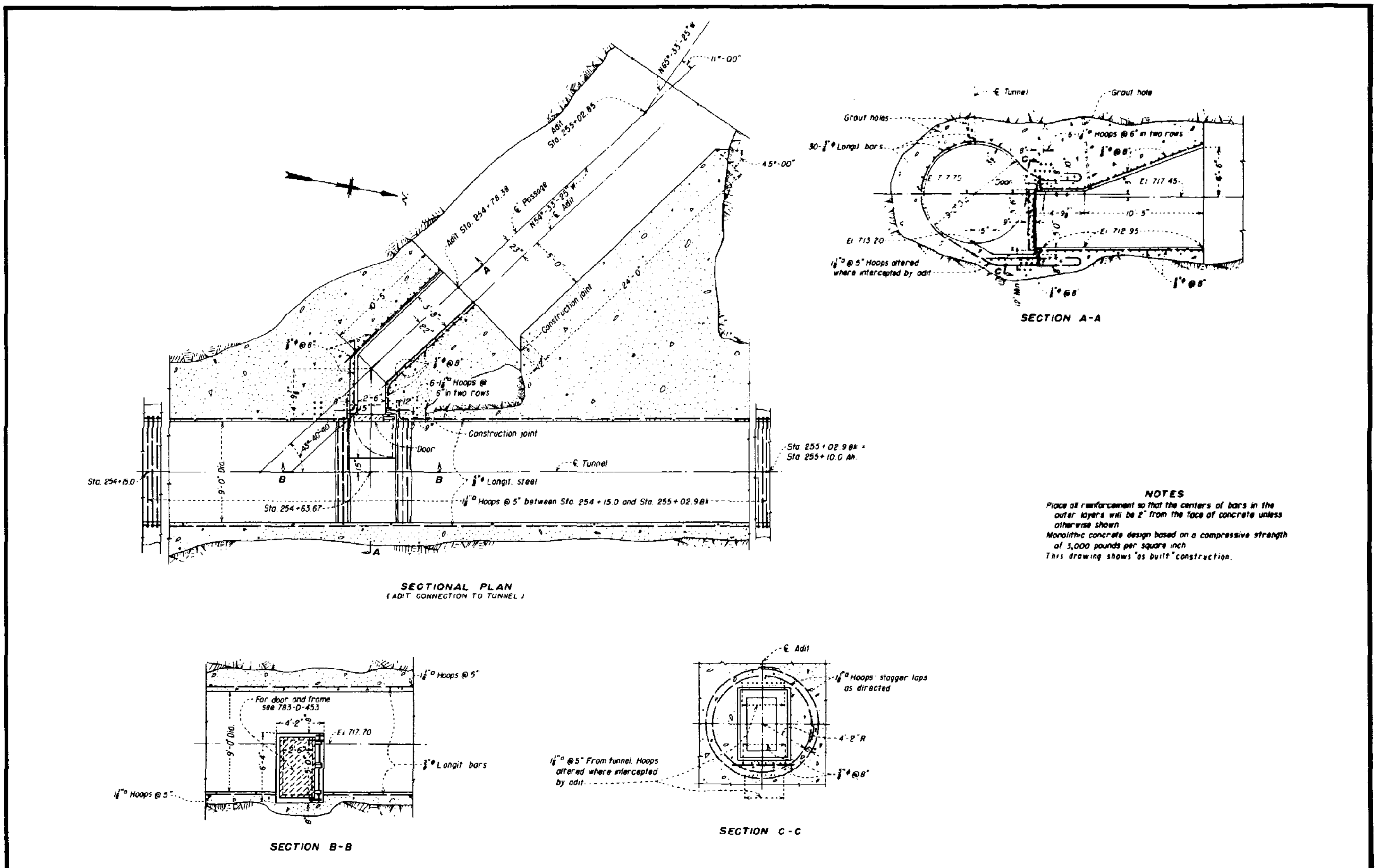
Water Rights

Permit Number: 44944, State of Alaska
Quantity: 700 cfs

Power Plant

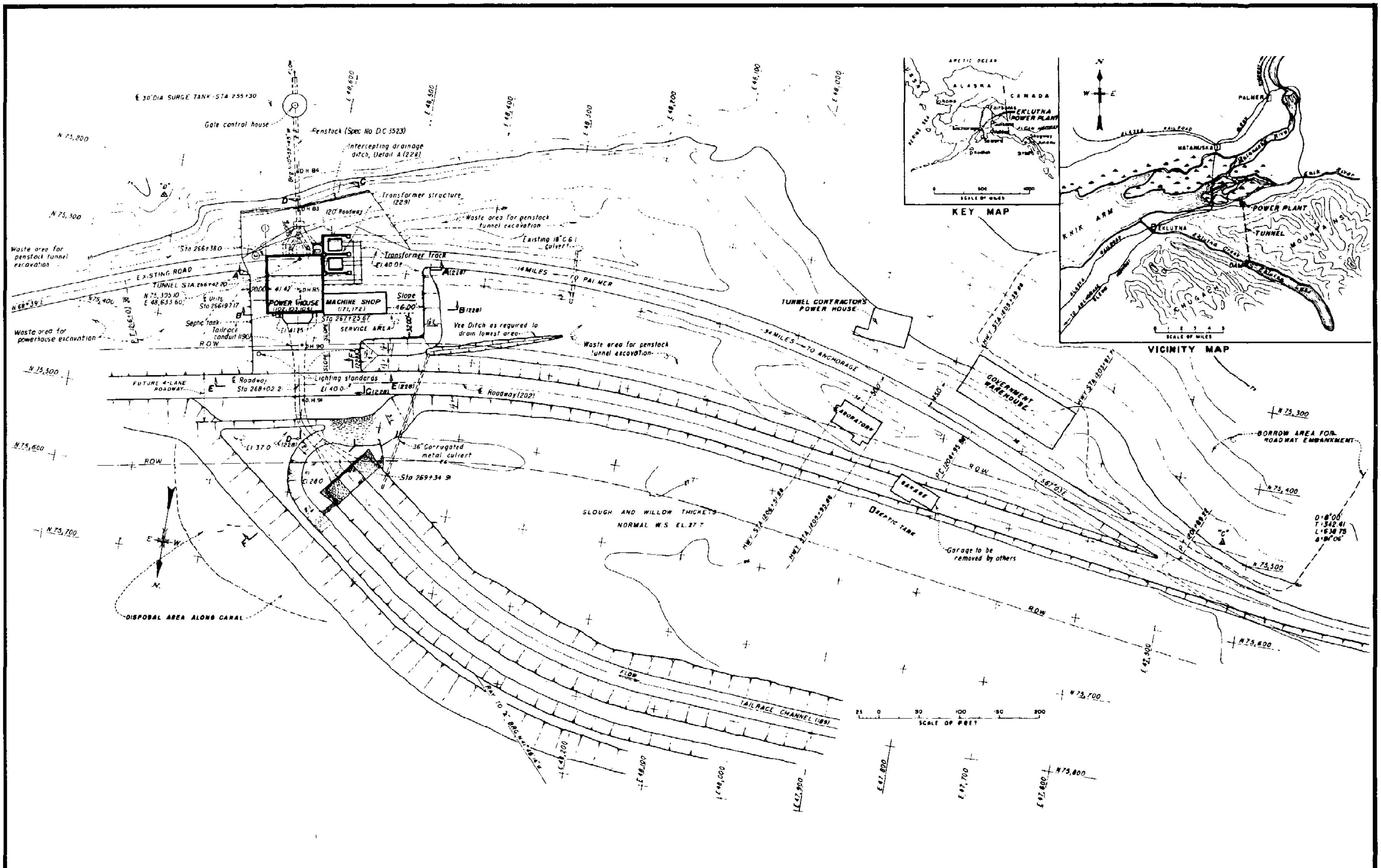
A location map of the Eklutna power plant is shown in Figure 3-6.

Location: Adjacent to Old Glenn Highway, 34 miles northeast of Anchorage
Type: Reinforced concrete
Maximum head: 850 feet as originally constructed; 865 feet with new dam.
Number of units: 2
Installed capacity: 33,334 kilovolt-amperes
Turbines: Francis type, 25,000 horsepower at a rated speed of 600 revolutions per minute and an 800-foot effective head
Generators: Vertical-shaft type, 16,667 kilovolt-amperes at 90-percent power factor, 3-phase, 60 cycles, 6,900 volts
Transformers: Two main power transformers, 3-phase, 60 cycles, forced-air cooled, 20,000 kilovolt-amperes, 6,600 to 115,000 grounded wye-volts



SOURCE: U.S. Bureau of Reclamation. 1958.

Figure 3-5
Pressure Tunnel Adit
Closure Details



SOURCE: U.S. Bureau of Reclamation. 1967.

Figure 3-6
Eklutna Hydroelectric Project Location Map

Switchyard

Location: At three levels, on and adjacent to the power plant: roof elevation, 92.50 feet; intermediate roof elevation, 58.54 feet; and ground level elevation 41.25 feet

Number of units: Two 115-kilovolt bays
One 12.47-kilovolt bay

Tailrace

Location: Extending north from power plant under Old Glenn Highway

Type: Combination pressure type and open channel. A reinforced concrete pressure conduit 209 feet long and of varying width and depth discharges into an open channel with a bottom width of 25 feet, side slopes of 2 to 1, a depth of 12.5 feet, and a length of about 2,000 feet, that conveys the water into the Knik River.

ENERGY OUTPUT

Prior to construction, the Eklutna project was intended to yield 143 million kWh of firm energy and 16 million kWh of nonfirm energy (mostly during the summer and early fall) in an average year (U.S. Bureau of Reclamation, 1950). Table 3-1 presents the actual total energy output, by year, for the project. These figures show that the plant has generally met or exceeded its total generation targets, with the major exception of the drought year of 1973.

Table 3-1
EKLUTNA GROSS GENERATION

Year	Total (kWh)	Year	Total (kWh)
1955	102,523,000	1969	167,986,000
1956	127,779,000	1970	155,422,000
1957	154,339,000	1971	144,515,000
1958	166,953,000	1972	164,680,000
1959	165,771,000	1973	96,854,000
1960	188,178,000	1974	125,624,000
1961	198,825,000	1975	135,609,000
1962	150,521,000	1976	118,508,000
1963	156,508,000	1977	204,182,000
1964	159,138,000	1978	180,650,000
1965	135,343,000	1979	171,615,000
1966	138,863,000	1980	184,814,000
1967	184,150,000	Total	4,043,613,000
1968	164,263,000	Average	155,520,000

Data Source: Eklutna Hydroelectric Facility Operating Records.

Chapter 4
SUPPLY ALTERNATIVES

Previous studies have identified several projects on or near Eklutna Lake that could provide a water supply for the Municipality of Anchorage. These projects include diversion of water from the tailrace of the existing Eklutna hydroelectric facility, diversion of Eklutna Lake water by tapping the hydroelectric project penstock, pumping water from Eklutna Lake and transporting it through a pipeline along the Eklutna Lake Road, and developing a new lake tap for gravity flow from Eklutna Lake by pipeline.

Our review of the area's potential indicates that additional supply can be developed by diverting runoff water from the Eklutna River watershed below Eklutna Lake.

Many possible alternatives can be developed from the various combinations of supply and diversion points, treatment locations, and pumping facility locations. Additionally, it is possible to stage the construction of system components to meet increasing demands.

POSSIBLE DIVERSION SITES

In this study, three places were considered for diversion from Eklutna Lake: the Eklutna power plant tailrace, the Eklutna power plant tunnel, and directly from the lake. The power plant penstock is not a feasible point of diversion because of possible serious effects to downstream hydraulics and possible impacts to operation of the hydroelectric facility.

Any diversion of water upstream of the turbines will reduce hydroelectric energy output, and any diversion of water below the turbines will require large amounts of pumping energy.

It is assumed that diversion of water from the tunnel near the existing surge tank would have only a single source of supply, Eklutna Lake. A tailrace diversion or a diversion directly from the lake is assumed to be supplemented by water from the Eklutna River watershed below the lake (Eklutna River and Thunderbird Creek). These supplemental diversions would reduce pumping energy requirements and any impacts on the hydroelectric facility.

Water from the Eklutna River and Thunderbird Creek could be diverted either at the old Eklutna River dam or downstream at the Old Glenn Highway bridge. Project energy requirements would be lower with a diversion from the old dam because it is approximately 150 feet higher than the lower site. However, for purposes of this study, the lower site was chosen because it has more water available, it is much more accessible, and it doesn't depend on a 50-year-old structure whose condition is not known. Before the abandoned dam and tunnel could be incorporated into a project, their structural integrity must be determined.

The estimated annual water diversion during an average water year to meet increased demands is shown in Figure 4-1* for each diversion source. The curve representing the diversion from the Eklutna power plant tunnel also represents the total project diversion requirements.

Each diversion offers distinct advantages and disadvantages, and various combinations of diversions are possible. The following descriptions note advantages and disadvantages of each principal diversion site.

Tailrace

A diversion from the Eklutna hydroelectric facility tailrace offers the following advantages:

- o Unless the operation of the facility is changed, for example, to power peaking as the primary function, there will always be at least 70 mgd coming through the tailrace
- o Staged construction potential

Its disadvantages are as follows:

- o Difficult construction of the pipeline from the tailrace to the village of Eklutna
- o High pumping energy requirements
- o Possible hydroelectric facility emergency shutdowns

This diversion may or may not be institutionally acceptable. It is preferred by the APA because it does not interfere with the operation or the capacity of the Eklutna hydroelectric facility nor does it reduce the facility's total annual energy generating capabilities. Also, the APA has maintained since 1978 that the tailrace diversion is better than diverting water upstream of the turbines because of lower pipeline design pressure requirements and staged construction opportunities.** However, the pumping facilities may conflict with a fish hatchery, proposed by the Cook Inlet Aquaculture Association, to be located between the Old Glenn Highway and the power plant tailrace on land leased from the Federal Government. (Cook Inlet, 1981). The request for

*The figures have been placed at the end of the chapter so as not to impede the flow of the text.

**Correspondence from Bob Cross, director of the APA, to William Lloyd, MAUS Study Manager, U.S. Corps of Engineers. November 22, 1978.

proposal indicates that the proposed fish hatchery will be ready for operation during the 1982 brood year. The use of mitigating measures such as fish screens or louvers at the pump station can protect the proposed fishery. Another possible means of reducing potential problems in this area, which was recently suggested by the APA, would be to locate the pump station on the power plant side of the highway. However, the intake structure and associated pipeline could still cause conflicts.* Planning, design, and construction of components for a tailrace diversion will require close coordination with all interested parties.

Additionally, to enhance the reliability of this supply the APA should schedule any power plant maintenance shutdowns during the summer months when runoff from the Eklutna River and Thunderbird Creek is at maximum.

Tunnel

Diverting water from the tunnel offers the following advantages:

- No pump stations
- Continued water supply during hydroelectric facility shutdowns
- Few moving parts

Disadvantages include the following:

- Purchase of lost hydroelectric facility generating capability
- Regulation of flow under varying heads
- Difficult access to tunnel connection and penstocks for construction and maintenance
- Difficult pipeline construction to the village of Eklutna
- Possible effects on power plant operation
- High-head pipe
- Semi-remote water treatment plant location at a high elevation
- Construction of numerous pressure-reducing stations along the route for the various users

*Verbal communication from Bob Cross, director of the APA, to Floyd Damron, CH2M HILL. December 1, 1981.

Eklutna Lake

Based on optimum hydroelectric facility operations (rule curve), water may be diverted from the lake through the gate under the existing spillway for 4 months by gravity during an average water year. During the remaining 8 months, water could be diverted to the river by a low-lift pump station.

Diverting water directly from Eklutna Lake to the Eklutna River has some advantages over diverting water from the tunnel:

- No interference with the components of the Eklutna hydroelectric facility
- Less diversion of water or lost generating capability because of the additional water available from the river watershed
- Less capital expenditures because 8 miles of pipeline, in difficult terrain, between the power plant and the village of Eklutna would be eliminated
- Staged construction potential

The following are the principal disadvantages of an Eklutna Lake diversion:

- Operation and maintenance costs of operating pump stations at Eklutna Lake, the water treatment plant, and at Mirror Lake
- Reduction of energy production at the power plant
- Frazil ice could have a high impact on the intake facility (this should be studied in more detail)

Following a detailed analysis of the possible diversions during preliminary design, a lake tap may prove to be the most economical and reliable method for diverting water from Eklutna Lake to the river.

ASSUMPTIONS AND CRITERIA

In developing alternatives for the Eklutna project, certain assumptions were made on the basis of information presented in the MAUS report, information supplied by the Municipality of Anchorage and the APA, and field inspections of the proposed alternative sites. In addition, criteria were used for the pipelines, pump stations, intake structures, and diversion dams to develop conceptual plans and to prepare order-of-magnitude cost estimates. For purposes of this initial evaluation, three alternatives were developed that appear the most feasible. A detailed description of each alternative follows this section on assumptions and criteria.

Water Demands

It is assumed that the Eklutna diversion project would divert 70 mgd of water. Of this 70 mgd, 12.2 mgd would be available to the Eagle River-Eklutna area along the pipeline, and the remaining 57.8 mgd would be diverted to the Anchorage Bowl.

Flow contributions for the Eagle River-Eklutna area were developed for various points along the system by using population projections presented in the report Eagle River-Chugiak-Eklutna Comprehensive Plan prepared by Anchorage Planning Department and adopted September 13, 1979. The Comprehensive Plan divided the area between the Eagle River and the Eklutna River into seven subareas and assigned a Transportation Analysis Zone (TAZ) number to each.

The 12.2 mgd was distributed along the route, based on the proportion of each subarea saturated population to the total saturated population. The flows distributed to each subarea are as follows:

Subarea	Design Flow (mgd)	Saturation Flow (mgd)
Eklutna (TAZ 417)	1.1	1.6
Peters Creek (TAZ 415)	3.5	4.7
Birchwood (TAZ 412)	2.7	3.7
Chugiak (TAZ 410)	1.0	1.4
Eagle River (TAZ 405)	1.5	2.1
N. Eagle River Valley (TAZ 408)	1.8	2.5
S. Eagle River Valley (TAZ 400)	0.6	0.6
Total	12.2	16.6

The approximate location of each point flow is shown on the plan and profile sheets (see Figures 4-3, 4-4, and 4-12 through 4-16). It should be emphasized that the location and size of each point flow is approximate and will vary as comprehensive water distribution master plans are developed for each community.

Transmission Pipeline

Conceptual plans developed for pipeline routes for each alternative extend from the point of diversion to the Eagle River. It is assumed that the remainder of the pipeline to the Municipal Water Treatment Plant in Anchorage would follow the route described in Appendix IV, Transmission Main Design.

Pipeline criteria and other considerations related to the pipeline are contained in Exhibit A of this report.

Pump Stations

Pump stations for the alternatives were assumed to have the following characteristics:

- Maximum plant efficiency of 70 percent
- Metering and telemetry required
- Surge control required for all pump stations
- Eklutna Lake and tailrace pump stations will require pile-supported foundations
- Staged construction of each station should be considered for final sizing of the station; for estimating purposes, an ultimate capacity of 70 mgd was assumed

Intake Structures

Intake structure features were assumed to be the following:

- Trashracks required
- Intake designed so that invert is minimum of 6 feet below low water elevation
- Designed for ultimate flow of 70 mgd
- Two-pipe barrels between intake and pump stations to allow for staged construction of pump stations
- Stop logs and slide gates to facilitate cleaning of sediment

Diversion Dams

Any proposed diversion dam was assumed to have the following features for purpose of developing conceptual plans:

- Weir-type low-head concrete dam
- Spillway designed for maximum probable storm
- Six-foot submergence of diversion pipe
- Designed for maximum diversion of 70 mgd

- o Gravity flow from dam to water treatment plant

- o Gates at bottom of dam to pass sediment buildup

Treatment Plants

The conceptual size and type of any proposed treatment plant and the proposed treatment processes are described in Chapter 5. Only locations of treatment plants are included in descriptions of the alternatives.

ALTERNATIVE 1: TAILRACE AND RIVER DIVERSION

This alternative draws water from the hydroelectric project tailrace and from the Eklutna River. Early in the life of the project, a large percentage of the summer demand would be provided by the river flows. Later, as demands increased and during periods of low flow in the river, more water would be pumped from the tailrace. Components of this alternative include an intake structure and pump station located adjacent to the Eklutna power plant, a water treatment plant and pump station located at the Eklutna River, a diversion dam and gravity pipeline at the Eklutna River, a booster pump station between Mirror Lake and Peters Creek, and approximately 22 miles of pipeline between the power plant and the Eagle River. Treated water would be available to communities along the line. A layout for this alternative for Alternatives 2 and 3 is shown on Figure 4-2.

Transmission Pipeline

The 54-inch transmission pipeline generally follows Glenn Highway from the Eklutna power plant to the Eagle River (Figures 4-3 and 4-4). The pipeline begins just south of the Eklutna power plant, with a diversion structure on the tailrace of the Eklutna power plant to divert water to the tailrace pump station. The first 18,000 feet of the pipeline parallels the eastern right-of-way of the Old Glenn Highway. From that point, the next 4,000 feet of pipeline parallels the Alaska Railroad. The pipeline then parallels the eastern right-of-way of Glenn Highway for 18,000 feet to the new water treatment plant (WTP). The water is again pumped from the WTP in a pipeline paralleling Glenn Highway for 25,000 feet to Peters Creek. Between Mirror Lake and Peters Creek the pressure is boosted. From that point, the pipeline parallels the Old Glenn Highway for 35,000 feet to Eagle River Loop Road. It parallels the Eagle River Loop Road for 2,500 feet, then turns south for 5,500 feet to the Eagle River Road. The pipeline continues 2,750 feet along Eagle River Road to its intersection with Eagle River Loop Road and then turns south 5,250 feet to the Eagle River.

The pipeline route measures approximately 116,000 feet (21.97 miles) in length. It would cross the Eklutna River, Peters Creek, the Eagle River, and several small creeks. It also requires two crossings of the Alaska Railroad. The route shown in the Eagle River area may be shortened by approximately 8,000 feet by following Glenn Highway. This would require construction of a pipeline in the business area of the town of Eagle River and in the Chugiak State Park Campground.

Tailrace Intake Structure and Pump Station

The site plan of the proposed tailrace intake structure and pump station is shown in Figure 4-5. The site location selected is tentative because of numerous unknowns. Also, a fish hatchery is scheduled to be constructed in 1982 in the area between Old Glenn Highway and the tailrace.

The proposed tailrace intake structure will consist of a trash rack, two bays, and two 48-inch outlet pipes with slide gates.

The construction of the intake structure within the tailrace may require the shutdown of the power plant so that a temporary diversion canal can be constructed around the construction site. Once the intake structure is completed, the power plant may have to be shut down again so that the tailrace can be restored to its original location. So that disruption of the hydroelectric facilities can be kept to a minimum, it is recommended the intake structure and piping within the tailrace cross section be constructed for the ultimate diversion of 70 mgd rather than in stages.

For the purpose of comparing the cost of the alternatives, the pump station was assumed to have a capacity of 70 mgd. The proposed tailrace pump station consists of eight 350-hp pumps, four 150-hp pumps, flow meters, surge suppression equipment, controls, and telemetry. The concrete structure would be pile supported as shown on Figure 4-6. The construction of this pump station could be staged by constructing redundant stations, each with 35-mgd capacity. (Shown on Figures 4-5 and 4-6 as "proposed" and "future" 35-mgd pump stations.)

The total average annual pump station energy requirements and the maximum horsepower requirements for the years 1985 to 2012 are shown on Figure 4-7. The average annual power consumption is based on a tailrace water elevation of 25.0 and the maximum horsepower requirement is based on a minimum tailrace water elevation of 18.0.

Eklutna River Water Treatment Plant and Pump Station

The proposed water treatment plant would be located near the Eklutna River at an approximate elevation of 110 feet.

The associated pump station would pump water to Mirror Lake and would have an ultimate capacity of 70 mgd and a peak power requirement of approximately 8,500 hp. Figure 4-8 shows this station's energy and maximum horsepower requirements.

Eklutna River Diversion Dam

The Eklutna River diversion dam would be located immediately upstream of the Old Glenn Highway-Eklutna River Bridge. The dam would be a fixed-crest concrete structure that would provide 6 feet of submergence over the diversion pipeline. Gates would be installed in the structure for sediment sluicing.

Water would gravity flow through a 48-inch-diameter outlet pipe to the intake of the water treatment plant, at an approximate elevation of 110 feet. The inlet of the pipe would be equipped with a trash rack.

Mirror Lake Booster Pump Station

Figure 4-9 is a plan view of the proposed Mirror Lake booster pump station. The structure for this station would be sized to accommodate the pumps, motors, and miscellaneous equipment to handle an ultimate flow of 65.4 mgd (4.6 mgd used upstream). Initially, only the pumps and motors required to handle the year 2000 flows would be installed. The annual energy requirements and maximum horsepower requirements for the years 1985 to 2012 are shown on Figure 4-10.

The total annual energy requirements for Alternative 1, excluding the water treatment plant, are shown on Figure 4-11.

ALTERNATIVE 2: TUNNEL DIVERSION

In this alternative, water would be diverted upstream of the turbines from the pressurized Eklutna hydroelectric facility tunnel at the adit near the surge tank by means of a tunnel connection. All of the ultimate 70-mgd demand would be provided from this location. The water would be treated at a high-altitude treatment plant along Eklutna Lake Road and would flow by gravity to Anchorage through a 24.7-mile-long pipeline. Communities along the pipeline would take water through pressure-reducing valves.

Transmission Pipeline

Alternative 2, the tunnel diversion, would deliver water by gravity. Plan and profile drawings for the proposed route to the Eagle River are shown on Figures 4-12 and 4-13. The pipeline begins just east of the Eklutna power plant with a connection to the existing tunnel near the surge tank and adit tunnel. The first 1,400 feet of the 48-inch-diameter pipeline (penstock) would drop 650 feet in elevation to a point near the power plant. From the power plant, a 60-inch pipeline would parallel the eastern right-of-way of the Old Glenn Highway 19,000 feet to the Alaska Railroad. The next 17,000 feet of the pipeline parallels the Alaska Railroad. The pipeline then would turn east paralleling the Eklutna Lake access road for 6,400 feet to a new water treatment plant, located at an approximate elevation of 650 feet. The water gravity flows from the WTP 7,500 feet along the Eklutna Lake access road to Glenn Highway. The pipeline would parallel Glenn Highway for 27,000 feet to Peters Creek. From that point, it would parallel the Old Glenn Highway for 36,000 feet to the Eagle River Loop Road. The pipeline then would parallel the Eagle River Loop Road for 2,500 feet where it turns south for 5,500 feet to Eagle River Road. It would continue 2,750 feet along Eagle River Road to its intersection with Eagle River Loop Road and then south 5,250 feet to the Eagle River.

The pipeline route is 130,300 feet long (24.68 miles). The pipeline will require three major water crossings, the Eklutna River, Peters Creek, and the Eagle River. It also requires two crossings of the Alaska Railroad. The pipeline will require up to 400-psi pipe because of high static and dynamic heads.

Eklutna Tunnel Connection

The proposed Eklutna tunnel connection would be made upstream of the existing surge tank. A short tunnel would be constructed from the existing adit tunnel to tap the tunnel. This would allow continued access to the Eklutna tunnel through the existing steel access door. The connection would require shutdown and dewatering of the tunnel during construction. This shutdown may remove the tunnel from service for 5 to 10 days. The tunnel connection would have an automatic shutoff valve that would respond to a break in the pipeline, and the tunnel head gate should be automated as a backup. A number of options exist for making the actual connection to the tunnel; these options can be studied prior to design. This effort would require close coordination among the APA, the Municipality of Anchorage, and the design engineer.

Eklutna Lake Water Treatment Plant

The proposed water treatment plant would be located north of the Eklutna Lake Road at an approximate elevation of 650 feet.

ALTERNATIVE 3: EKLUTNA LAKE AND RIVER DIVERSION

This alternative would divert water directly from Eklutna Lake and the Eklutna River. Except for the Eklutna Lake dam, none of the existing hydroelectric project facilities would be affected. Early in the life of the project, a large percentage of the increasing demand would be provided by the river flows. Much of the winter low flows in the river would be required for minimum streamflow maintenance downstream of the old diversion structure near the Old Glenn Highway. To meet demands not met by the river, water would be diverted into the river by opening the 30-inch by 30-inch gate in the existing Eklutna Lake dam. Components of this alternative would be a pump station and river discharge pipeline at Eklutna Lake, a diversion dam and gravity pipeline near the intersection of the Eklutna River and the Old Glenn Highway, a water treatment plant and pump station near the Eklutna River, a booster pump station between Mirror Lake and Peters Creek, and approximately 14.4 miles of pipeline between Eklutna River and Eagle River. Treated water would be available to communities along the pipeline.

Transmission Pipeline

The 54-inch transmission pipeline generally follows the Old Glenn Highway from the Eklutna River diversion to the Eagle River (Figures 4-14, 4-15, and 4-16). Water from Eklutna Lake would be diverted by gravity into the Eklutna River, when possible, via a gate under the spillway and pumped to the river by a low-lift pump station when the lake is too low for gravity diversion. The diverted water would flow approximately 8 miles down the Eklutna River stream channel to the Eklutna River diversion dam described for Alternative 1. There it would be diverted from the river to the proposed water treatment plant. The water would then be pumped from the water treatment plant in a 54-inch pipeline following the same route described for Alternative 1 to the Eagle River.

The pipeline route measures 76,000 feet (14.39 miles) in length. It would cross the Eklutna River, Peters Creek, and the Eagle River. Two pump stations would be required to lift water from the diversion dam to hydraulic elevation 553 at the Eagle River.

Eklutna Lake Pump Station

Eklutna Lake water will be diverted only when required to supplement water available from the Eklutna River watershed below Eklutna Lake. During later summer and in the fall, water can be diverted by gravity through a gate in the existing dam. The invert in the gate is at an elevation of 852 feet. Once the lake drops to an elevation of 854 to 856 feet, the water would have to be pumped.

A tentative site plan of the proposed pump station, diversion channel, and discharge pipeline is shown on Figure 4-17. The plan was developed solely for the purpose of preparing an order-of-magnitude cost estimate and for estimating the annual energy requirements. Components of this system would include the following:

- o 2,000 lineal feet of intake channel
- o Pump station with a maximum power requirement of 1,000 hp at 70 mgd
- o Check dam to prevent backflow into the lake when water is being pumped from the lake to the existing dam and to reduce the amount of discharge piping required
- o Flow measuring station located downstream of the existing dam

The annual energy requirements and the maximum horsepower requirements for the pump station for the years 1985 to 2012 are depicted on Figure 4-18.

Water Treatment, Diversion, and Pumping Facilities

A description of the Eklutna River diversion and pumping facilities and the location of the treatment plant are presented in the detailed description of Alternative 1 in this chapter. The total annual energy requirements, excluding the water treatment plant, for Alternative 3 for the years 1985 to 2012 are shown on Figure 4-19.

FURTHER CONSIDERATIONS

Transmission Pipeline Routes

It should be emphasized that the routes shown for each alternative are general corridors and do not represent final alignments. Final alignment selection will reflect the results of meetings with the various agencies involved, detailed design, and a detailed analysis of costs and specific environmental constraints and utility conflicts. An alignment paralleling the Alaska Railroad should be considered during more detailed studies.

Utilities

Conflicts with existing gas, water, sewer, and electrical utilities are not significant with any of the alternatives.

The following types of utility problems will require solutions:

- o Protecting the proposed pipeline from existing cathodic protection systems
- o Separating the proposed water transmission main from existing sewers in accordance with Alaska State Health Department standards

- Protecting existing utility poles and towers from overturning

- Protecting workmen from hazards associated with nearby high-voltage lines and natural gas mains

- Maintaining the operation of existing utilities

Easements and Permits

Each alternative would require permits from the same agencies. However, because Alternative 3 would require construction in and around Eklutna Lake, which is part of Chugach State Park and a more environmentally sensitive area, permits may be more difficult to obtain. Alternative 2 would require the water treatment facility to be built in Chugach State Park and may present permitting difficulties.

Three major water crossings would be required for all the alternatives. All crossings will be scheduled with the Department of Fish and Game to minimize the risk to the fisheries and to reduce sedimentation.

Public Interface

Problems caused by noise, dust, traffic control, and interruption of public and governmental access are manageable for all routes. There would be temporary disruption of visitor facilities at Eklutna Lake during construction of Alternative 3, and some long-term visual impact would be incurred. This alternative, however, would make electricity available to several nearby residents and to campers because a new powerline is required for the lake pump station. Alternatives 1 and 2 would require more pipeline than Alternative 3 and would, therefore, have greater construction impact.

Traffic control along the pipeline route during construction would be required for all alternatives. One-way traffic may be required during daytime construction at many places along the pipeline route. Normal two-way traffic flow would be restored after working hours.

Each alternative would require close coordination with the State of Alaska, Eklutna, Inc., Alaska Power Administration, the communities north of Eagle River, and several Municipality of Anchorage departments.

Operation, Maintenance, and Accessibility

The transmission pipeline, like any other facility, requires routine and special maintenance. Routine maintenance primarily consists of inspection on a regularly scheduled basis. Items that should be checked are blowoff air valves and pressure versus flow readings to determine if sediments are depositing in the pipeline. Should cathodic protection be necessary to prevent pipe corrosion, a routine monitoring program would also be needed.

Special maintenance consists of repairing leaks, cleaning the pipeline if required (particularly during low initial flows), and repairing any special linings or coatings.

For routine maintenance or special maintenance, the pipeline must be accessible. Alternative 1 would offer the best accessibility. Access to the tunnel connection and penstock of Alternative 2 would present some difficulties, but these would not be insurmountable. Access to the Eklutna Lake pump station and river diversion facilities may present the most difficulties (Alternative 3).

During the preliminary design phase, methods of providing access into the pipeline and provisions for dewatering the pipeline should be addressed. Blowoffs located in the sags of the pipeline and access manholes at convenient stations would allow direct visual as well as television inspection of the inside of the pipe.

Geotechnical and Geological Considerations

With each alternative, substantial geotechnical input will be necessary for pump station and treatment plant siting, pipeline routing, and foundation and earthwork design. Geologic hazard evaluations would include (1) seismicity evaluation, which must be done to establish the design parameters, and (2) evaluation of the seismically induced hazards of ground shaking, soil liquefaction, landspreading and cracking (lateral displacement of soil), landsliding, fault rupture, tectonic subsidence, and soil consolidation. These hazards have occurred in the past and must be evaluated prior to construction of a project.

Alternative 1

Some potentially severe geotechnical and geologic conditions near the diversion and pump station facilities need to be evaluated:

- o Very soft, recent sedimentary deposits where the Eklutna powerhouse tailrace diversion must be constructed.

- o A tidal marsh consisting of soft organic and silty soils, which the intake pipes must cross. Landspreading and cracking is a potentially severe problem during seismic events. High groundwater may also occur. The potential exists for Lake George breakouts to flood the site as in the past.

- Slope stability, where the site is close to the mountain base. The best geologic maps available and the construction records from the Eklutna hydroelectric project indicate the Knik Fault Zone passes directly through the proposed site. As part of the site exploration, the exact location of this fault will have to be established and an evaluation made of the potential for fault rupture. The degree of acceptable risk from this hazard may differ substantially from that established in the 1950's for the Eklutna powerplant.

The pipeline from the pump station to the treatment plant near the Eklutna River will be constructed mostly in coarse, granular soils along the base of the mountains; this should not require any special geotechnical considerations. Starting about 1 mile east of Glenn Highway, the route crosses tidal marsh areas with potentially severe landspreading and cracking, soil liquefaction, high ground water, and pipeline support problems.

Discontinuous permafrost is present along portions of this alternative from about 1 mile east of Glenn Highway to the proposed treatment plant. These portions will have to be located during the pipeline subsurface exploration.

No special geotechnical conditions are involved at the proposed water treatment plant site. Normal foundation exploration and analysis will be sufficient.

From the treatment plant to the Eagle River, ground conditions are generally good. Isolated areas of organic (peat) soil, soft silt and clay, or permafrost will be encountered. Some slope stability and potential landspreading or cracking problems may be encountered at stream crossings, especially in recent alluvium.

Alternative 2

Rock in the area of the tunnel east portal is described in the Eklutna project construction report as shattered or broken, iron-stained, and containing many fault gouge seams. This will be difficult rock through which to access the Eklutna tunnel, and the rock quality must be established through exploration and evaluation. Slope stability will have to be evaluated and any necessary mitigation measures designed for the pipeline route down to the toe of the mountain.

Bedrock may be encountered in the northeast corner of Section 30, along the northwest-southeast trending sections that lead to the proposed water treatment plant. Thick peat deposits are also present along this section. The locations of these materials will have to be carefully determined for the pipeline design.

At the proposed water treatment plant site, 3 to 4 feet of peat is present in places. A thorough foundation exploration will be necessary at this site.

Alternative 3

Intake Channel. Material around the edge of the lake is described in the Eklutna construction report as soupy and unconsolidated silt. Cut slopes in this material for the pump station intake channel will have to be 10:1 or flatter because of the low strength of this material. Deeper portions of this same cut may encounter dense clay and boulders that will be difficult to excavate. The use of sheet piling may prove advantageous. For the intake channel design, a difficult subsurface exploration will be necessary to determine the materials to be excavated and appropriate cut slopes.

Old Eklutna River Diversion Dam and Tunnel. A structural engineer, a geotechnical engineer, and an engineering geologist should examine the old dam to determine its condition. Stability analysis by the geotechnical engineer may be required. The geotechnical engineer and geologist should also examine any accessible portions of the tunnel.

No special geotechnical conditions are known to exist at the proposed Eklutna River diversion site. The site should be evaluated for the use of sheet pile dam construction as well as other conventional designs.

Optimization of Costs

The three alternatives described can be further refined to optimize their costs. A detailed study would evaluate staged construction of each physical component, alignment alternatives, cost of pipe size versus energy cost, and the use of the old Eklutna River diversion dam and tunnel.

Staged Construction

Methods of staging the project need to be thoroughly explored. Each pump station and the water treatment plant would be constructed in stages. Phased construction of the pump stations could consist of building the station structures large enough to house the equipment for the ultimate flow, but initially installing only the pumps and motors for an interim flow. Another staging possibility would be to construct a station for the interim flow and construct an additional station when the capacity of the initial station is reached. It also may be advantageous to construct the water treatment plant pump station initially so that the interim flow can be lifted to Anchorage without requiring the Mirror Lake booster pump station. As demand increases and the capacity of the treatment plant pump station is reached, the booster pump station would be added.

Alignment Alternatives

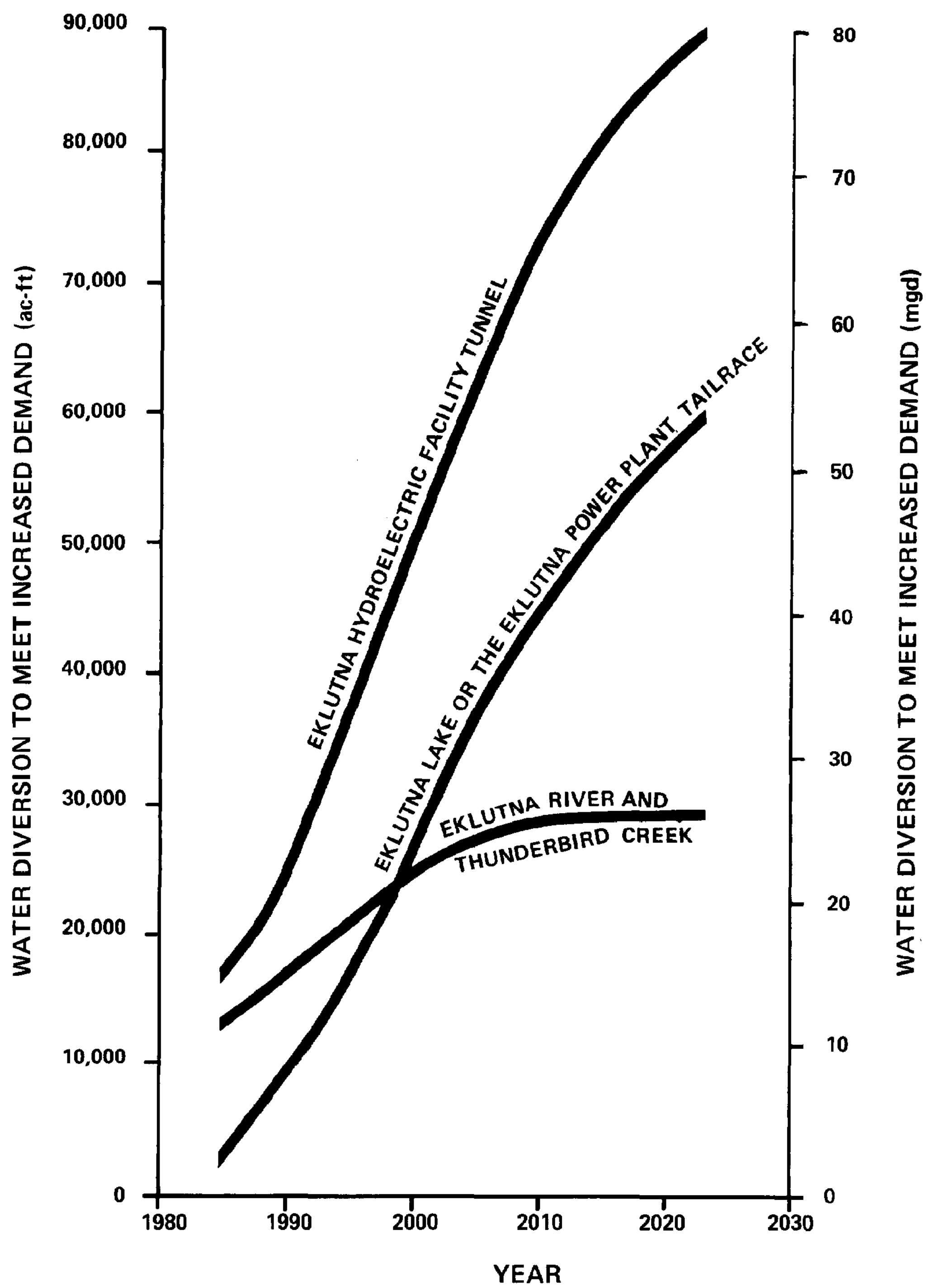
The alignment shown for each alternative is tentative. For example, in the Eagle River area a route was selected that would tie into the alignment of the Eagle River pipeline developed in Appendix IV. A route through the business district of Eagle River and the Chugach State Park Campground would eliminate the need for constructing approximately 8,000 feet of pipe.

Pipe Size Versus Energy

As energy costs increase, the head loss caused by pipe friction needs to be more closely analyzed. For example, if the 54-inch pipe selected for Alternatives 1 and 3 were enlarged to 60 inches, head loss in the system could be reduced by approximately 100 feet. An economic analysis of energy saving versus the added cost of capital improvement will need to be performed.

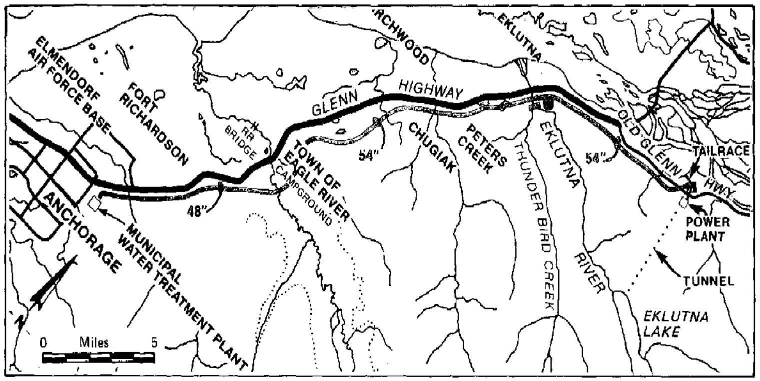
Old Eklutna River Diversion Dam and Tunnel

The use of the old dam and tunnel on Eklutna River should be evaluated if Alternative 3 is further studied. The use of these facilities could reduce the system head requirements by approximately 130 to 140 feet.



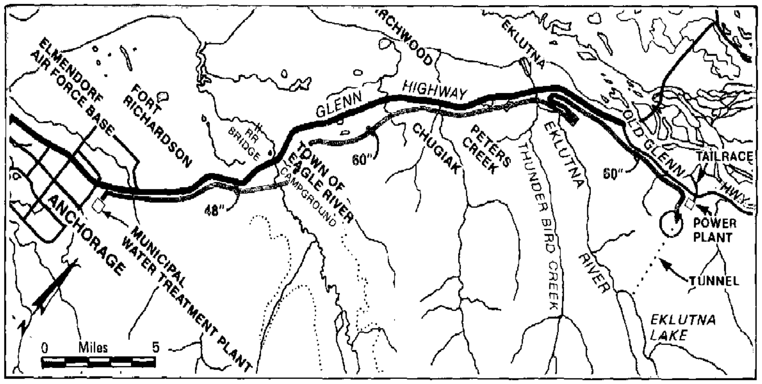
NOTE: Time base assumes no additional supplies developed within the Anchorage Bowl.

Figure 4-1
Annual Water Diversion from Proposed Water Sources



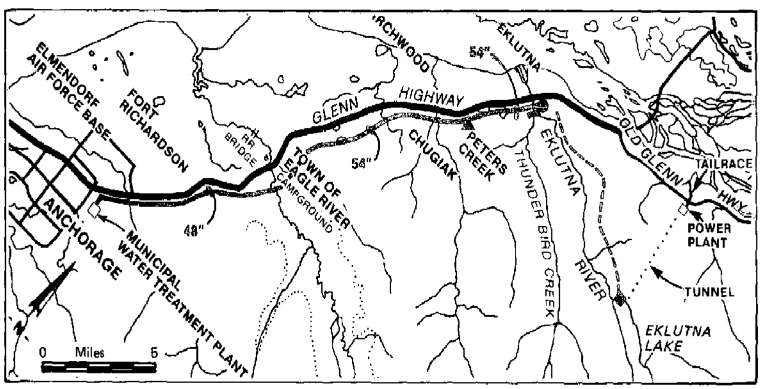
ALTERNATIVE 1
(TAILRACE AND RIVER DIVERSION)

LEGEND
PROPOSED FACILITIES:
- TAILRACE PUMP STATION
- EKLUTNA RIVER DIVERSION DAM
- TREATMENT PLANT AND PUMP STATION
- PIPELINE



ALTERNATIVE 2
(TUNNEL DIVERSION)

LEGEND
PROPOSED FACILITIES:
- WATER TREATMENT PLANT
- TUNNEL DIVERSION
- PIPELINE



ALTERNATIVE 3
(EKLUTNA LAKE AND RIVER DIVERSION)

LEGEND
PROPOSED FACILITIES:
- MIRROR LAKE BOOSTER PUMP STATION
- EKLUTNA LAKE PUMP STATION
- POWER LINE TO PUMP STATION
- EKLUTNA RIVER DIVERSION DAM
- WATER TREATMENT PLANT AND PUMP STATION
- PIPELINE

Figure 4-2
Alternatives 1, 2, and 3 Layout

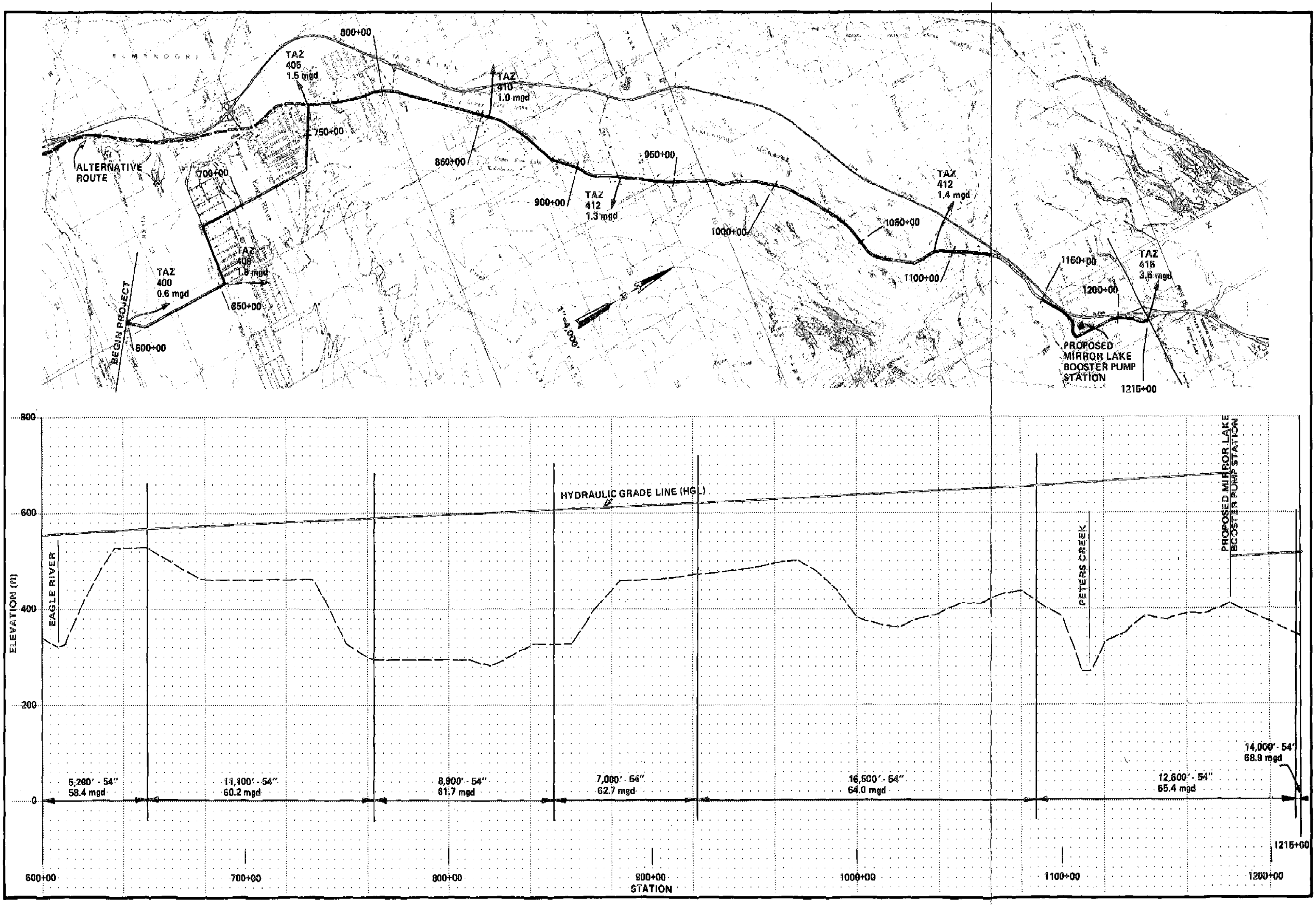


Figure 4-3
Alternative 1
Tailrace and River Diversion
Plan and Profile
Station 600+00 to 1215+00

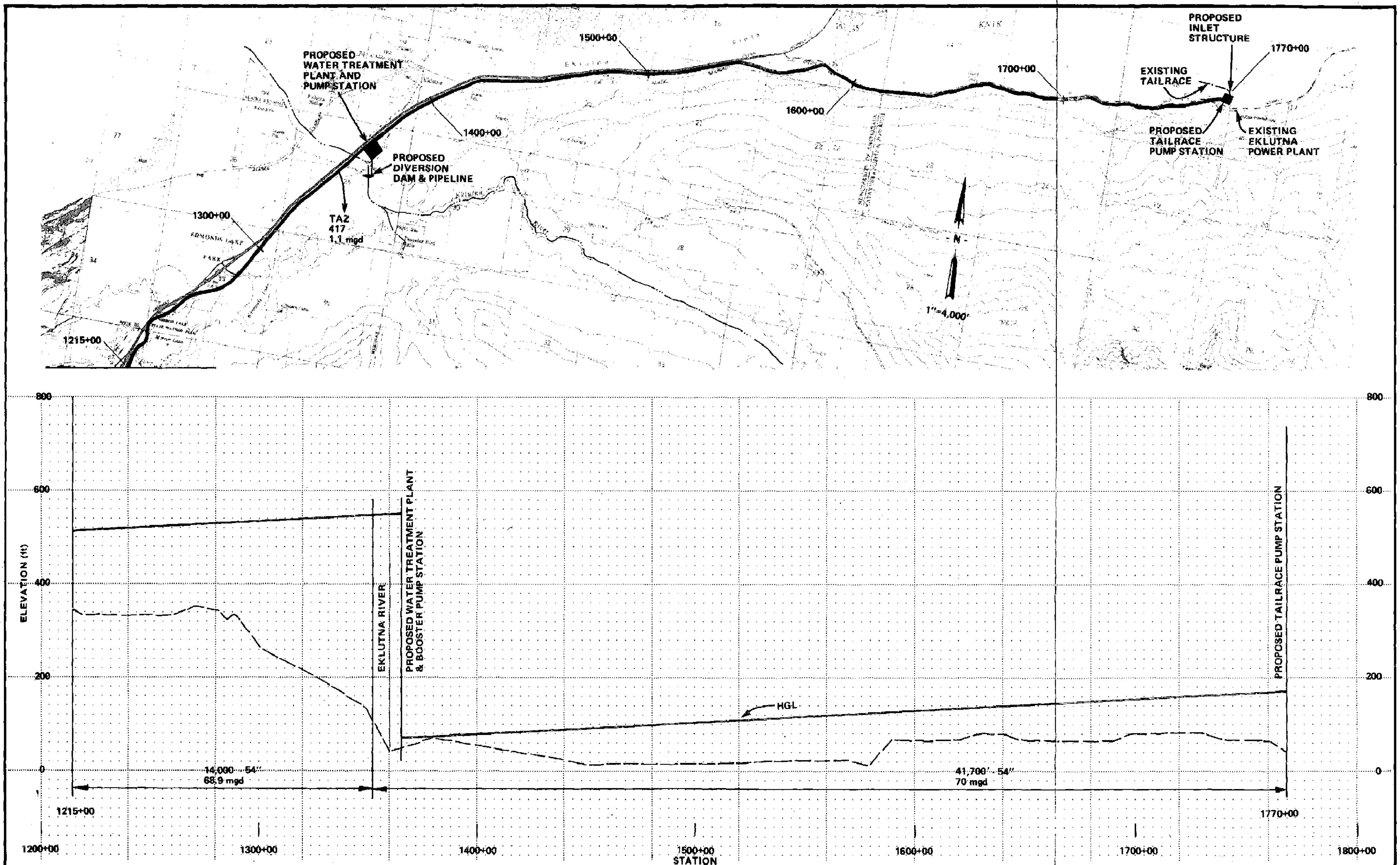


Figure 4-4
Alternative 1
Tailrace and River Diversion
Plan and Profile
Station 1215+00 to 1770+00

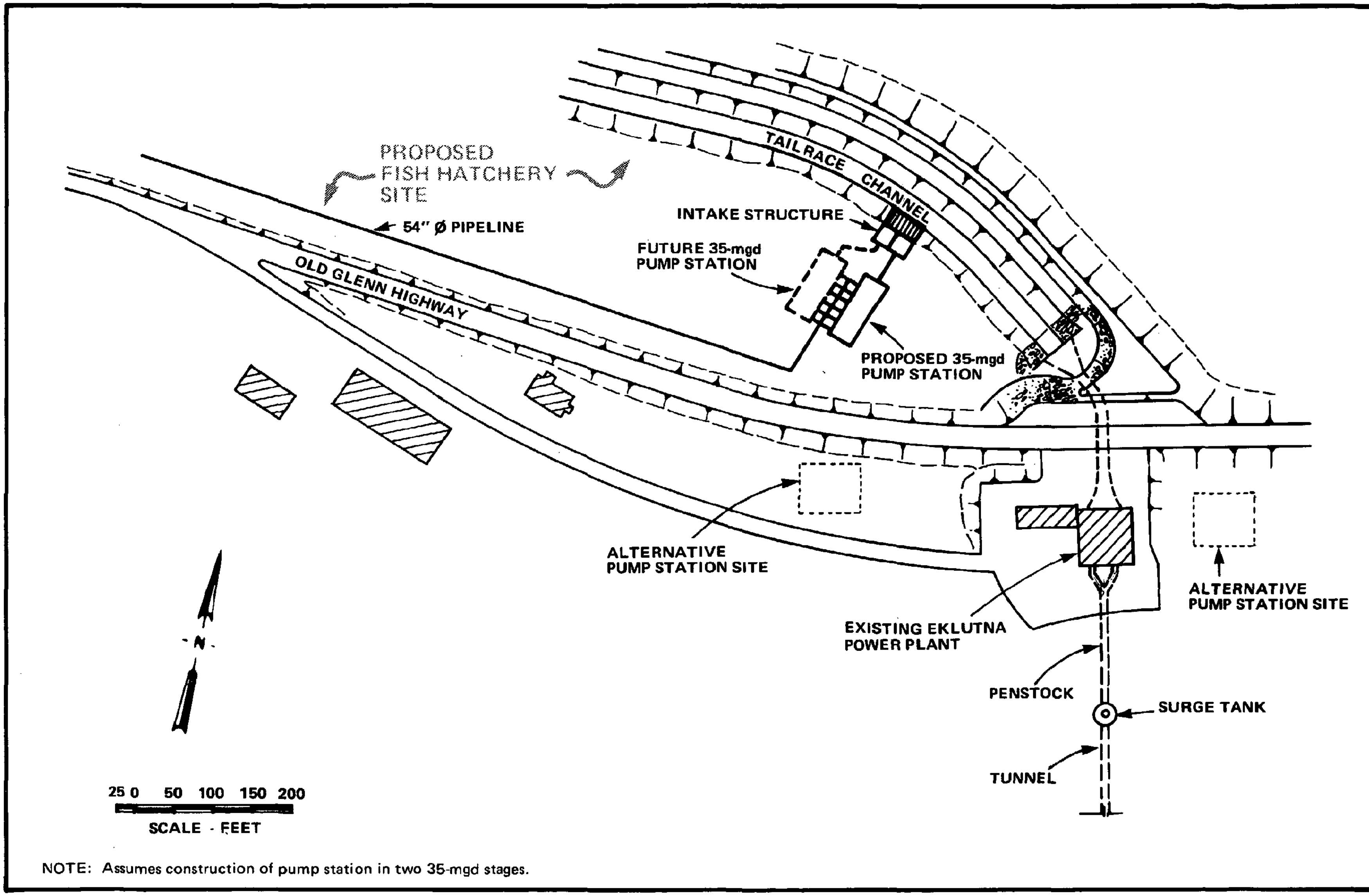
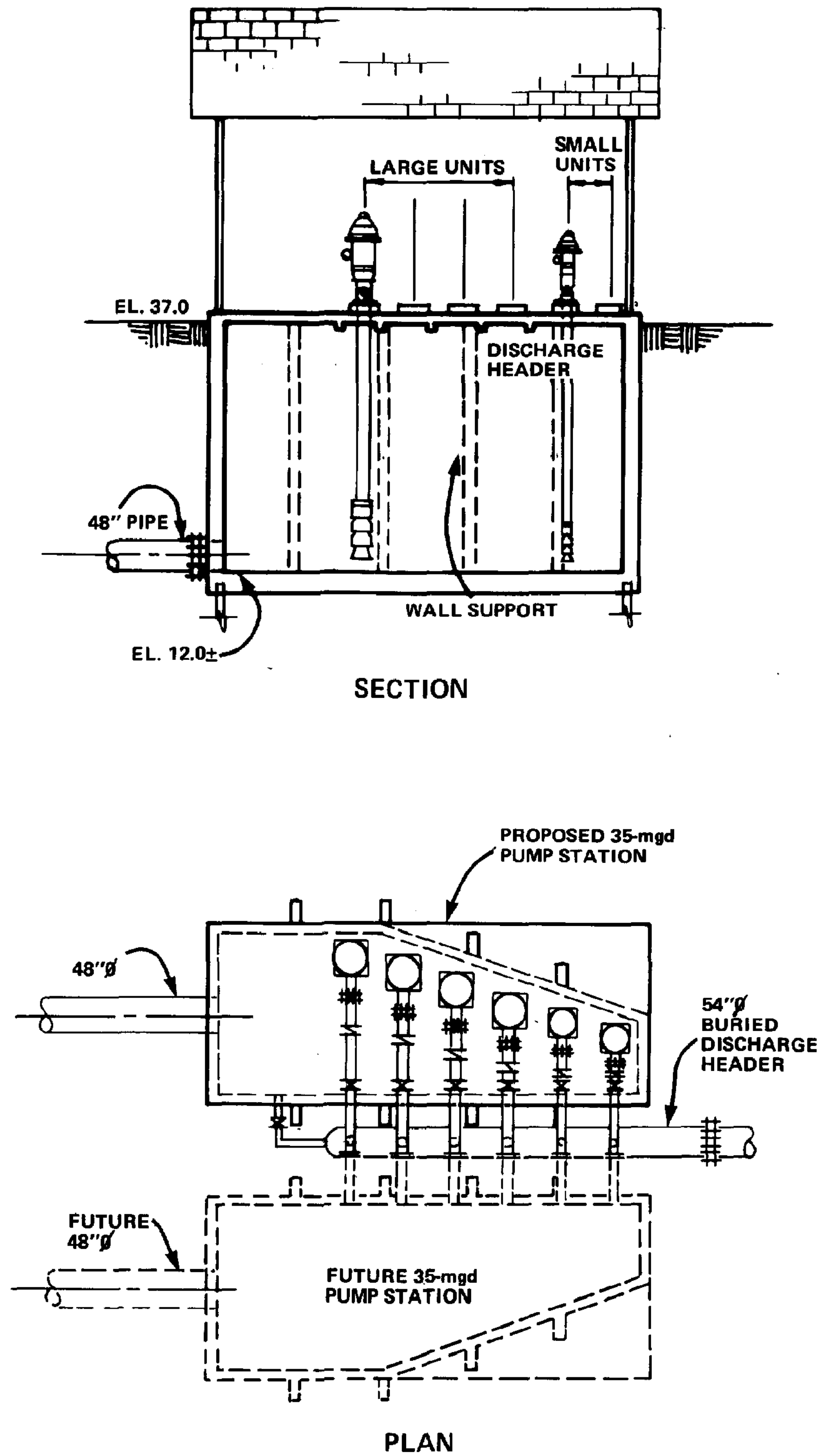
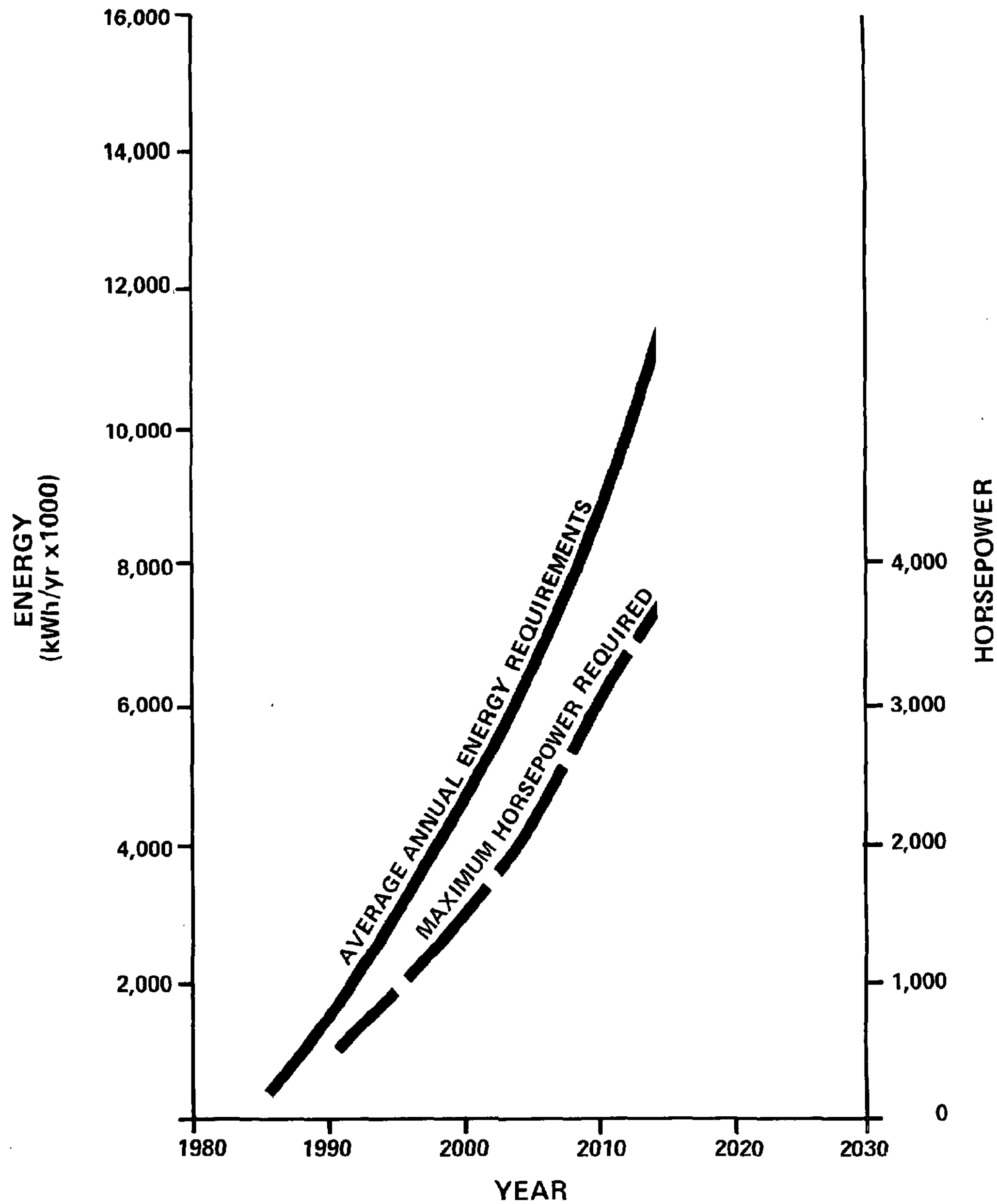


Figure 4-5
Tailrace Intake Structure and Pump Station Site Plan



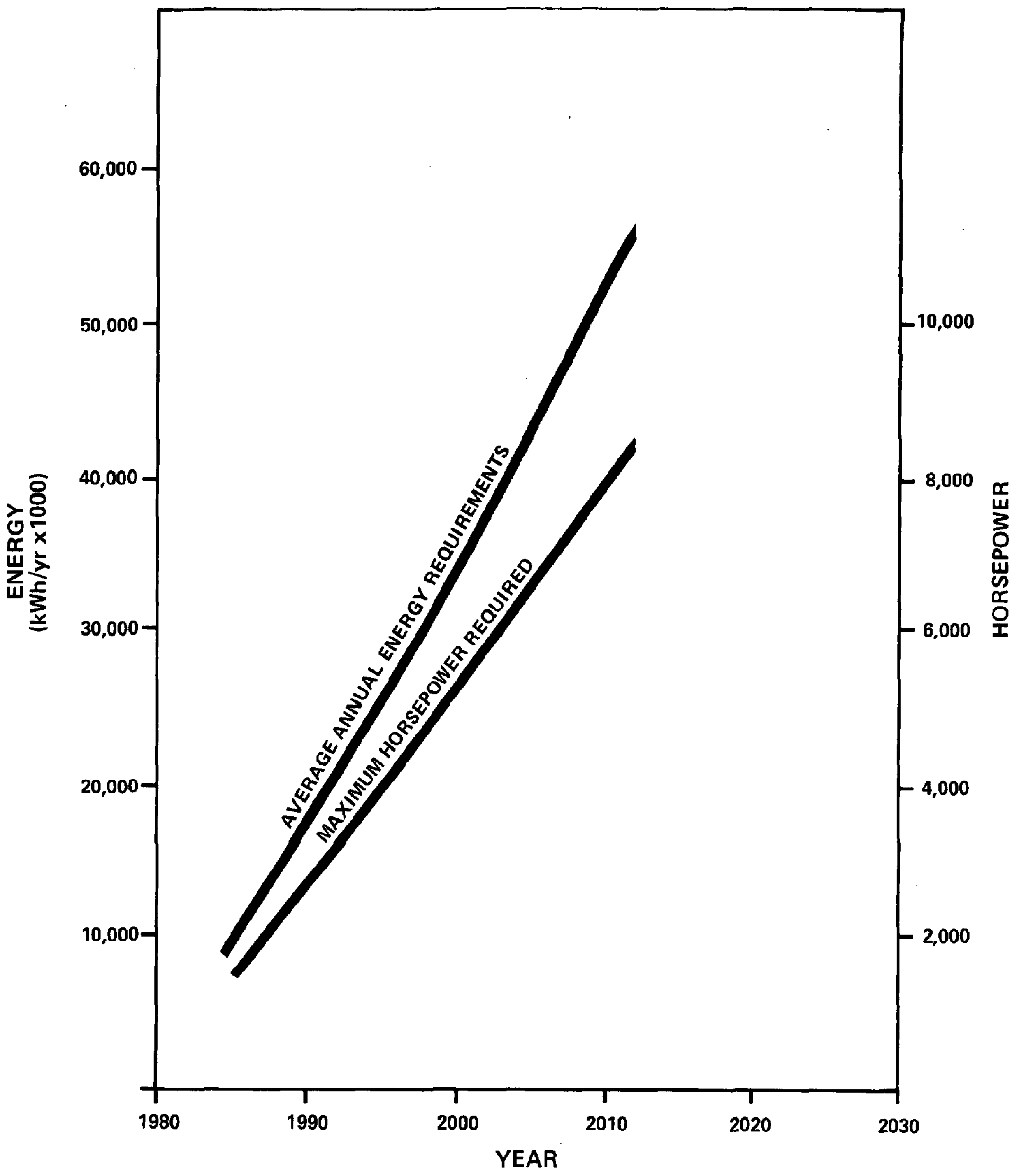
NOTE: Assumes construction of pump station in two 35-mgd stages.

Figure 4-6
Tailrace Pump Station Plan and Section



NOTE: Time base assumes no additional supplies developed within the Anchorage Bowl.

Figure 4-7
Tailrace Pump Station
Annual Energy and
Maximum Power Requirements



NOTE: Time base assumes no additional supplies developed within the Anchorage Bowl.

Figure 4-8
Eklutna River Water Treatment Plant Pump Station
Annual Energy and Maximum Power Requirements

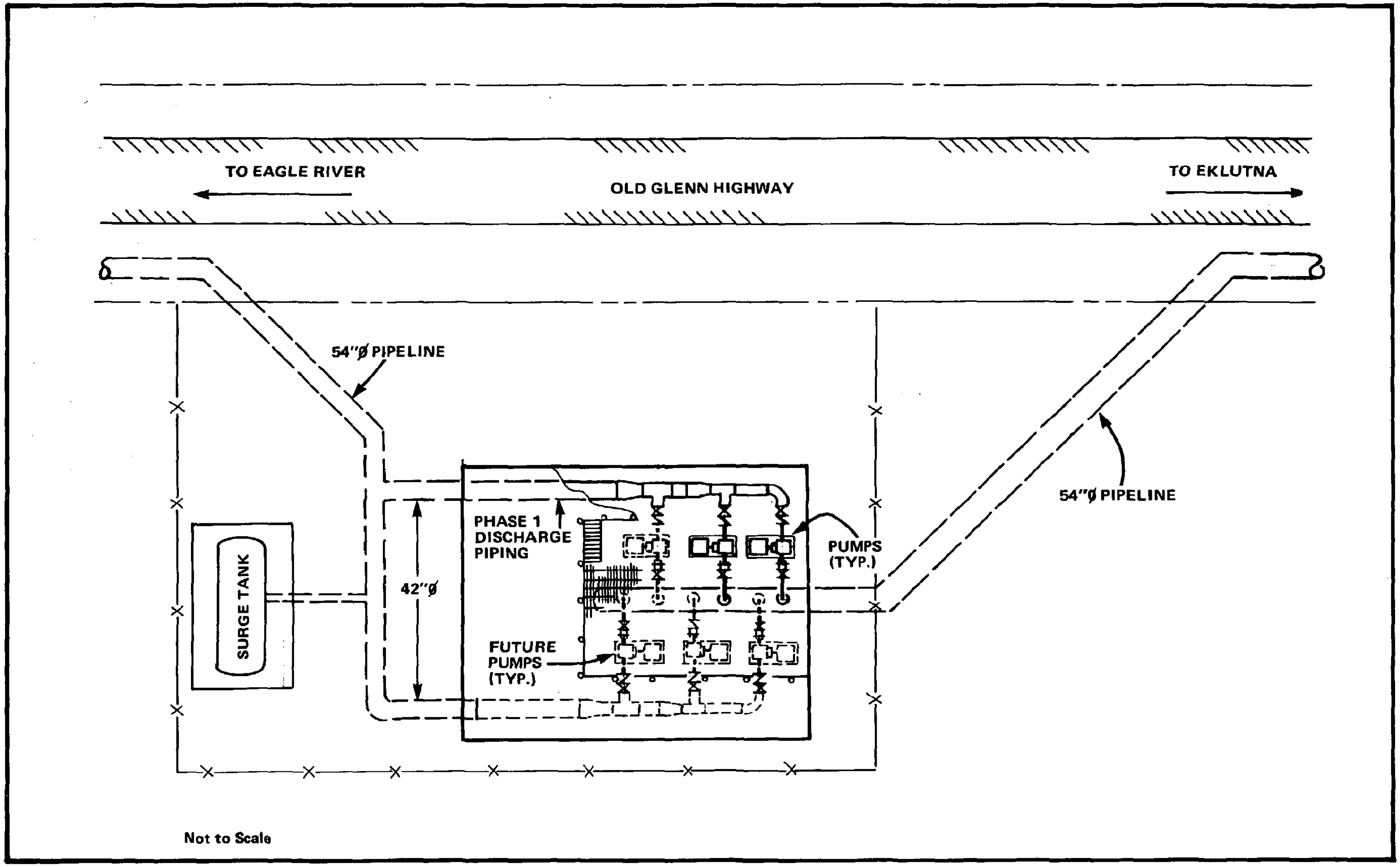


Figure 4-9
Mirror Lake Booster
Pump Station
Plan View

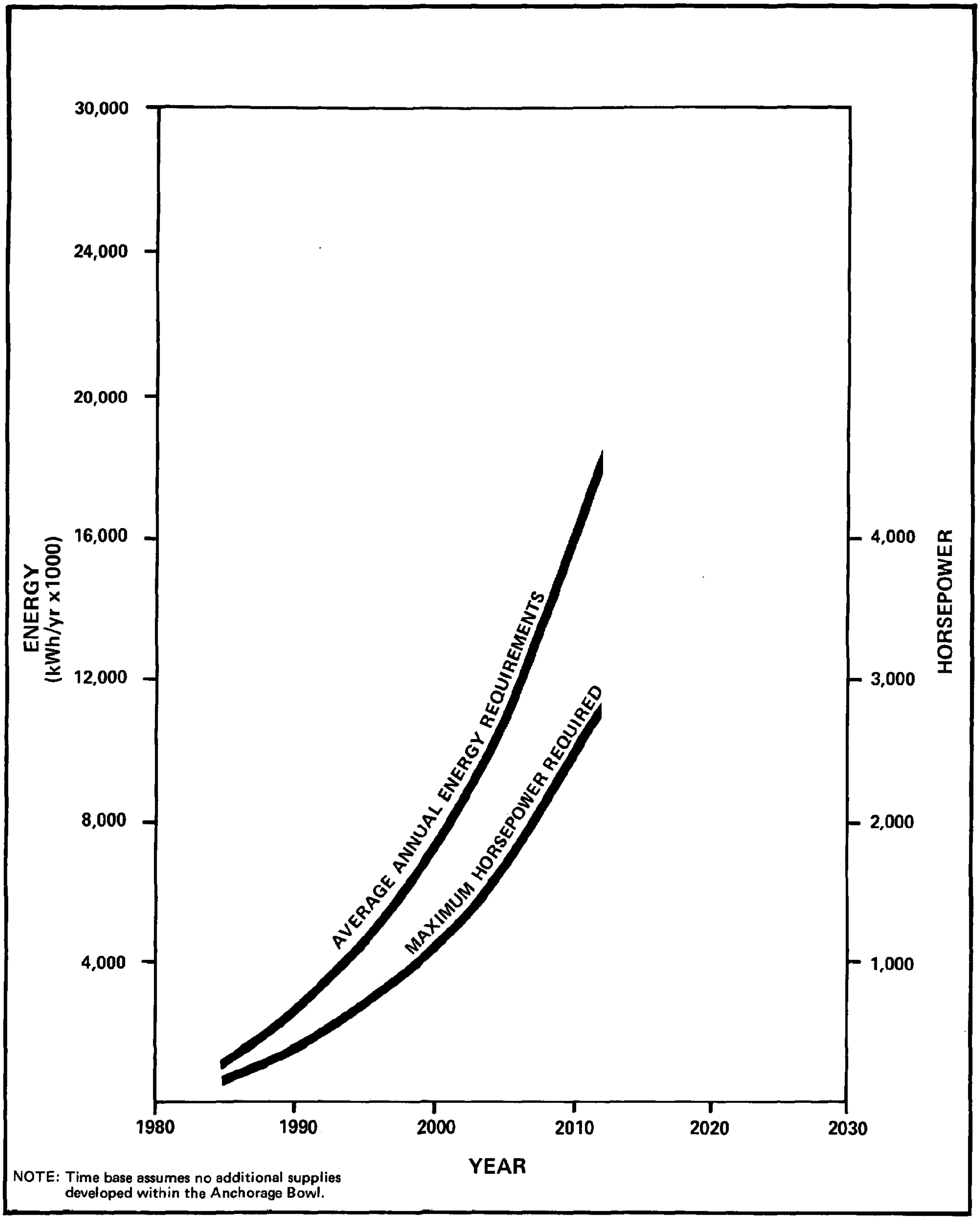


Figure 4-10
Mirror Lake Booster Pump Station Annual Energy and Maximum Power Requirements

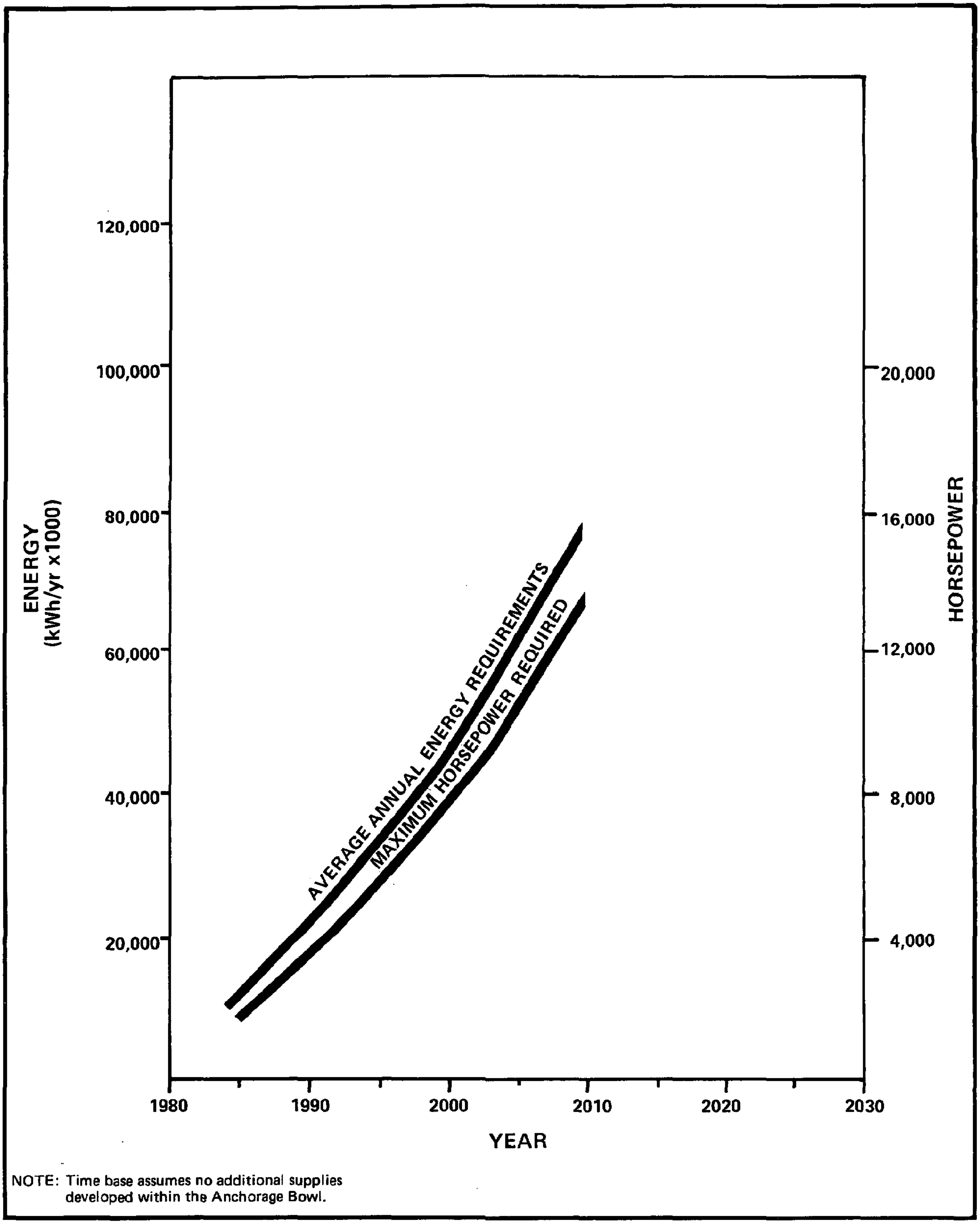


Figure 4-11
Alternative 1
Total Annual Energy and Maximum Power Requirements (Excluding Water Treatment Plant)

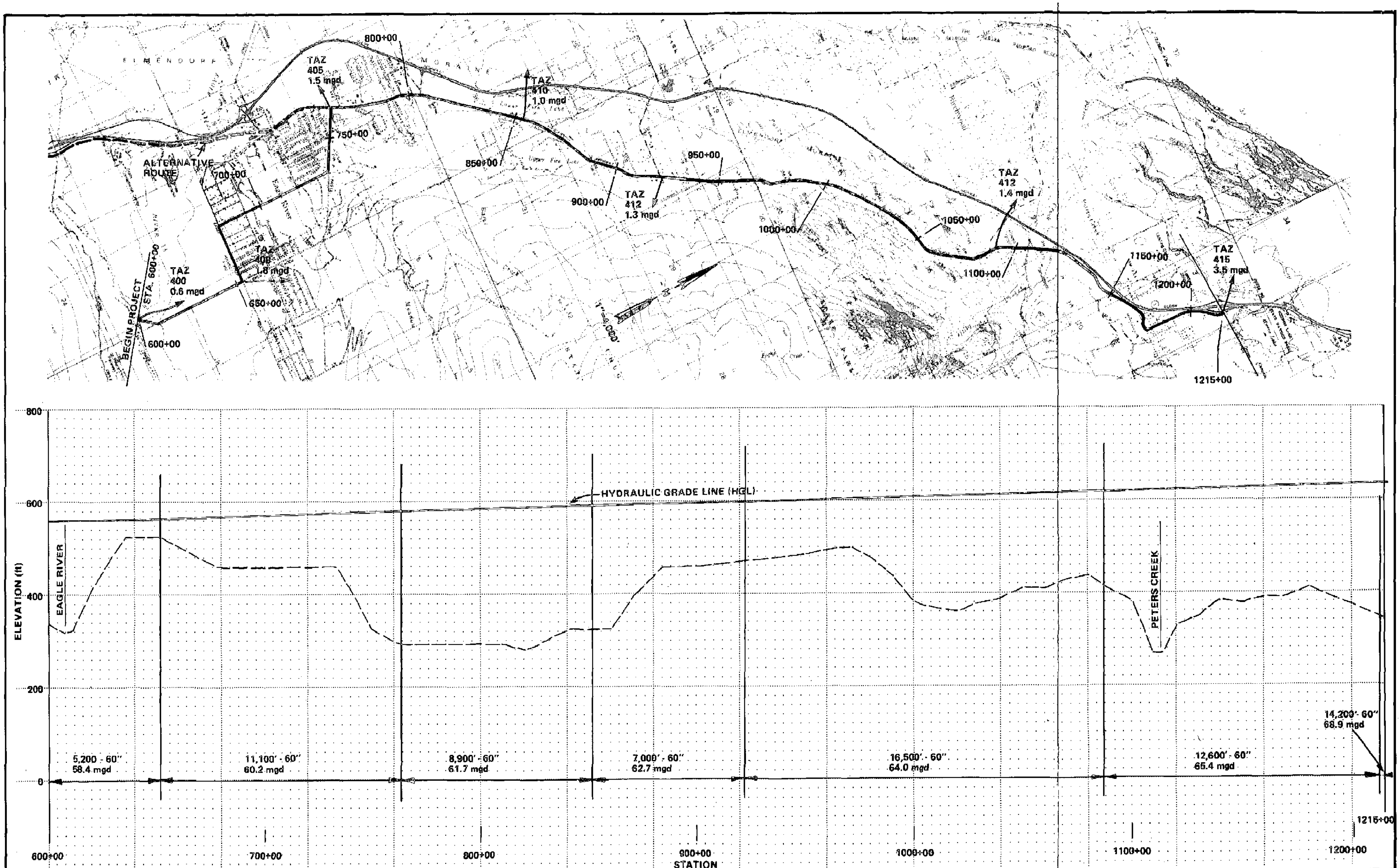


Figure 4-12
Alternative 2
Tunnel Diversion
Plan and Profile
Station 600+00 +1215+00

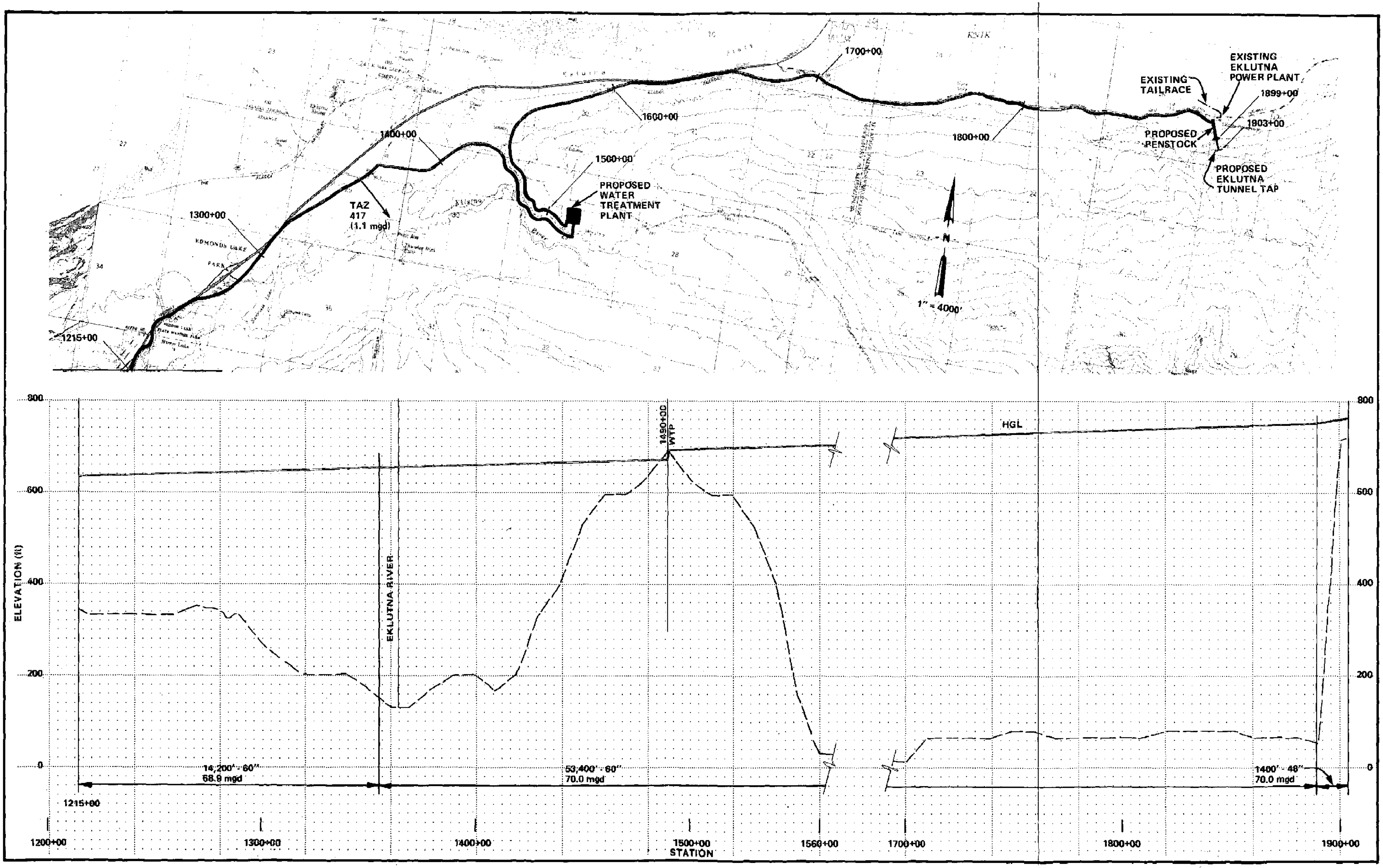


Figure 4-13
Alternative 2
Tunnel Diversion
Plan and Profile
Station 1215+00 + 1900+00

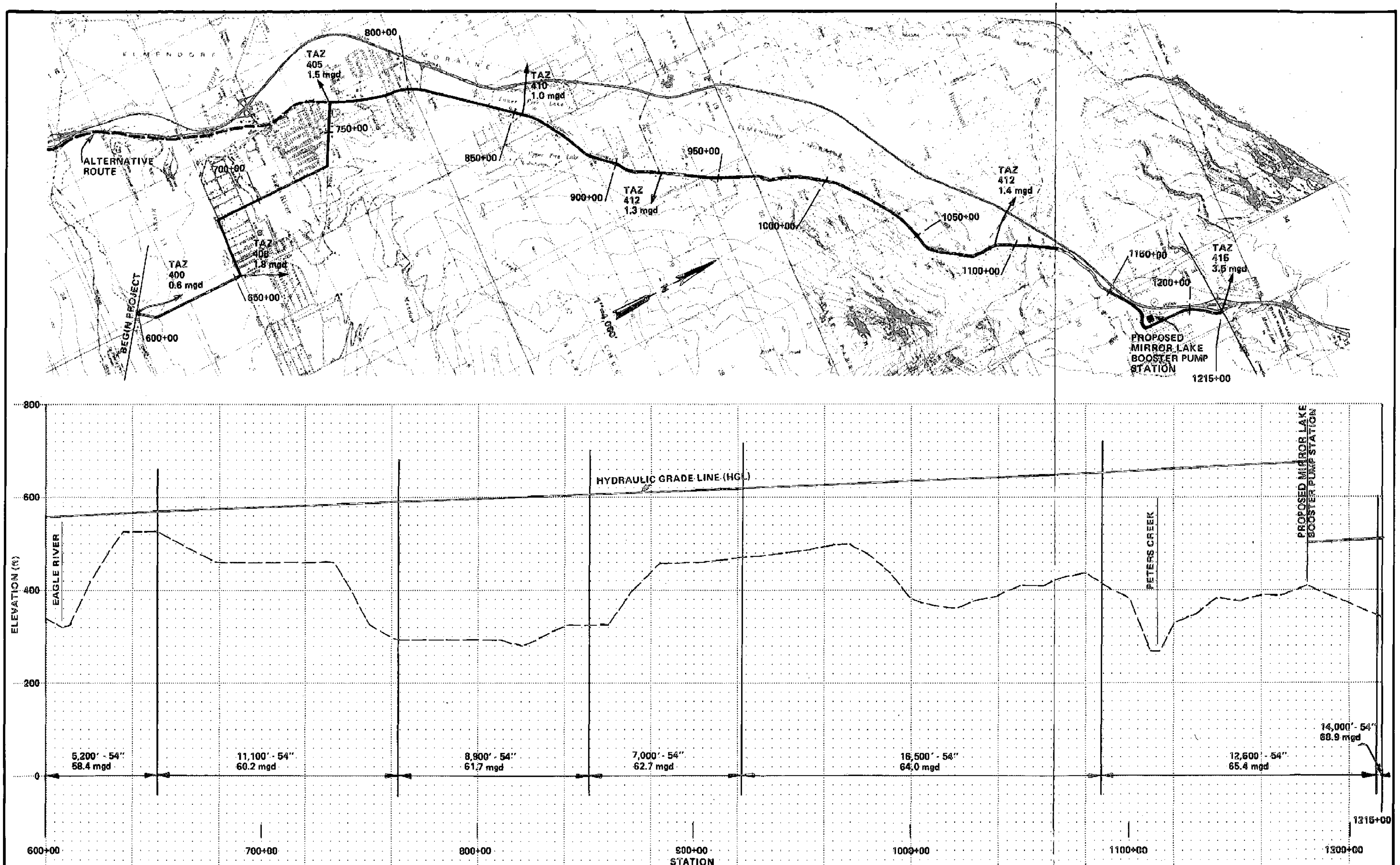


Figure 4-14
Alternative 3
Eklutna Lake and River Diversion
Plan and Profile
Station 600+00 to 1215+00

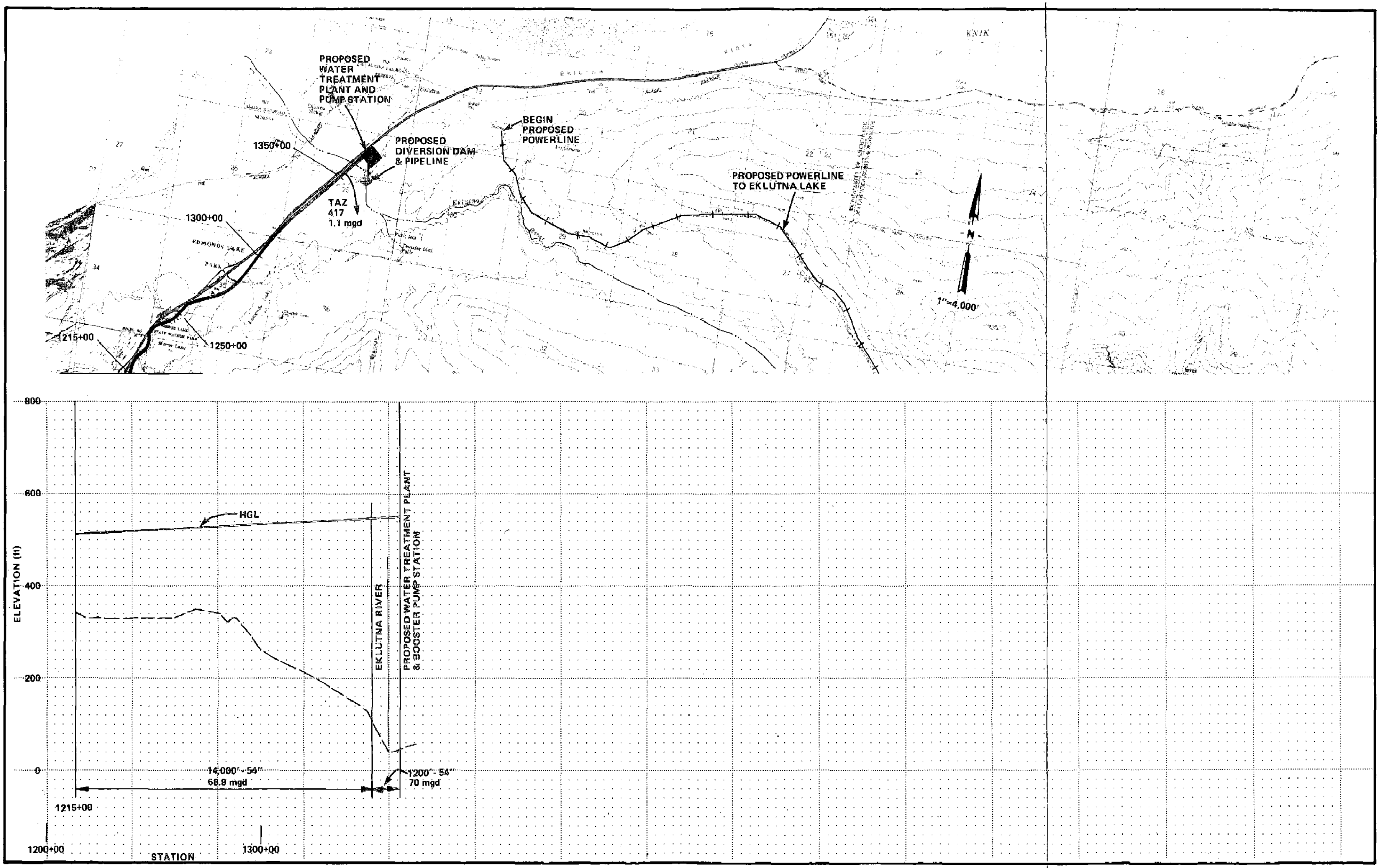


Figure 4-15
Alternative 3
Eklutna Lake and River Diversion
Plan and Profile
Station 1215+00 to 1365+00

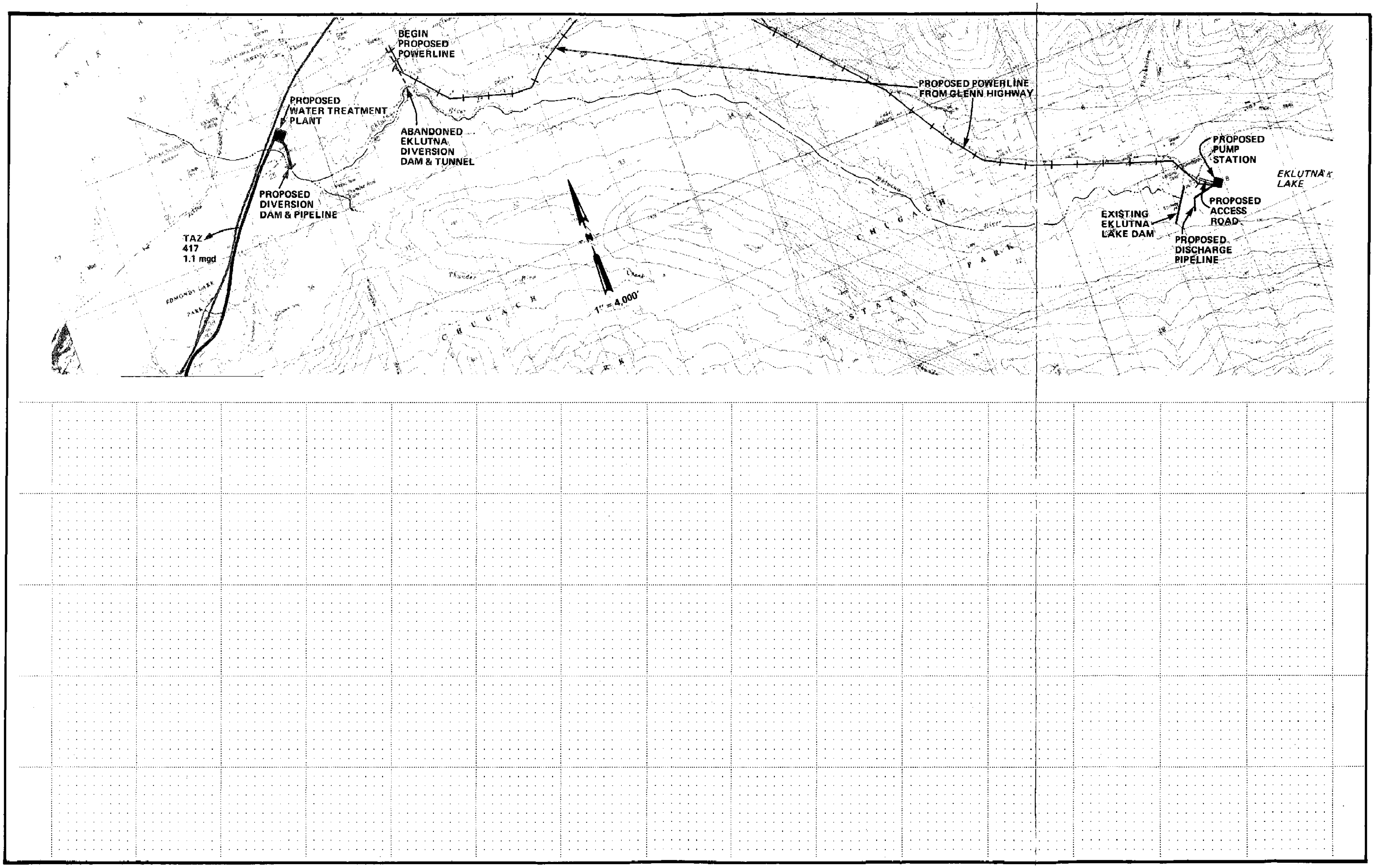


Figure 4-16
Alternative 3
Eklutna Lake and River Diversion Plan

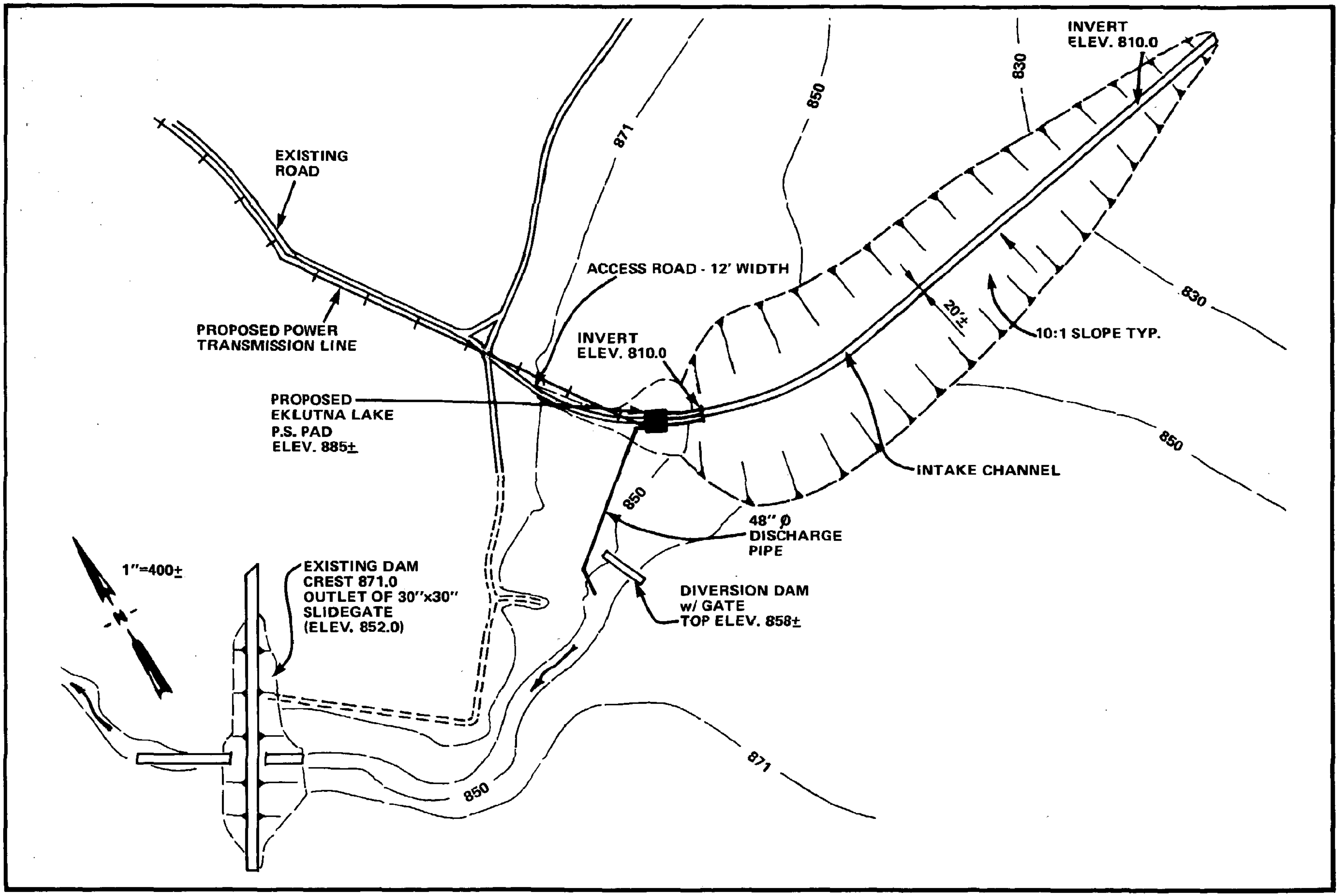


Figure 4-17
Eklutna Lake Diversion
Site Plan

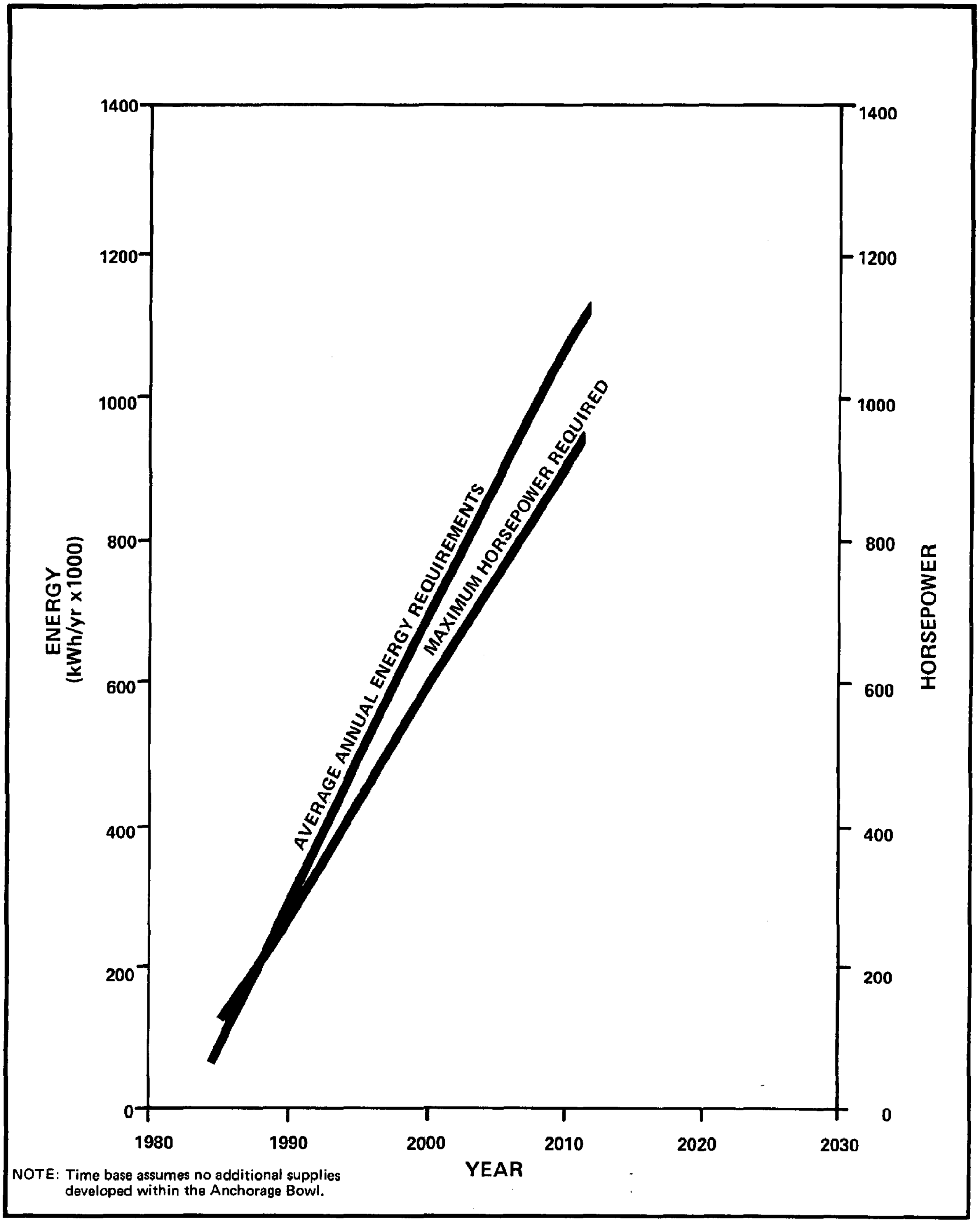
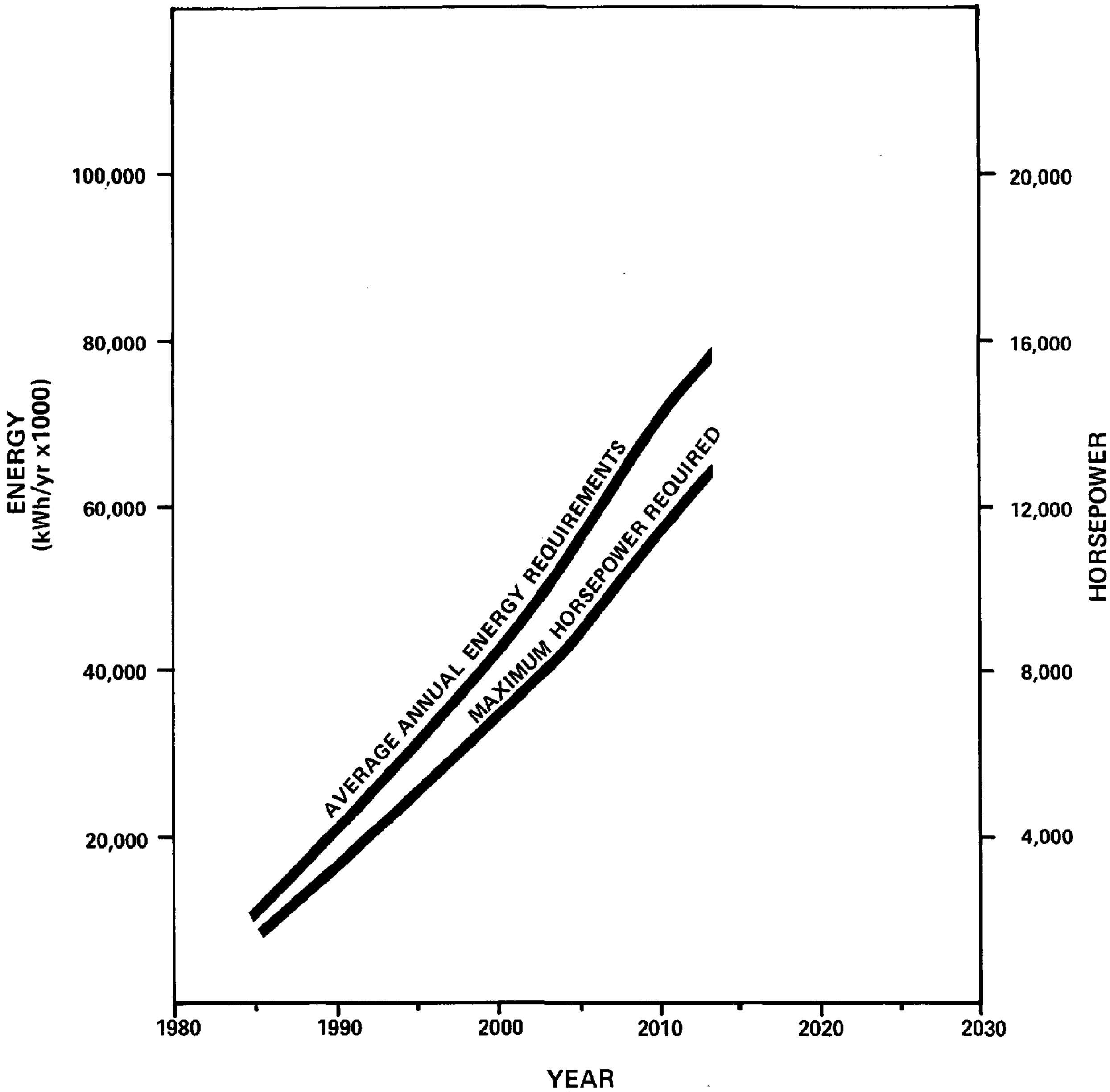


Figure 4-18
Eklutna Lake Pump Station Annual Energy and Maximum Power Requirements



NOTE: Time base assumes no additional supplies developed within the Anchorage Bowl.

Figure 4-19
Alternative 3
Total Annual Energy and Maximum Power Requirements (Excluding Water Treatment Plant)

Chapter 5
WATER QUALITY AND TREATABILITY

The objective of this chapter is to present both our investigation of the suitability of Eklutna Lake water as a potable water supply source and our comparison of Eklutna water and Eagle River water. The purpose of the comparison is to determine the need for treatment processes different from those proposed for Eagle River. This chapter is intended to complement the MAUS and to augment water quality data collected by the United States Geological Survey (USGS) between 1948 and 1973.

This chapter summarizes the USGS water quality data; presents the results and evaluation of field and laboratory tests; identifies treatment criteria and the best treatment processes for both the summer glacial melt period and the winter clear water period; and presents estimated project and annual operation and maintenance costs for a treatment plant suitable for operating the recommended processes.

DATA COLLECTION AND EVALUATION

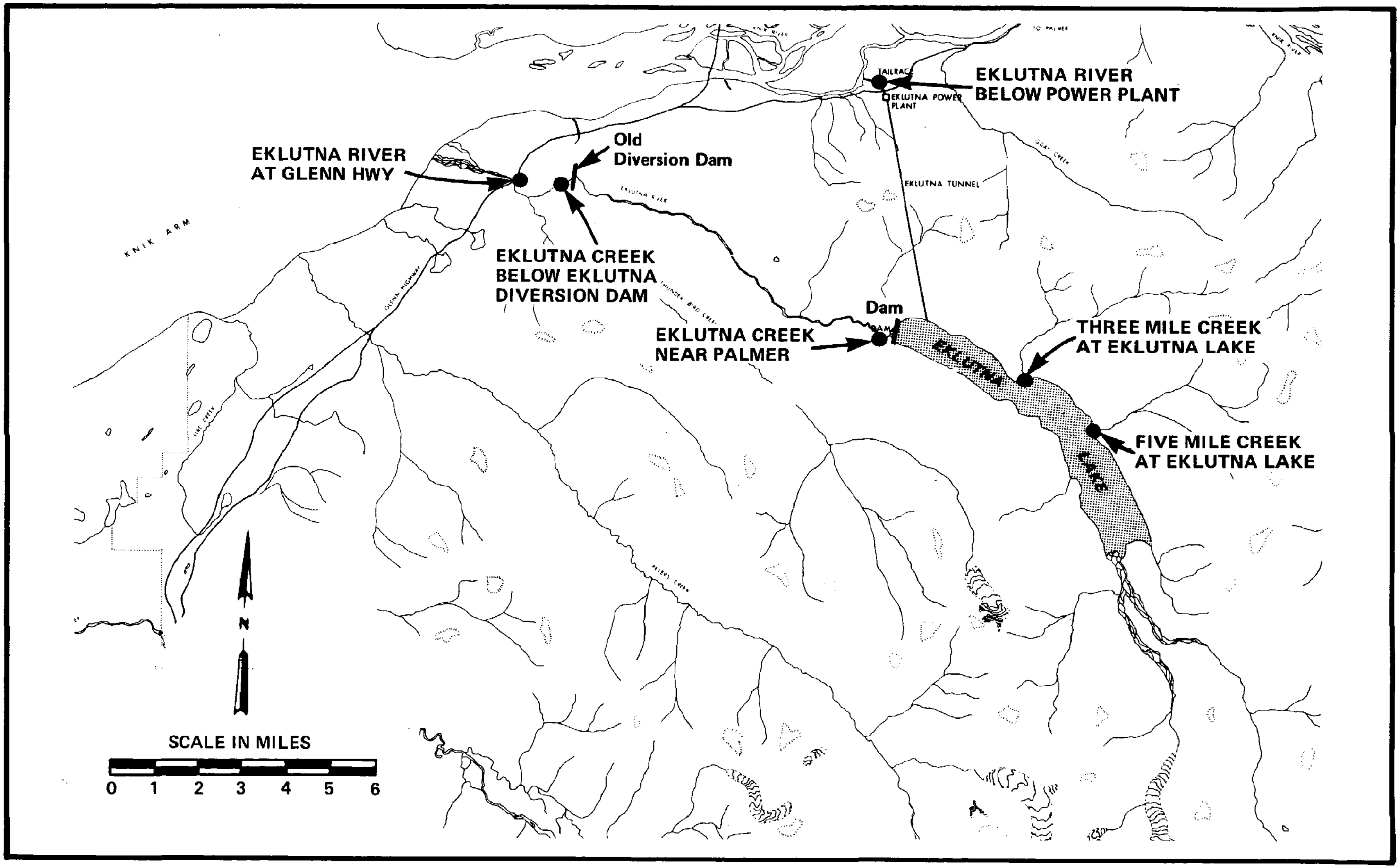
Water samples were collected during a 5-week period from the last week in September through October 1981. During this period data were gathered regularly and observations were made of variations in Eklutna Lake water quality. Because of the short study period, only a limited amount of new water quality data could be gathered. Some reliance has therefore been placed on the USGS water quality data.

USGS Water Quality Data

Water quality data collected by the USGS between 1948 and 1973 are included in Exhibit B to this appendix. Water was sampled from six different points along Eklutna Lake and the streams below the lake (Figure 5-1):

- Five Mile Creek at Eklutna Lake
- Three Mile Creek at Eklutna Lake
- Eklutna River at Glenn Highway
- Eklutna Creek near Palmer
- Eklutna Creek below Eklutna Diversion Dam
- Eklutna River below the hydroelectric facility

These data are summarized in Table 5-1. The USGS data for the sampling point below the hydroelectric facility are most applicable to this study because they represent water from essentially the same source as that sampled in September and October 1981 in the power plant. The water represented by the USGS data does contain contaminants (very small quantity) from the floor drains of the power plant, however.



SOURCE: U.S. Corps of Engineers. 1979.

Figure 5-1
USGS Water
Sampling Points

Table 5-1
COMPARISON OF EAGLE RIVER AND VARIOUS EKLUTNA WATER QUALITIES

Parameter	Eagle R	Eklutna Water: 5-Mile	3-Mile	Glenn Hwy	Near Palmer	Below Dam	Below Hydro Facility	Sept. to Oct. 1980 Powerhouse
Temp (°C)	3-8	--	--	?-11.5	0-13	?-11.5	0-12.5	8-9
Ca (mg/l)	11-21	30	34	23	19(16-21)	16-24	18-25	3.0-3.1
Fe (mg/l)	.4-4.6	--	--	.03	.01-.11	.01-.11	.01-.11	.41-.9
Mn (mg/l)	.04-.08						.01-.12	.01- .05
Silica (mg/l)	2.7-30.9	5.9	6.7	4.3-4.9	3(2.3-6.4)	1.9-8.7	2.6-6.3	3-3.1
Nitrate-N (mg/l)	.26(.1-.67)	.32	.38	.16-.27	.15	.6-.7	.11	.2-.37
Sulfate (mg/l)	.5-38	30	30	18-19	16(13-35)	14-20	13-20	10
TDS (mg/l)	71-137(41-167)	135	159	94	75(64-86)	71-100	71-88	104-105
Turbidity (NTU)		5-400						26-30
Suspended Solids (mg/l)	6.4-400						3-20	4.3-5.6
Hardness $CaCO_3$ (mg/l)	34-134	114	138	77-79	60(50-74)	65(51-93)	60(57-74)	56-61
Hardness Noncarb (mg/l)	43-78	24	23	15-16	15(9-18)	14(3-20)	11(7-19)	--
Alkalinity as								
$CaCO_3$ (mg/l)	44	90	115	62-63	45	55	50	43-46
HCO_3 (mg/l)	52	110	140	76-77	55(46-110)	65	60	--
CO_3 (mg/l)	0	0	0	0	0	0	0	--
Conductivity (umhos)	100(84-165)	219	264	161-167	130(107-214)	140(112-187)	130(120-144)	103-110
Color (cu)	30(10-70)	10	10	5	5-10	5	10(3-30)	25-55
Cl (mg/l)		0	0	1-1.4	.4-2.5	.5-5.8	.9-3.4	1-1.0
Coliform (cols/100 ml)							80-817	0
Arsenic (mg/l)							.001	.01
Ba (mg/l)							.1	.5
Cd (mg/l)							.002	.01
Cr (mg/l)							0	.01- .05
F (mg/l)		--	--	--	0-.2	0-.3	.1-1.0	.1
Pb (mg/l)							.002	.01
Hg (mg/l)							.011	—
Se (mg/l)							.001	0.01
Ag (mg/l)							0	.01- .05
Na (mg/l)		3.6	4.5	2.5-3.4	1.8	2.1-2.7	2.5-3.0	2-2.1
Mg (mg/l)		9.1	12	4.7-5.2	2.4-3.9	2.8-5.6	2.7-3.2	--
K (mg/l)		1.0	.9	--	1.1-5.8	0.6-7.5	.2-.6	--
Cu (mg/l)							.011	--
Zn (mg/l)							.05	--
pH (mg/l)	6.4-8.1	7.4	7.7	6.8-6.9	7.2(6.6-7.7)	7.3(7.0-7.8)	7.8(7.5-8.1)	7.5-7.7
CO_2 (mg/l)	--	7.0	4.5	15-20	5(2-20)	5(1.6-12)	2(.9-3.3)	--

Source: USGS Water Quality Data, 1948-1973

Sampling Location

All samples for testing done in September and October 1981 were collected from a sampling tap off the piping just upstream of the turbine inside the Eklutna power plant. This water is piped from Eklutna Lake through the 5-mile-long tunnel and penstock to the power plant, and is withdrawn from the downstream end of the Lake at approximately elevation 800, 70 feet below the full lake level. Water quality at this point should be relatively constant throughout the year. This sampling site was readily accessible and provided a convenient location to perform jar testing and take other field measurements of water quality.

Equipment

Equipment used for on-site testing included a four- and six-paddle stirrer, a Hach Model DREL turbidimeter, and a pH meter.

Tests

Tests performed at the sampling point included temperature, pH, and turbidity. Jar testing was performed to determine optimum coagulant dosage, effects of rapid and slow mixing, and floc settling rate. Testing was done weekly.

In addition to on-site testing, samples were collected and transported to an off-site laboratory for routine chemical and physical analyses. These tests were performed three times during the testing period. No particle size analysis was done. One sample was tested for radioactivity. The testing started on September 29, 1981, and continued through October 30.

Temperature

No air or surface water temperature measurements were made at Eklutna Lake during the September to October 1981 sampling period. Water temperature at the penstock sampling point in the power plant held fairly constant at 8 to 9 degrees centigrade (C). Powerhouse records indicate that average winter temperature of water in the penstock is 4 degrees C. As air temperature dropped through the month of October, it was observed that the color and turbidity of Eklutna Lake began to improve slightly.

Turbidity

Table 5-2 shows turbidity of water from the powerhouse ranging from approximately 26 NTU* to 30 NTU. Turbidity at the outlet end of Eklutna Lake is probably linked to air temperature and rate of melt of the glaciers feeding the lake, but the sampling period was not long enough to confirm this. The lake appears

*Nephelometric Turbidity Unit, a measurement of turbidity.

light greyish to green in color, which is typical of the rock flour solids that create the turbidity. Several parameters in Table 5-1 suggest that turbidity in the lake is lower at the outlet end, and possibly more constant. The USGS data contain direct measurements of turbidity only for the sampling point below the hydroelectric facility. There, turbidity does change over the year in response to glacial melt.

Table 5-2
FIELD TEST QUALITY RESULTS

Parameter	1981 Sept 29	Oct 5	Oct 9	Oct 16	Oct 23	Oct 29
Temp (°C)	9	8	9	8	8	8
Turbidity (NTU)	30	30	30	30	26, 28	26
pH	7.7	7.5	7.6	7.65	7.6	7.6

Samples were analyzed for both dissolved and suspended solids. Results are shown in Table 5-3. The rough correlation between turbidity and suspended solids demonstrated for Eagle River in Appendix III was also found in this study, with turbidity ranging from 1.1 to 1.5 times suspended solids in the colder months to 3 times the suspended solids during the glacial melt season. As shown in Table 5-1, dissolved solids measured at the powerhouse are less than those found at Five Mile and Three Mile Creeks, but more than those downstream of the dam. Suspended solids particles that cause turbidity were not analyzed for size distribution.

The data from tests taken during our testing period resemble the USGS data. Suspended solids measurements and turbidity generally agree with historic data.

pH

The pH of Eklutna Lake water varies between 7.0 and 7.8. This information is tabulated in Tables 5-1 and 5-2.

Alkalinity and Hardness

According to the USGS data (Table 5-1) alkalinity and hardness appear to be relatively constant for a given location in the lake and seem to correlate with turbidity. Both alkalinity and hardness decrease downstream of Three Mile and Five Mile Creeks. Alkalinity varies from 45 to 60 mg/l; hardness varies from 60 to 90 mg/l. Both alkalinity and hardness are expressed in milligrams per liter as $CaCO_3$ (see Tables 5-1 and 5-3). The higher

Table 5-3
LABORATORY TEST QUALITY RESULTS

Parameter	1981				
	Sept 29	Oct 6	Oct 9	Oct 16	Oct 23
Ca (mg/l)	18		18		19
Fe (mg/l)	0.9		0.41		0.65
Mn (mg/l)	0.02		0.01		0.05
Si/SiO_2 (mg/l)	3.1		2.8		3.0
Nitrate-N (mg/l)	0.37		0.20		0.23
Sulfate (mg/l)	10		12		10
TDS (mg/l)	105		65		104
Suspended solids (mg/l)	4.3		5.6		4.3
Hardness $CaCO_3$ (mg/l)	59		56		61
Alkalinity as $CaCO_3$	43		46		44
Conductivity (umhos)	110		103		110
Color (cu)	55		25		40
Chloride (mg/l)	1		1		1.0
Coliform (cols/100 ml)	0		0		0
As (mg/l)	0.01		0.01		
Ba (mg/l)	0.5		0.5		
Cd (mg/l)	0.010		0.010		
Cr (mg/l)	0.01		0.05		
F (mg/l	0.10		0.10		
Pb (mg/l)	0.01		0.01		
Hg (mg/l)	0.001		0.001		
Se (mg/l)	0.01		0.01		
Ag (mg/l)	0.05		0.01		
Na (mg/l)	2.0		2.1		
Organics					
Endrin (mg/l)	0.0002		0.0002		
Lindane (mg/l)	0.004		0.004		
Methoxychlor (mg/l)	0.1		0.1		
Toxaphene (mg/l)	0.005		0.005		
2,4-D (mg/l)	0.1		0.1		
2,4,5-TP Silvex (mg/l)	0.01		0.01		
Radionuclides					
Gross Alpha Particle (pCi/l)	0.6 ± 0.7				
Gross Beta Particle (pCi/l)	4.5 ± 5.6				

level of hardness (approximately 150 mg/l) reported in the MAUS report are not indicated in the USGS data nor by our laboratory tests.

Iron and Color

According to the USGS data (Table 5-1 and Exhibit B), iron and color content appear to be less, on the average, at all USGS sampling points than at the power plant. Also, both iron and color are higher than the EPA treatment goals only during the glacial melt period.

Jar Testing

Jar testing is a bench-scale test used to give coagulation and settling insight into full-scale processes. The primary purpose of jar testing in this task was to determine how different coagulant (alum) dosages react over the range of raw water quality sampled from the powerhouse. When the optimum alum dosage was determined, other parameters were investigated to refine further the treatment requirements of Eklutna Lake water. Those parameters included the effects of rapid and slow mixing rates and of the duration of mixing.

As in Eagle River water testing, initial jar testing of Eklutna Lake water showed that two separate alum dosages achieved coagulation and clarification within a broad range of alum dosage. Figure 5-2 shows alum dosage plotted against turbidity after mixing and settling. The plot shows four distinct zones that occur frequently in treating highly turbid water. From left to right, the zones can be described as follows: (1) insufficient alum, thus no coagulation; (2) effective alum dosage, which achieves coagulation-clarification through destabilization of turbidity particles; (3) another zone of ineffective coagulation; and (4) a second zone of effective coagulation-clarification, this time resulting from adsorption and enmeshment of turbidity particles.

Plant-scale operation would use Zone 2 rather than Zone 4 for alum dosage since less chemical is used and a reduced volume of sludge is produced. Subsequent testing focused on this lower dosage zone to establish how dosage requirements varied with changing lake turbidity and temperature. Over the 5-week test period, raw water turbidity varied only slightly, from 26 to 30 NTU, and raw water temperature was nearly constant at 8° to 9°C. No significant change in alum dosage was required. The optimum alum dosage for the test program was between 10 and 15 mg/l.

The jar testing results showed that turbidity can be removed effectively through use of coagulation, flocculation, and sedimentation. The settled water produced from these procedures has a turbidity of 10 NTU or less. Figure 5-3 shows a typical plot of alum dosage against turbidity after settling.

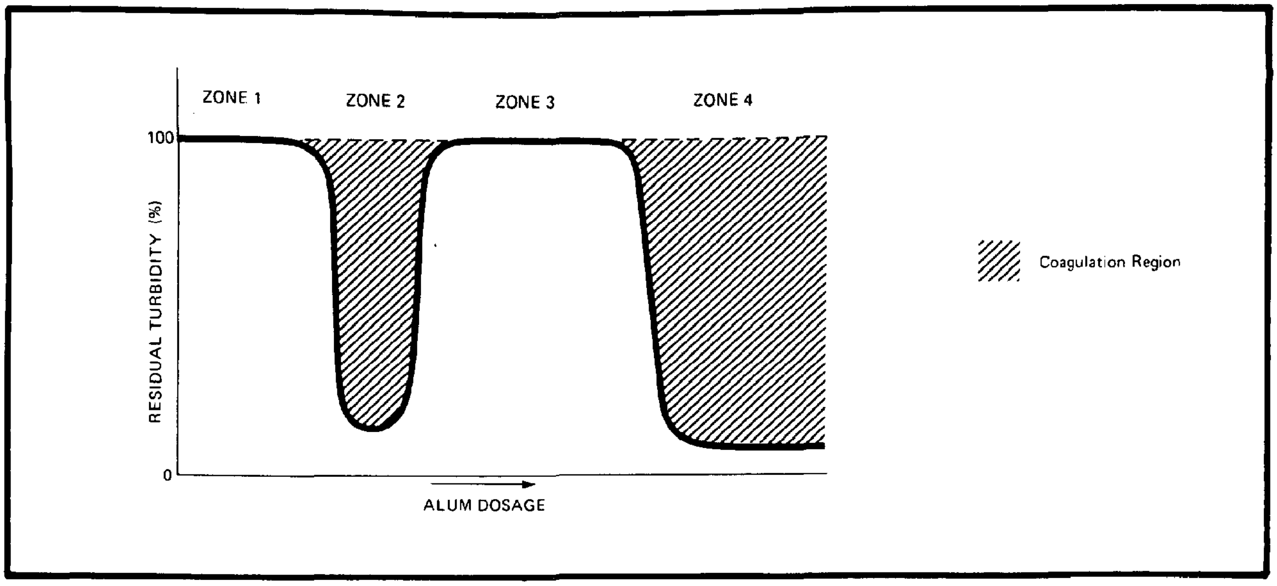


Figure 5-2
Coagulation of Water With High Turbidity

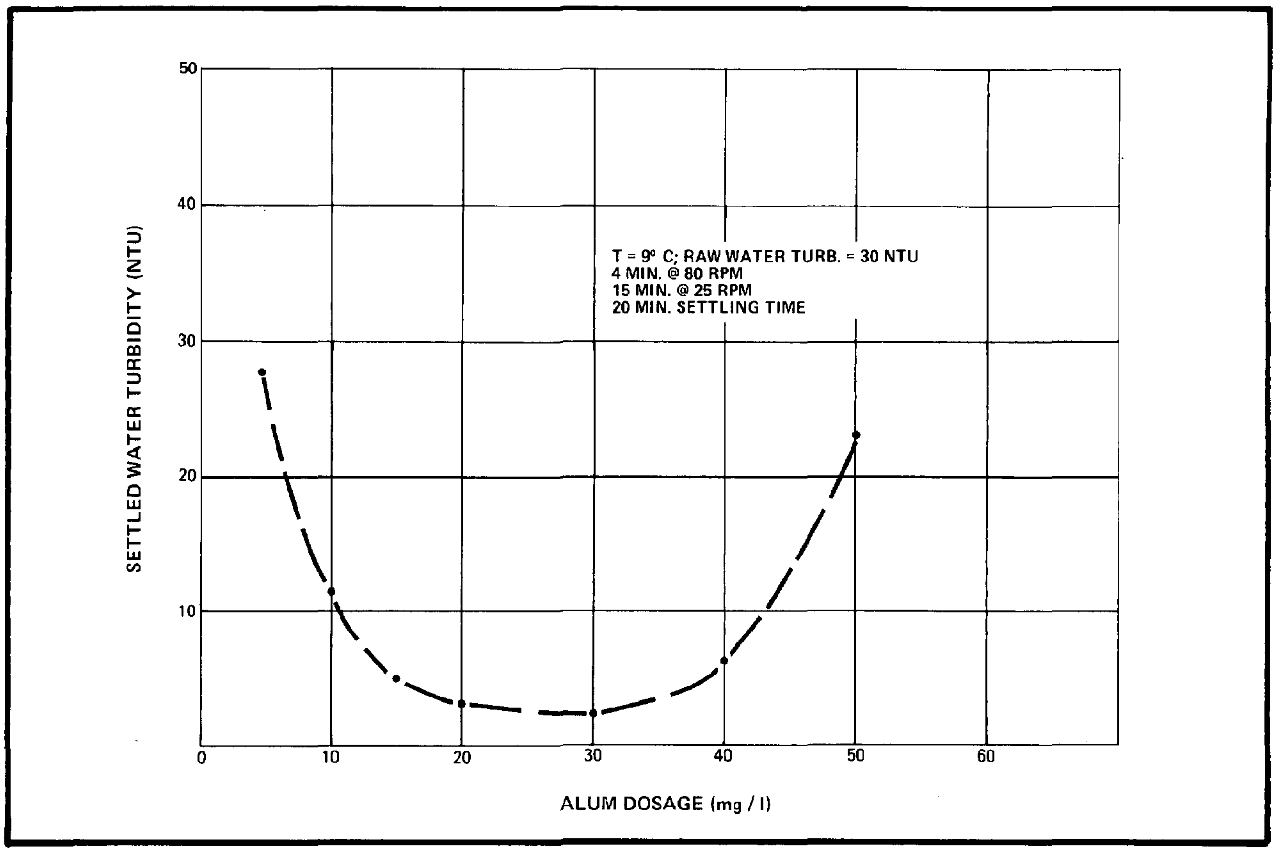


Figure 5-3
Settled Water Turbidity vs Alum Dosage

No testing was done to determine the effect of warming the water. Temperature variation tests on Eagle River water indicated little change in treated water quality. There is only a slight possibility that lake water could be preheated as it enters the treatment plant by waste heat energy from another source.

Additional testing established, in a general sense, the effect of varying either or both rapid mixing and slow mixing on floc formation and settling characteristics. Rapid mixing worked best with the stirrer set at 80 to 90 rpm for 3 to 4 minutes, and the slow mixing appeared to be most effective at 30 to 40 rpm for 12 to 15 minutes. Using optimum rapid and slow mixing, the best observed settled water characteristics resulted after 20 to 25 minutes. No attempt was made to correlate the jar stirrer with plant-scale mixing equipment. Figure 5-4 illustrates the typical relationship between settled water turbidity and settling time.

Because the alum dosage requirement was so low, the testing period was short, and the results using alum with Eklutna Lake and Eagle River water were similar, no testing was done using polymers as a substitute coagulant or as a coagulant aid.

It was observed that coagulation using 10 to 15 mg/l of alum resulted in a small decrease in pH from 7.5 to 7.2. (The use of alum as a coagulant has a side effect of lowering the pH of the water.) Lowering the pH often increases the corrosiveness of the water to piping systems and household plumbing. Because the lowering of the pH in this case is small, it may not be necessary to add lime to raise the pH after coagulation to reduce corrosion. Lime systems are typically a nuisance both to operate and maintain. Further investigation is needed during pilot plant testing.

TREATMENT REQUIREMENTS AND DESIGN CONSIDERATIONS

Treatment Goals

Treatment goals should achieve or exceed EPA standards as set forth in the National Interim Primary and Secondary Drinking Water Regulations and State of Alaska drinking water regulations.

Table 5-4 lists many of the more common water quality parameters and shows both EPA Maximum Contaminant Level (MCL) standards and natural levels in Eklutna Lake water taken from the power plant. More complete analyses including heavy metals, organic chemicals, and biological quality should be conducted before the design of treatment facilities begins, if Eklutna Lake is selected as a principal water supply source.

Raw Water Treatability

Based on the USGS water quality data and the water sampled from the power plant, Eklutna Lake displays relatively constant water

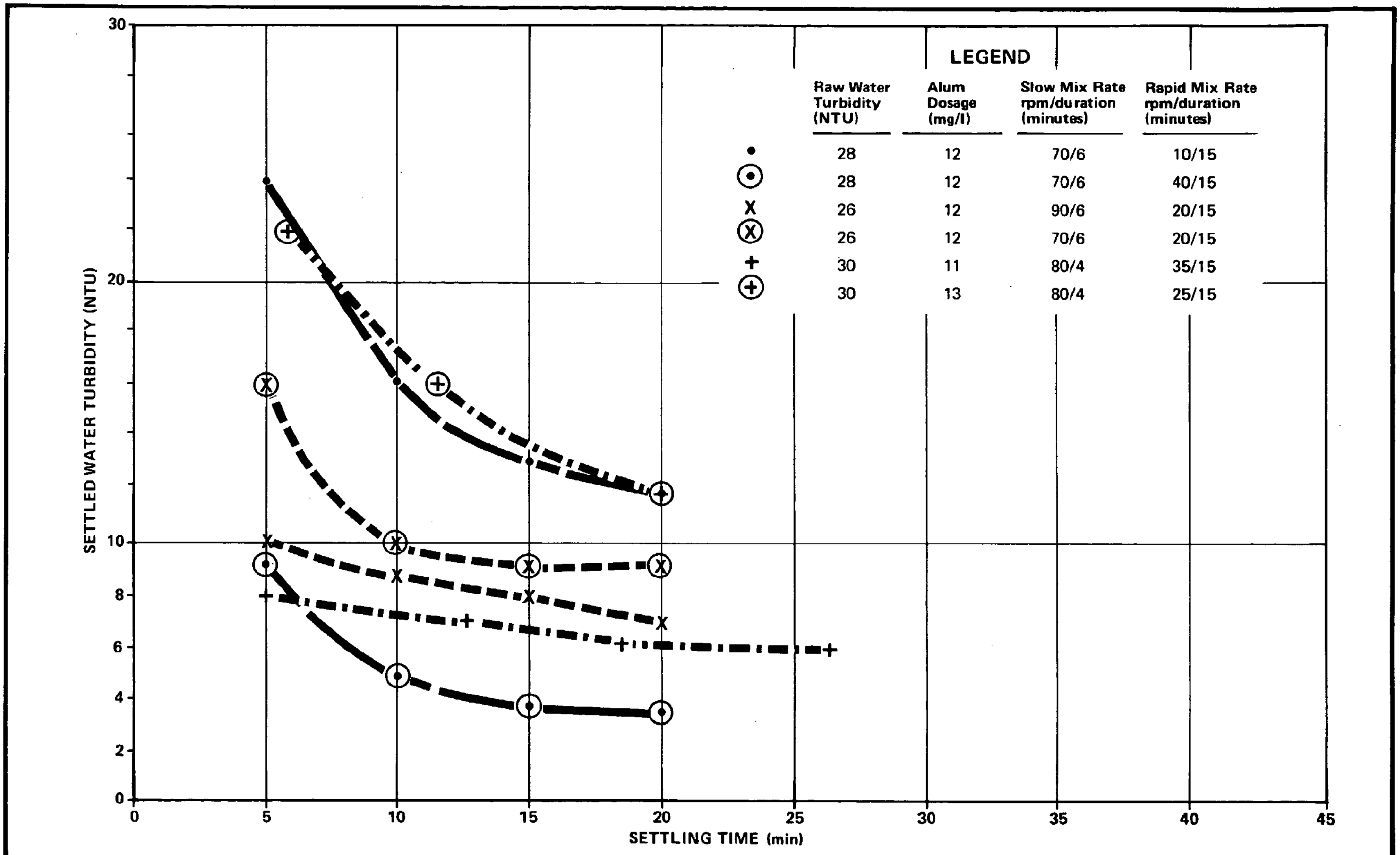


Figure 5-4
Settled Water Turbidity vs Settling Time for Various Mixed Speeds

Table 5-4
WATER QUALITY STANDARDS AND
EKLUTNA LAKE QUALITY

	EPA (MCL)[a]	Eklutna Lake (Power Plant)
Physical Factors		
Color (platinum cobalt units)	15	25-55[c]
Odor (threshold odor No.)	3	--
Turbidity (NTU)	1	26-30[c]
Suspended Solids (mg/l)	--	4.3-5.6
Conductivity (umhos)		103-110
Coliform (No./100 ml)	1	0
pH	6.5-8.5	7.5-7.7
Chemical Factors (mg/l)		
Iron	0.3	.41-.9[c]
Manganese	0.05	0.1-0.5
Chloride	250	1-1.0
Sulfate	250	10
Copper	1	--
Nitrate-N	10	.2-.37
Fluoride	2.4[b]	.1
Alkalinity (mg/l)		43-46
Hardness	--	56-61
Dissolved Solids	500	104-105
THM	0.10	
Arsenic	0.05	.01
Barium	1.0	.5
Cadmium	0.010	.01
Chromium	0.05	.01- .05
Lead	0.05	.01
Mercury	0.002	.001
Selenium	0.01	.01
Silver	0.05	.01- .05
Sodium	20	2.-2.1
Zinc	5	--
Calcium	--	18-19
SiO_2	--	3.0-3.1
Organics		
Endrin	.0002	.0002
Lindane	.004	.004
Methoxychlor	.1	.1
Toxaphene	.005	.005
2,4-D	.1	.1
2,4,5-TP Silvex	.01	.01
Radionuclides		
Gross Alpha Particle (pCi/l)	15	0.6±0.7
Gross Beta Particle (pCi/l)	50	4.5±5.6

[a]Maximum Contaminant Level.
[b]Maximum for annual average maximum daily air temperature 50 degrees F.
[c]These parameters exceed EPA MCL's.

quality characteristics. During the 8 coldest months when glacial melt ceases, the lake water is colder (approximately 4 degrees centigrade) with low turbidity (approximately 4 to 25 NTU). During the summer, warmer weather and glacial melting increase water temperatures to 8 or 10 degrees centigrade, and turbidities range from 25 to 40 NTU. The higher turbidity caused by glacial flour is not likely to present a greater treatment problem. It is cold, low-turbidity water that generally presents the greatest treatment problems.

In general, Eklutna Lake raw water will provide an excellent source of potable water. Only turbidity, color, and iron exceed the MCL established by the EPA regulations. The proposed treatment processes should reduce all of these parameters to acceptable limits. This will be verified during pilot plant testing, which is recommended as a part of subsequent predesign activities.

Treatment Process

On the basis of the limited year-round water quality data presently available, it appears that different water treatment operational modes will be required to accommodate summer and winter variations most efficiently. Figure 5-5 illustrates each of three possible operational modes. The first, conventional treatment, includes flash-mixing of coagulants, flocculation, sedimentation, and filtration. This mode would be applicable during the summer months when the lake water turbidity and color are each over approximately 20 units.

Direct filtration involves most of the above facilities but would bypass the sedimentation basins. In-line filtration would bypass the flocculation and sedimentation basins and would move the coagulant application point closer to the filters. Both direct and in-line filtration should be applicable for Eklutna Lake water treatment during the late fall, winter, and spring months when glacial melt is at a minimum and, therefore, raw water turbidity and color are each less than approximately 20 units and iron content is low. Because of the cold water temperature and the small coagulant dosages required, it is not likely that direct or in-line filtration alone will be sufficient to remove the required amounts of color and iron in the summer months; therefore conventional treatment capability should be provided. Because the available data indicate a hardness of less than 100 mg/l, there is no apparent need for a lime softening process as suggested in the MAUS report.

Conventional treatment is compatible with either the direct or in-line filtration process. The seasonal transition from one process to the other would be simple; bypass channels or piping achieve operational flexibility. As might be expected, operational cost of

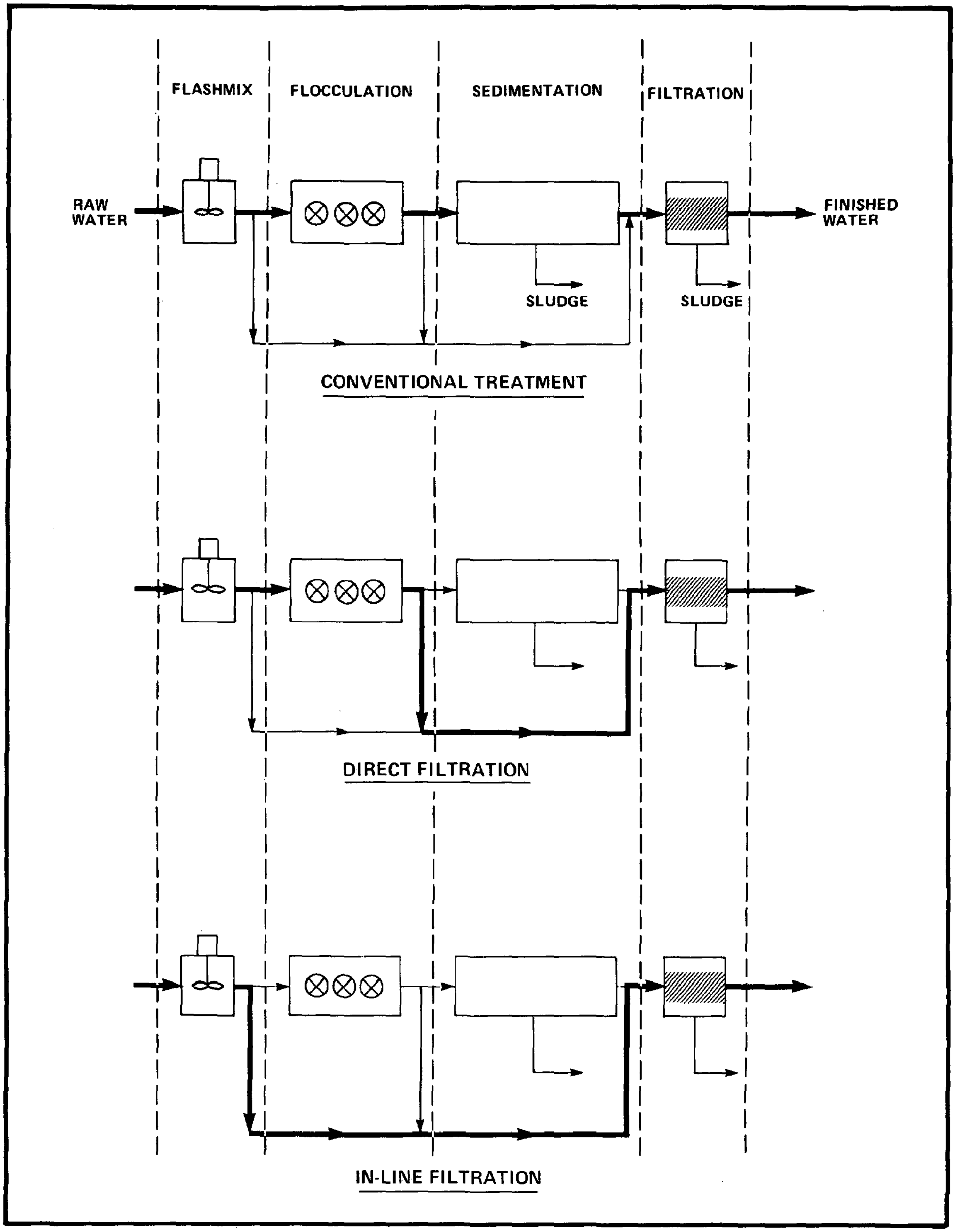


Figure 5-5
Treatment Process Options

either direct or in-line filtration will be substantially lower than that of conventional treatment. This results from lower chemical dosages, reduced sludge production, and less equipment maintenance.

Experience with Ship Creek water at the Municipal Water Treatment Plant indicates that removal of color and turbidity during periods of low raw water turbidity requires special treatment beyond the addition of 10 to 15 mg/l of alum. The same may be true of Eklutna Lake water. Raw water quality data for samples taken during the test period of October 1981 as well as USGS data indicate an excess of color. To enhance the coagulation, sedimentation, and filtration processes for effective color and low turbidity removal, lime addition at the headworks or other treatment methods might be required.

It is strongly recommended that, prior to final design, a pilot plant testing program be carried out over a full 1-year period with a minimum 1-mgd plant to establish process design criteria. This testing program should address iron, color, and turbidity removal; chemical dosages required over the full range of raw water parameters; filtration rates and media selection; and the effectiveness of the recommended treatment processes.

Treatment Plant

Figure 5-6 shows a typical filtration plant flow schematic, and Figure 5-7 shows a preliminary layout for a 70-mgd plant. The layout is amenable to phased construction. The plant could be constructed in increments, with basins and filters added as necessary with little disruption to continuing operation of existing facilities. A 7-acre site would be required.

Desirable plant sites would be those that provide easy access during all weather conditions, minimize pumping requirements through careful site selection at the proper elevation, and eliminate the need for either raw or finished water pumping. Elimination of raw water pumping is more desirable because it provides construction cost savings and reduced equipment wear, while finished water pumping facilitates customer service along the transmission pipeline.

Headworks

The headworks contains facilities for applying and mixing chemicals plus a metering device to measure raw water flow into the plant. Chemicals can be mixed using either an "in-channel rapid mixer" or a metering device such as a Parshall flume.

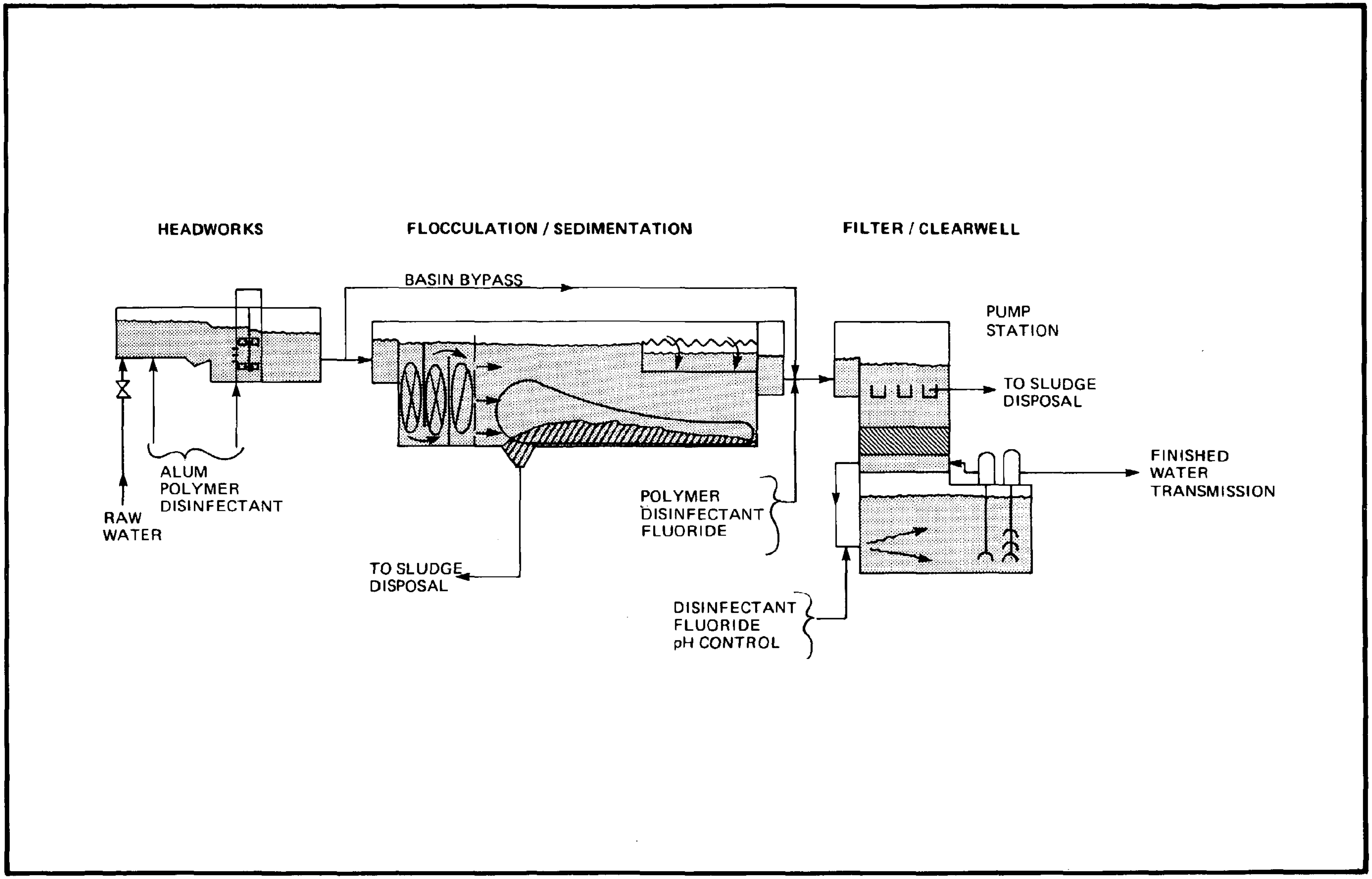


Figure 5-6
Typical Plant Flow Schematic

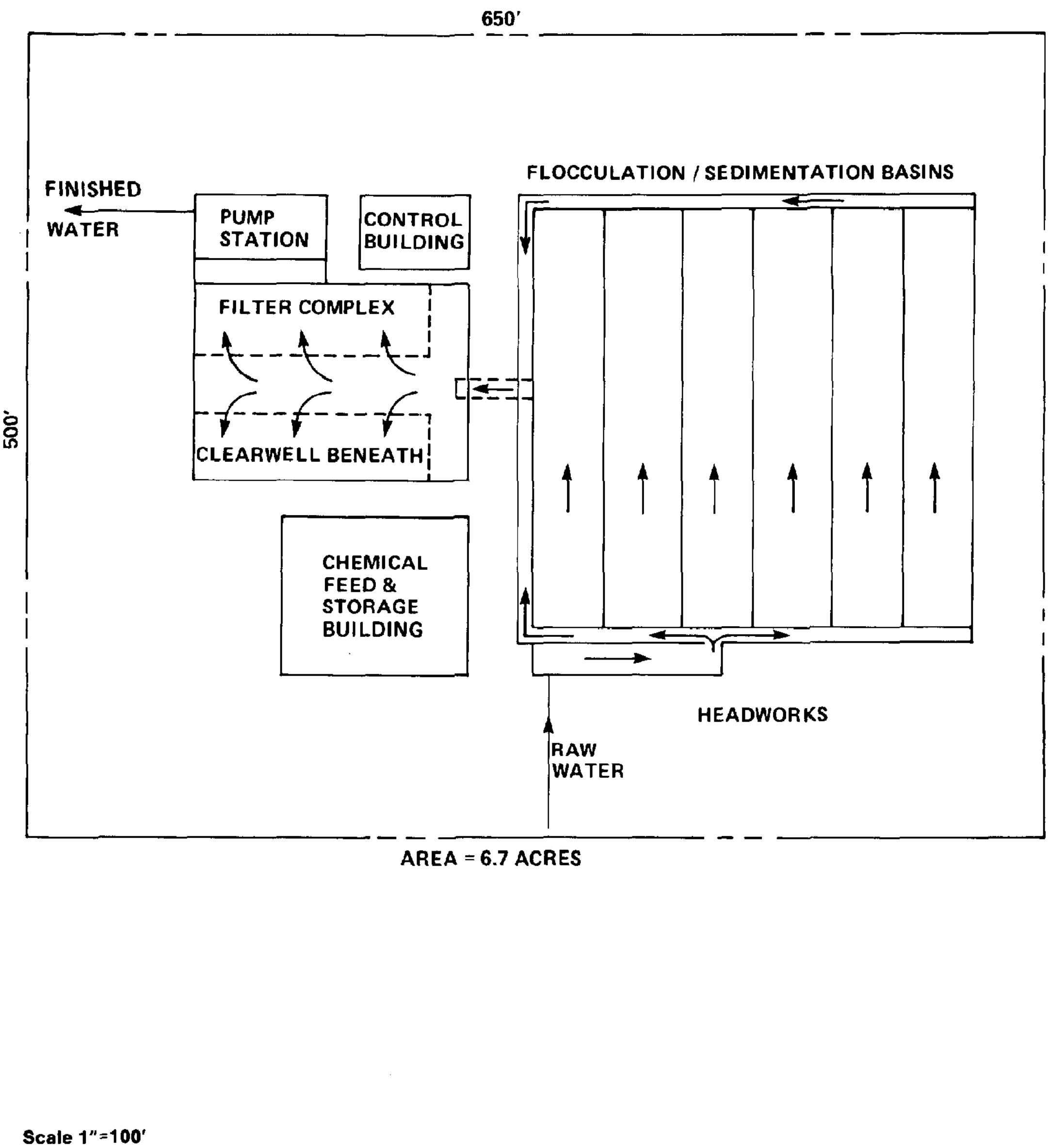


Figure 5-7
Preliminary Plant Layout

Flocculation

Flocculation is a building or bridging process wherein floc nuclei (aluminum hydroxide) resulting from coagulation (particles combining chemically into larger aggregates) join together through numerous contacts and envelop suspended particles. After sufficient mixing, the floc grows to a size and density that settles readily.

It is important in both the flash-mixing and flocculation zones that equipment be furnished with variable-speed drives to allow variation in energy inputs. Since optimum mixing requirements vary from season to season, substantial waste of chemicals can occur if proper adjustments cannot be made.

Sedimentation

Dense floc particles, including suspended solids, settle out in the sedimentation area leaving comparatively clear water containing a minimum of floc. Because of the heavy rock flour load, the sedimentation basins should be equipped with mechanical sludge removal equipment. It is anticipated that between 3 and 7 tons of equivalent dry solids sludge will be produced daily when the plant is operated at 70 mgd.

Filtration System

The settled water, containing a small amount of unsettled floc, proceeds from the sedimentation area to the filters. The filters remove the remaining floc. Granular media filters consist of either two or three layers, each exhibiting a different size and specific gravity. The largest grain media, having the lowest specific gravity, is located at the top of the filter with progressively smaller and heavier sizes toward the bottom. This arrangement permits floc and sediment particles to be removed throughout the entire filter rather than mostly at the surface, as typically occurs in single-grain-media filters. The addition of polymer as a filter aid immediately ahead of filtration improves floc removal within a filter, even at higher filtration rates. A nominal filtration rate of 6 gallons per minute per square foot is suggested for an Eklutna Lake filtration plant. Pilot filter testing is needed to (1) verify the design filter rates, both summer and winter; (2) select filtering media specifically for local conditions; and (3) identify which filter aid chemicals are needed and in what quantity.

Wastewater Disposal

Sludge containing rock flour and sediment from the lake water would be produced in two locations in the plant. The first is the sedimentation basin underflow and the second is the filter backwash water. At a plant flow rate of 70 mgd and a raw water turbidity of 30 NTU, the quantity of sludge produced would equal

7 tons per day of dry solids, which would equal approximately 100 cubic feet per day of solids. Removal of solids from sludge for ultimate disposal is often the most complex problem to be solved in the design of a water treatment plant.

Generally, there are two methods of dewatering sludge solids. The first includes drying by natural means such as evaporation, percolation, and freezing. The second is by such mechanical means as vacuum filters, filter presses, and centrifuges. The cost for mechanical dewatering is usually three to ten times the cost for natural drying.

For Eklutna, however, the most practical choice of sludge (and backwash water) disposal is to pipe it directly to Knik Arm, without dewatering. At 3 percent of plant production (70 mgd), the volume of wastewater in the summer would be approximately 2 mgd. This wastewater could be piped to Knik Arm without pumping provided the treatment plant is located at an elevation above sea level such that sufficient head is available for gravity flow.

Disinfection

With the addition of disinfection agents, the water leaving the filters is potable and ready for transmission and distribution to the public. Although chlorine has been the universal disinfectant in public water works, further consideration should be given to the use of other disinfectants for preliminary disinfecting, while continued use of chlorine or hypochlorite will likely remain the choice for postdisinfection as the water enters the transmission and distribution systems. Further investigation is required prior to selecting disinfectants and their application points within the plant. Trihalomethane* formation potential needs to be determined.

Alternative Treatment Methods

Other treatment methods were also considered, some reported by others in previous studies. These include hydroclone separators, screening with microstrainers, and precoat filters. Only precoat filtration is applicable to the Eklutna Lake conditions and could be considered an alternative to granular media filtration. Historically, granular media filtration is the choice for public water supplies, especially installations over 5 mgd. The disadvantage of precoat filtration is the hazard of loss of the precoat from the filtering septum, which permits raw water to short circuit through the filter. Loss of precoat can be caused by hydraulic surges, changing flow rate, power failure, and operator error. Granular media filters do not present these handicaps except, possibly and to a lesser degree, the potential for operator error.

*An organic compound formed when certain natural organic compounds (particularly humic acids) come in contact with chlorine. Thought to cause cancer in animals.

COST ESTIMATE

Table 5-5 shows the total estimated project costs for a 70-mgd plant as well as a 23.33-mgd plant, which provides for ultimate plant development in three equal increments.

Table 5-5
ESTIMATED PROJECT COSTS[a]

	Plant Capacity	
	23-1/3 mgd	70 mgd
Capital		
Construction (Anchorage)	$10,900,000	$26,000,000
Contingency, Bonds & Insurance, and Technical, Adm. & Legal Services (Anchorage)	6,459,000	15,400,000
TOTAL CAPITAL COSTS[b]	$17,359,000	$41,400,000
Annual O&M		
Labor	$ 443,000	$ 895,000
Chemicals	335,000	1,006,000
Power	193,000	580,000
Maintenance Materials	98,000	212,000
Miscellaneous	6,000	17,000
TOTAL ANNUAL O&M COSTS	$1,075,000	$2,710,000

[a]In January 1981 dollars.

[b]Land costs are not included.

The estimated construction costs and operation and maintenance costs are based on actual experience with plants constructed and operated in the Pacific Northwest, and have been adjusted to reflect costs for Alaska. They are also based on EPA Estimating Water Treatment Costs, Volumes 1 and 2, and on the MAUS, Volume 2. These estimates are considered as "order-of-magnitude" estimates with a -30 to +50 percent reliability range.

Construction costs assume the use of reinforced concrete construction with all basins and filters enclosed. The estimates include sludge piping to Knik Arm but do not include raw water and finished water pumping, standby power, or water transmission piping.

Construction costs are for January 1981, using an Engineering News Record Construction Cost Index of 347. Land costs are not included in the estimates; the site requirements are 7 acres for the plant and an additional 10 acres for sludge-drying ponds if sludge is not piped to Knik Arm.

SUMMARY AND CONCLUSIONS

USGS water quality data and field and laboratory testing indicate that Eklutna Lake water is treatable. Treatment facilities will require two different seasonal treatment processes that can be provided in a single water treatment plant. Transition between processes will occur in June and October, correlating with glacial melting at the lake's headwaters.

The recommended treatment processes are (1) flocculation, sedimentation, high-rate filtration, and disinfection for the higher turbidity, glacial melt period and (2) coagulation, high-rate filtration, and disinfection for the lower turbidity period during the colder months.

The estimated capital cost for a 70-mgd plant facility is $41.4 million (1981 construction dollars). Operation and maintenance costs are estimated at $2.7 million per year.

If Eklutna Lake is selected as the source for additional water supply, we recommend the following prior to starting final design:

- Pilot plant tests for a full year to determine applicable process design criteria and the effects of lime softening (if needed)
- An investigation of disinfection alternatives to identify trihalomethane formation potential (formation of potentially carcinogenic substances during the disinfection process)
- Sludge disposal alternatives and cost research
- Use of polymers as a substitute coagulant or as a coagulant aid

If other sources of water are used to supplement Eklutna Lake water, those sources should also be investigated.

Chapter 6
ENERGY IMPACT AND COST ANALYSES

This chapter contains discussions of the present use of Eklutna Lake as a hydroelectric reservoir, the impact of the three Eklutna water diversion alternatives on the south-central Alaska power supply, and the total capital and operation and maintenance costs associated with each of the three alternatives. The power requirements and costs of these alternatives are then compared with those for the Eagle River diversion.

BACKGROUND

The normal peaking capability of the Eklutna Hydroelectric power plant is 35 MW, and it has operated at 36 MW on occasion. The output of the plant is sold to the Anchorage Municipal Light and Power Utility and the several electric associations operating in south-central Alaska. The contracts for the sale of power provide for delivery of a firm supply of energy at an annual load factor of 58.22 percent. Energy generated in excess of this firm supply is sold at a reduced rate as nonfirm, interruptible energy. The entire project was constructed on federally owned land which had been reserved for a power site. At present, the operation of the plant is by the APA.

RESERVOIR OPERATIONS

Since the Eklutna hydroelectric project uses essentially all of the inflow to Eklutna Lake, any diversion of water from Eklutna Lake, upstream of the turbines, for a municipal water supply project will reduce the total annual energy production of the hydroelectric project. In order to evaluate Eklutna Lake as an alternative water source for Anchorage, an estimate of the impact on power generation at the power plant was made. Historical records from the hydroelectric project were used.

Historical Lake Level and Hydroelectric Water Use

The annual cycle of the level of Eklutna Lake is a rough indicator of the amount of power that can be generated at Eklutna Lake. The lake level usually varies between elevation 825 and elevation 870 throughout the year, with the lowest levels occurring in March through May and the highest normally occurring in September and October. An analysis has been made by the U.S. Bureau of Reclamation to determine the target daily lake levels to provide the optimum hydroelectric generation. These lake levels, when plotted, form a rule curve for hydroelectric generation (Figure 6-1). Near the top of Figure 6-1, at elevation 871.0, a line indicates the spillway crest elevation. The spillway was constructed

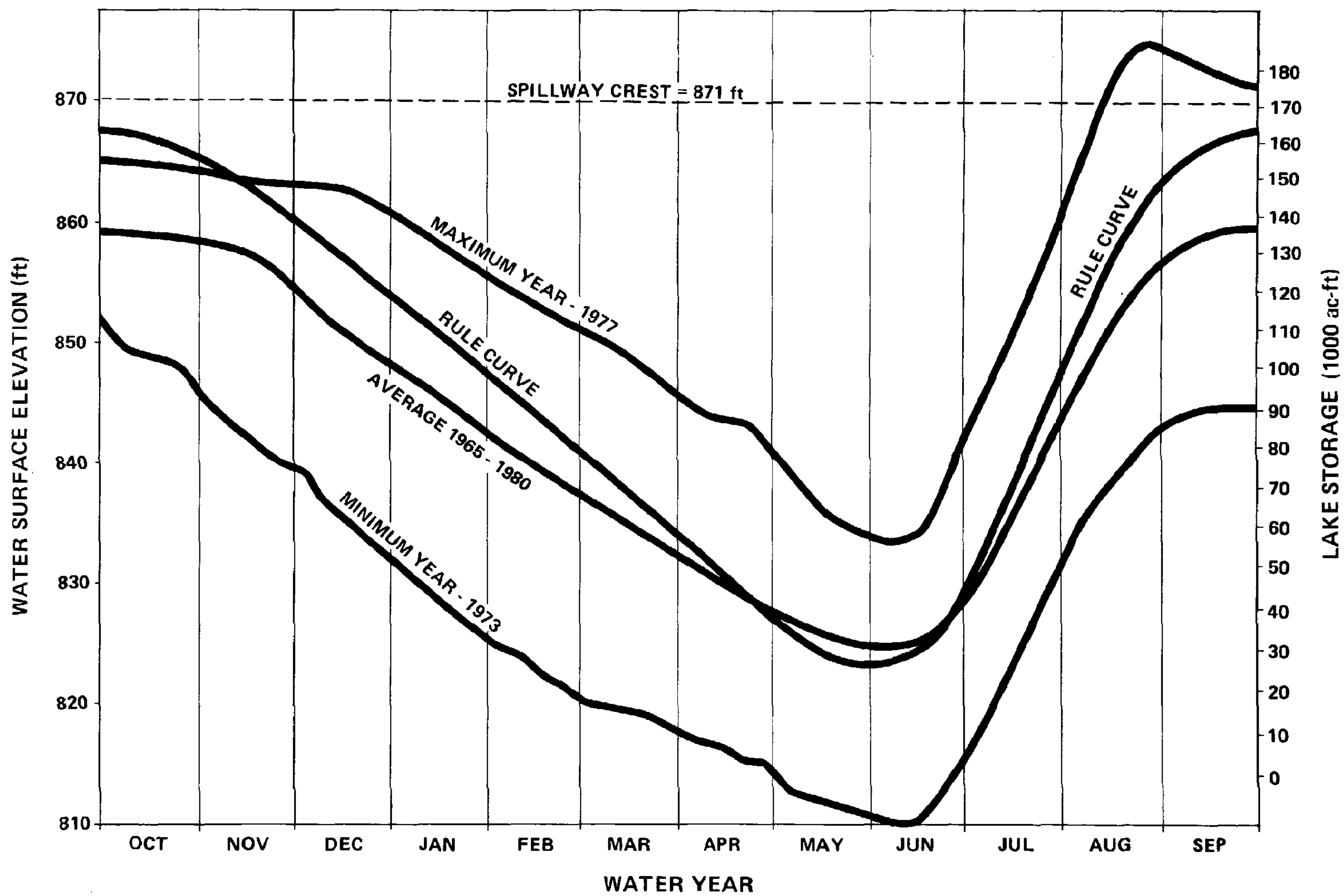


Figure 6-1
Eklutna Lake Levels
Since 1965

in 1965 after the 1964 earthquake. Prior to that time, the crest was slightly lower on a different dam.

The figure indicates that the monthly changes in lake levels have been similar each year, but are either above or below the rule curve.

A statistical analysis of the total annual inflow to Eklutna Lake (total annual inflow is shown on Table 2-1, Chapter 2) was made to determine the predictable inflow range. It showed that the average low flow with a 50-year return period is approximately 160,000 ac-ft (143 mgd), and the 50-year high flow is approximately 324,000 ac-ft (289 mgd). The historical record of 1947 through 1981 shows that the range of inflows is from 164,700 to 328,800 ac-ft (147 to 294 mgd).

The water usage of the Eklutna hydroelectric project was also analyzed. Monthly and annual water usages were statistically analyzed to determine whether any of the historical data were from unusually heavy or low water usage periods. (See Table 2-2 of Chapter 2 for actual water usage.) On an annual basis, water usage was not unusually high or low; however, during several months, abnormal water usage did occur. Water usage was never higher than expected, but it was lower than expected during 4 months of the historical record. (April 1971, April 1972, July 1973, and August 1973.) Inflow to Eklutna Lake was below average during these months. Lake levels were also below normal. This indicates that power generation was cut back during these months because of adverse hydrologic conditions. It is probable that, in the future, low lake levels and low inflow could again cause curtailment of the power plant's water usage.

Predicted Reductions in Hydroelectric Water Supply

The percent reduction in energy production that could occur at the Eklutna hydroelectric project because of diversion for a municipal water supply was estimated. First, a relationship among Eklutna Lake level, water usage of the project, and the amount of energy generated was determined. This relationship made it possible to predict potential hydroelectric generation based on the lake level and the amount of water used. From the MAUS (Volume 2), it has been estimated that 25 mgd diversion will be required in the 1990's, 50 mgd diversion by 2005, and 70 mgd by 2012. Planned water supply developments in the Anchorage Bowl will delay the need for intermediate and peak diversions. These diversion amounts were considered in the estimates for energy reduction. As with the Eagle River dam analysis (Appendix II), the demands are assumed to be constant year-round. In a future detailed analysis, demand variation considerations will be appropriate. Table 1-10, "Water Demand Increase" on page 1-15 of MAUS, lists in 5-year increments the population and water demand projections, including the increased demand over 1977. These projections are subject to revision, possibly downward, and new demand projections should be made prior to final design of any major water supply project.

For water year 1977, the high lake level year, monthly estimates of energy reduction due to diversions of 25 mgd, 50 mgd, and 70 mgd were made. The water used by the hydroelectric project was reduced by the amount diverted, which assumes all of the diverted water comes from Eklutna Lake somewhere upstream of the turbines. This corresponds to Alternative 2. During periods of spill at Eklutna Lake, smaller water reductions were used since excess water was available. The reduced monthly volume of water available for use by the hydroelectric project was converted to potential energy output. These hypothetical energy outputs were then compared to the actual generation to determine the percentage of energy reduction.

Calculations of monthly energy reduction also were made for water year 1973, the low lake level year, the monthly averages of water years 1966 through 1980, and the monthly averages of 1971 through 1980. Average annual energy reductions for these computations ranged from 10 to 16 percent for 25 mgd diversion, 19 to 32 percent for 50 mgd diversion, and 27 to 44 percent for 70 mgd diversion.

The percent of energy reduction based on average annual values only, as compared to monthly values, was computed for water years 1966 to 1981. Reduction values ranged from 8 percent to 20 percent for 25 mgd diversion, 19 to 37 percent for 50 mgd diversion, and 28 to 49 percent for 70 mgd diversion.

It estimated that the average annual hydroelectric energy reduction for a 25-mgd diversion from Eklutna Lake would be 14 percent (22 million kWh). For a diversion of 50 mgd, the reduction would be 28 percent (44 million kWh), while for a 70-mgd diversion, the energy reduction would be about 39 percent (61 million kWh).

Table 6-1 lists the average and extreme monthly variations calculated for the period after the 1964 earthquake.

ENERGY LOST BY DIVERSION OF WATER UPSTREAM OF TURBINES

Alternative 1 uses lake water after it passes through the turbines. Both Alternative 2 and Alternative 3 would divert water above the turbines and would reduce the energy produced. Alternative 2, the tunnel diversion, would divert all of the water supply flow away from the power project. The energy lost would average from 11 million kWh in 1985 to 40 million kWh in the year 2000, and up to 61 million kWh in the year 2012 when it is expected that the full 70 mgd will be required. These power supply impacts are summarized in Table 6-2 and Figure 6-2.

Table 6-1
EKLUTNA HYDROELECTRIC ENERGY REDUCTION SUMMARY[a]

Month	Energy Reduction (%) (25-mgd Diversion)[b]			Energy Reduction (%) (50-mgd Diversion)[b]			Energy Reduction (%) (70-mgd Diversion)[b]		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
January	14	14	11	27	27	24	38	38	33
February	18	19	12	32	33	27	41	46	37
March	17	19	10	32	35	23	43	50	33
April	21	22	15	37	39	30	49	53	41
May	14	21	8	30	42	16	42	55	23
June	13	21	10	30	42	20	39	58	28
July	13	36	9	27	75	19	38	100	26
August	13	17	0	26	70	0	36	85	0
September	16	19	0	30	45	0	41	79	0
October	12	17	6	25	35	17	36	49	25
November	13	20	11	25	41	21	36	57	29
December	10	15	10	23	29	21	33	41	30
Year	14	20	8	28	43	18	39	59	25

[a]Based on Eklutna hydroelectric project records for water years 1966-1980 for average and water years 1973, 1977, and 1980 for maximum and minimum analysis.

[b]All water diverted upstream of turbines.

Alternative 3 would obtain some water from sources below the lake, so it would divert less water from the hydroelectric project. In 2012, 38 percent would come from below the lake and only 62 percent would be diverted from the hydroelectric project. The average annual loss of energy would be 3.6 million kWh in 1985, 23 million kWh in 2000, and 40 million kWh in 2012. This is a smaller impact on hydroelectric generation than that which would be produced by Alternative 2.

ENERGY REQUIRED FOR PUMPING

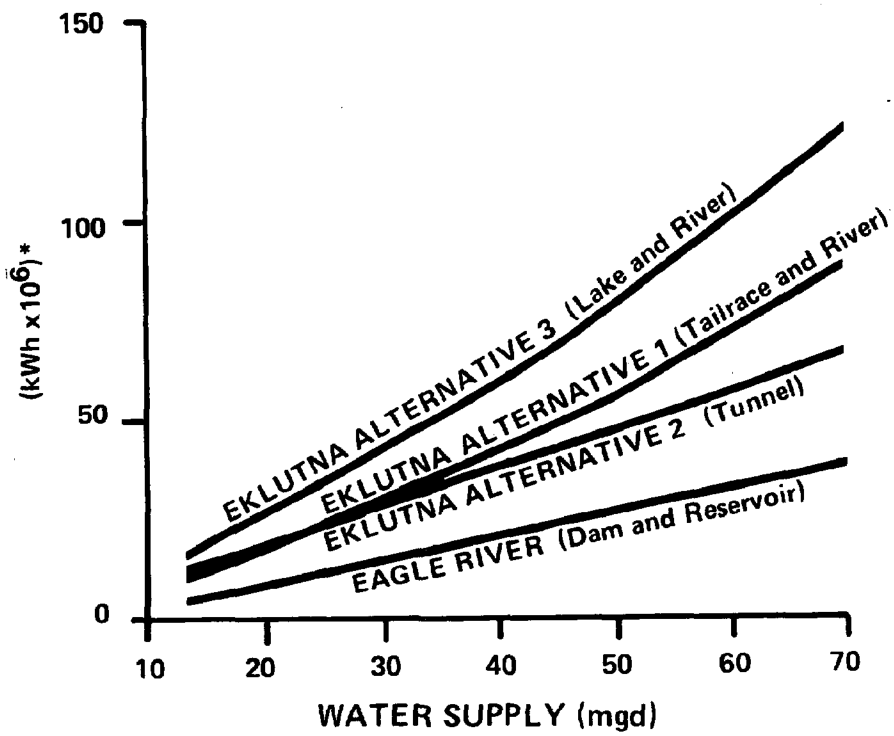
Both Eklutna Alternatives 1 and 3 would require energy for pumping water to the treatment plant and to Anchorage. All of

Table 6-2
POWER SUPPLY IMPACT OF ALTERNATIVE
DIVERSIONS OF EKLUTNA WATER AND EAGLE RIVER[a]

	Eklutna Alternative 1	Eklutna Alternative 2	Eklutna Alternative 3	Eagle River
Energy Impact (MWh)				
Reduction in Generation				
14 mgd	--	11,000	3,562	--
45 mgd	--	40,000	22,759	--
70 mgd	--	61,629	40,307	--
Pumping Energy				
14 mgd	10,719	--	10,959	5,700
45 mgd	45,596	--	42,286	19,500
70 mgd	81,895	--	75,265	32,700
Treatment Plant				
14 mgd	1,150	1,150	1,150	1,150
45 mgd	3,900	3,900	3,900	3,900
70 mgd	6,108	6,108	6,108	6,108
Total Energy Impact				
14 mgd	11,869	12,150	15,671	6,850
45 mgd	49,496	43,900	68,945	23,400
70 mgd	88,003	67,737	121,680	38,808
Capacity Impact (kW)				
Pumping Capacity				
14 mgd	1,350	--	1,340	1,000
45 mgd	6,000	--	5,220	3,000
70 mgd	11,250	--	9,230	5,400
Treatment Plant[b]				
14 mgd	150	150	150	150
45 mgd	500	500	500	500
70 mgd	775	775	775	775
Total Capacity Impact				
14 mgd	1,500	150	1,490	1,150
45 mgd	6,500	500	5,720	3,500
70 mgd	12,025	775	10,005	6,175

[a]Without additional sources developed in the Anchorage Bowl, 14 mgd is needed by 1985, 45 mgd by 2000, and 70 mgd by 2012 (MAUS, 1979). Development of Anchorage Bowl water sources will postpone the need for these average volumes of water from a source outside of the Bowl.

[b]Assumes operation at 90-percent plant factor.



*REPRESENTS THE REDUCTION IN THE EKLUTNA HYDROELECTRIC FACILITY ENERGY GENERATION AND THE ENERGY REQUIRED FOR PUMPING AND WATER TREATMENT.

Figure 6-2
Eklutna Alternatives and Eagle River Dam and Reservoir Estimated Annual Impacts on Energy Production

Alternative 2 flow is by gravity; therefore, pumping energy would not be required. Except for the first few years of operation, Alternative 1 would require more pumping energy than would Alternative 3 because much of the Alternative 1 water would be diverted from near sea level at the tailrace of the power project.

The pumping energy requirements of Alternative 1 would increase from 10.7 million kWh in 1985 to 81.9 million kWh in 2012 when the full 70-mgd of water are estimated to be needed. The pumping would also require 1,350 kW of capacity in 1985, increasing to 11,250 in 2012. Energy requirements for Alternative 3 would increase from 10.9 million kWh in 1985 to 75.3 million kWh in 2012. Capacity requirements would increase from 1,340 kW in 1985 to 9,230 kW in 2012.

The Eagle River project would also require energy and capacity for pumping. The energy requirements would increase from 5.7 million kWh in 1985 to 19.5 million kWh in 2000 and to 32.7 million kWh in 2012. Capacity requirements would increase from 1,000 kW in 1985 to 3,000 kW and 5,400 kW in 2000 and 2012, respectively.

ENERGY REQUIRED FOR THE TREATMENT PLANT

Electrical energy would be required for the operation of a water treatment plant for each Eklutna alternative and for the Eagle River dam and reservoir project. Energy requirements, which would be the same in each case, would increase from 1.2 million kWh in 1985 to 3.9 million kWh in the year 2000 and to 6.1 million kWh in 2012.

EFFECT ON SOUTH-CENTRAL ALASKA POWER AND ENERGY SUPPLY

Each alternative will reduce the amount of electric energy available for other uses on the electric systems serving south-central Alaska. These are the electric associations and the electric systems with contracts for Eklutna energy. Alternatives 1 and 3 would also impact the capacity available to serve other customers.

Alternative 3 would have the greatest impact on the electrical supply because it would both reduce generation at Eklutna and require pumping energy and capacity. Altogether, under average water conditions Alternative 3 would reduce the supply of electricity for other uses by 15.7 million kWh in 1985, 68.9 million kWh in 2000, and 121.7 million kWh in 2012. Alternative 3 also would reduce the capacity of the systems to carry their other peak loads by 1,490 kW in 1985, 5,720 kW in year 2000, and 10,005 kW in 2012.

Alternative 1 would have the second greatest impact on the electric supply. Although it would not reduce generation at Eklutna, it would require large amounts of energy and capacity for pumping. Energy requirements would increase from 11.9 million kWh in 1985 to 49.5 million kWh in 2000 and to 88 million kWh in 2012.

Alternative 2 would have the least impact on the electric supply. Although it would reduce the energy generated at the Eklutna project, it would require no pumping capacity or energy.

COST OF REPLACING ENERGY LOST TO THE ELECTRIC SYSTEMS

The estimated electric energy impact of each Eklutna water supply alternative is either the result of a reduction of the water supply to the Eklutna hydroelectric generating plant or is due to the pumping energy needs of the water supply project. Alternative 3 reduces the water supply to the Eklutna plant and requires pumping energy. The lost energy will have to be replaced and new pumping energy demands generated if the growing electrical loads of the region are to be met. Though the region's electric energy prices are now relatively low, the future cost of electric power is expected to be much greater. At present, most of the region's electric power is generated in thermal plants using relatively inexpensive natural gas. In the future, when natural gas prices are decontrolled at the well head, gas prices (on a Btu basis) are expected to rise to a level close to or equal to the cost of No. 2 heating oil.

At that time it is believed that increases in power supply will be supplied from coal-fired thermal plants with generation cost of about 8.66 cents per kWh (1981 prices) compared with the current cost of less than 2 cents per kWh.

The energy lost at the Eklutna power plant and the energy required for pumping diverted Eklutna Lake water supply to Anchorage is assumed to cost 8.66 cents per kWh. The annual energy impacts of the three Eklutna alternatives and the Eagle River project are shown in Table 6-3 and Figure 6-3. The total cost of energy for Alternative 2, the tunnel tap, is 84 percent greater than for the Eagle River dam and reservoir project. Energy costs for the other alternatives are substantially higher.

CAPITAL COSTS

Order-of-magnitude capital cost estimates (reflecting November 1981 construction costs) were made for the three alternative methods of diverting Eklutna water to Anchorage. Order-of-magnitude estimates have a reliability range of -30 to +50 percent.

Tables 6-4 through 6-6 show itemized costs for the Eklutna water supply Alternatives 1, 2, and 3. Alternative 2, the most expensive, at $151 million, is 16 percent higher than Alternative 3, the least expensive, which costs $131 million. Table 6-7 summarizes the identifiable costs ($122 million) for the Eagle River dam and reservoir project. This does not include certain substantial cost items, such as:

- Acquisition of approximately 2,500 acres of reservoir land owned by Eklutna, Inc.
- Old Eagle River Dump water quality impacts mitigation

Table 6-3
COST OF FUTURE ENERGY AND CAPACITY INCURRED BY DIVERSION OF EKLUTNA AND EAGLE RIVER WATER TO ANCHORAGE

	Cost in $1,000			
	Eklutna Alternative			Eagle River
	1	2	3	
Annual Cost of Energy[a]				
14 mgd	1,028	1,052	1,357	593
45 mgd	4,286	3,802	5,971	2,026
70 mgd	7,621	5,866	10,537	2,832
Annual Cost of Capacity[b]				
14 mgd	108	4	107	83
45 mgd	468	36	412	252
70 mgd	865	56	720	389
Annual Cost of Impact				
14 mgd	1,136	1,056	1,464	676
45 mgd	4,754	3,838	6,383	2,278
70 mgd	8,486	5,922	11,257	3,221

[a]Based on October 1981 analysis of a 200-MW mine-mouth coal-fired steam electric station operating at 50 percent plant factor: 8.66¢/kWh.

[b]Based on 1.8 x annual capacity cost of most recently completed pump station built on the West Coast: $72/kW/yr.

- o Facilities and mitigation measures for fish passage
- o Special requirements determined during environmental analysis

Work has not been done to determine the cost impact of these items on the feasibility of the Eagle River dam and reservoir project. It is anticipated that these costs will be many millions of dollars.

The capital and operation and maintenance costs for all four projects are shown on a 1981 annual basis in Table 6-8. Fifty-year, 8-percent annualizing is assumed for the capital costs. Total annual costs for the Eklutna alternatives are also shown in Figure 6-4. Alternative 3 is the least expensive project until flows are 35 mgd, and most expensive at 70 mgd. Up to 30 mgd, Alternatives 1 and 2 are essentially equal; Alternative 2 is less expensive than either Alternative 1 or 3 at 70 mgd.

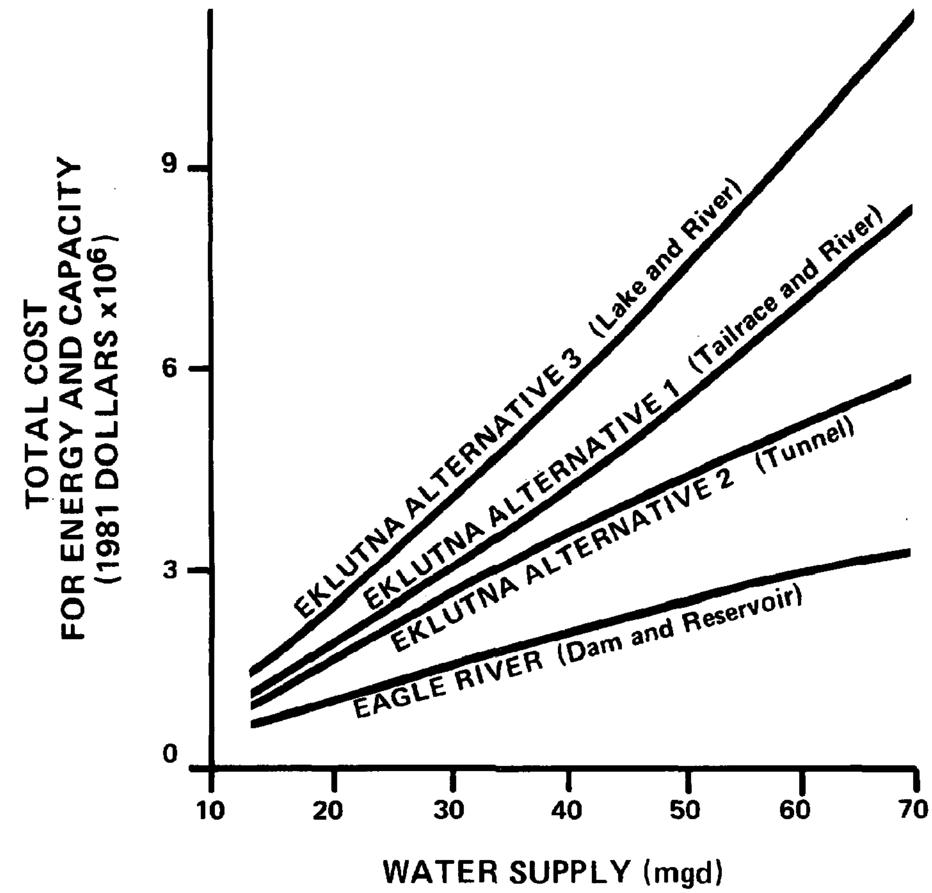


Figure 6-3
Eklutna Alternatives and
Eagle River Dam and Reservoir
Annual Cost of Energy
and Capacity Requirements

Although the cost estimate for the Eagle River dam does not include all items (such as reservoir land, old dump mitigation, and fish facilities, for example), those that are included were treated in greater detail than were the estimates for the Eklutna project. Extensive field data and detailed mapping were used for the Eagle River tasks (Appendixes II and IV), for example. Almost no new field data were collected and USGS scale maps were used to develop the three Eklutna alternatives. Therefore, the reliability of the Eklutna cost estimate must be less than for the Eagle River Dam project. The Eklutna design can be improved and made less conservative if more detailed studies are conducted. Figure 6-5 illustrates that Alternative 2, for example, may be quite comparable in total annual cost to the Eagle River project.

Table 6-4
ORDER-OF-MAGNITUDE COST ESTIMATE FOR ALTERNATIVE 1

Item	Quantity	Unit Price	Total Cost ($)
General Requirements	lump sum	lump sum	5,000,000
Transmission Piping			
Clearing and Grubbing	lump sum	lump sum	330,000
Pipe: 54-inch, Class 100-250	117,000 lf	$290	33,930,000
48-inch, Class 150	41,000 lf	$260	10,660,000
30-inch, Class 150	1,200 lf	$175	210,000
Valves and Appurtenances	lump sum	lump sum	940,000
Stream Crossings	lump sum	lump sum	180,000
Railroad Crossings	2 each	$145,000	290,000
Eagle River Crossing	lump sum	lump sum	120,000
Pavement Replacement	lump sum	lump sum	1,950,000
Telemetry and Controls	lump sum	lump sum	440,000
Tailrace Pump Station and Intake Structure	lump sum	lump sum	4,600,000
Mirror Lake Booster Pump Station	lump sum	lump sum	3,100,000
Water Treatment Plant	lump sum	lump sum	26,000,000
Water Treatment Plant Pump Station	lump sum	lump sum	4,800,000
Eklutna River Diversion Structure and Piping	lump sum	lump sum	750,000
Subtotal			93,300,000
Bonds and Insurance (2.5%)			2,330,000
Legal, Administrative, and Engineering (20%)			18,660,000
Subtotal			114,290,000
Contingency (30%)			34,290,000
Total			148,580,000

Table 6-5
ORDER-OF-MAGNITUDE COST ESTIMATE FOR ALTERNATIVE 2

Item	Quantity	Unit Price	Total Cost ($)
General Requirements			4,500,000
Transmission Piping			
Clearing and Grubbing	lump sum	lump sum	330,000
Pipe: 60-inch, Class 150	7,400 lf	$300	2,220,000
Class 200	29,600 lf	$320	9,470,000
Class 250	37,600 lf	$355	13,350,000
Class 300	17,000 lf	$375	6,380,000
Class 350	4,100 lf	$415	1,700,000
Class 400	33,200 lf	$435	14,440,000
48-inch, Class 150	41,000 lf	$260	10,660,000
, Class 400	1,400 lf	$450	630,000
30-inch, Class 150	1,200 lf	$175	210,000
Valves and Appurtenances	lump sum	lump sum	1,040,000
Stream Crossings	lump sum	lump sum	180,000
Railroad Crossings	2 each	145,000	290,000
Eagle River Crossing	lump sum	lump sum	120,000
Pavement Replacement	lump sum	lump sum	1,950,000
Telemetry and Controls	lump sum	lump sum	440,000
Penstock/Tunnel Connection	lump sum	lump sum	1,000,000
Water Treatment Plant	lump sum	lump sum	26,000,000
Subtotal			94,910,000
Bonds and Insurance (2.5%)			2,370,000
Legal, Administrative, and Engineering (20%)			18,980,000
Subtotal			116,260,000
Contingency (30%)			34,880,000
Total			151,140,000

Table 6-6
ORDER-OF-MAGNITUDE COST ESTIMATE
FOR ALTERNATIVE 3

Item	Quantity	Unit Price	Total Cost ($)
General Requirements			4,000,000
Transmission Piping			
Clearing and Grubbing	lump sum	lump sum	330,000
Pipe: 54-inch, Class 100-250	84,800 lf	$290	24,590,000
48-inch, Class 150	41,000 lf	$260	10,660,000
30-inch, Class 150	1,200 lf	$175	210,000
Valves and Appurtenances	lump sum	lump sum	660,000
Stream Crossings	lump sum	lump sum	180,000
Eagle River Crossing	lump sum	lump sum	120,000
Pavement Replacement	lump sum	lump sum	1,400,000
Telemetry and Controls	lump sum	lump sum	440,000
Eklutna Lake Pump Station, Intake Structure, and Power Transmission Line	lump sum	lump sum	5,250,000
Mirror Lake Booster Pump Station	lump sum	lump sum	3,100,000
Water Treatment Plant	lump sum	lump sum	26,000,000
Water Treatment Plant Pump Station	lump sum	lump sum	4,800,000
Eklutna River Diversion Structure and Piping	lump sum	lump sum	750,000
Subtotal			82,490,000
Bonds and Insurance (2.5%)			2,060,000
Legal, Administrative, and Engineering (20%)			16,500,000
Subtotal			101,050,000
Contingency (30%)			30,310,000
Total			131,360,000

Table 6-7
ORDER-OF-MAGNITUDE COST ESTIMATE
FOR EAGLE RIVER WATER SUPPLY
DAM AND PIPELINE

Item	Quantity	Unit Price	Total Cost ($)
General Requirements	lump sum	lump sum	3,650,000
Transmission Piping			
Clearing and Grubbing	lump sum	lump sum	330,000
Pipe: 48-inch, Class 150	41,000 lf	$260	10,660,000
30-inch, Class 150	1,200 lf	$175	210,000
27-inch, Class 150	5,200 lf	$160	830,000
24-inch, Class 150	20,000 lf	$140	2,800,000
20-inch, Class 150	23,500 lf	$120	2,820,000
18-inch, Class 150	12,600 lf	$110	1,390,000
10-inch, Class 150	14,200 lf	$ 60	850,000
Valves and Appurtenances	lump sum	lump sum	1,750,000
Ship Creek Crossing	lump sum	lump sum	60,000
Eagle River Crossing	lump sum	lump sum	120,000
Trench Stabilization and Compacted Embankment	lump sum	lump sum	40,000
Pavement Replacement	lump sum	lump sum	1,130,000
Telemetry and Controls	lump sum	lump sum	50,000
Eagle River Pump Station and Inlet Structure	lump sum	lump sum	6,750,000
Eagle River Booster Pump Station	lump sum	lump sum	1,000,000
Eagle River Dam (excl. land)	lump sum	lump sum	16,200,000
Water Treatment Plant	lump sum	lump sum	26,000,000
Subtotal			76,640,000
Bonds and Insurance (2.5%)			1,920,000
Legal, Administrative, and Engineering (20%)			15,330,000
Subtotal			93,890,000
Contingency (30%)			28,170,000
Total			122,060,000

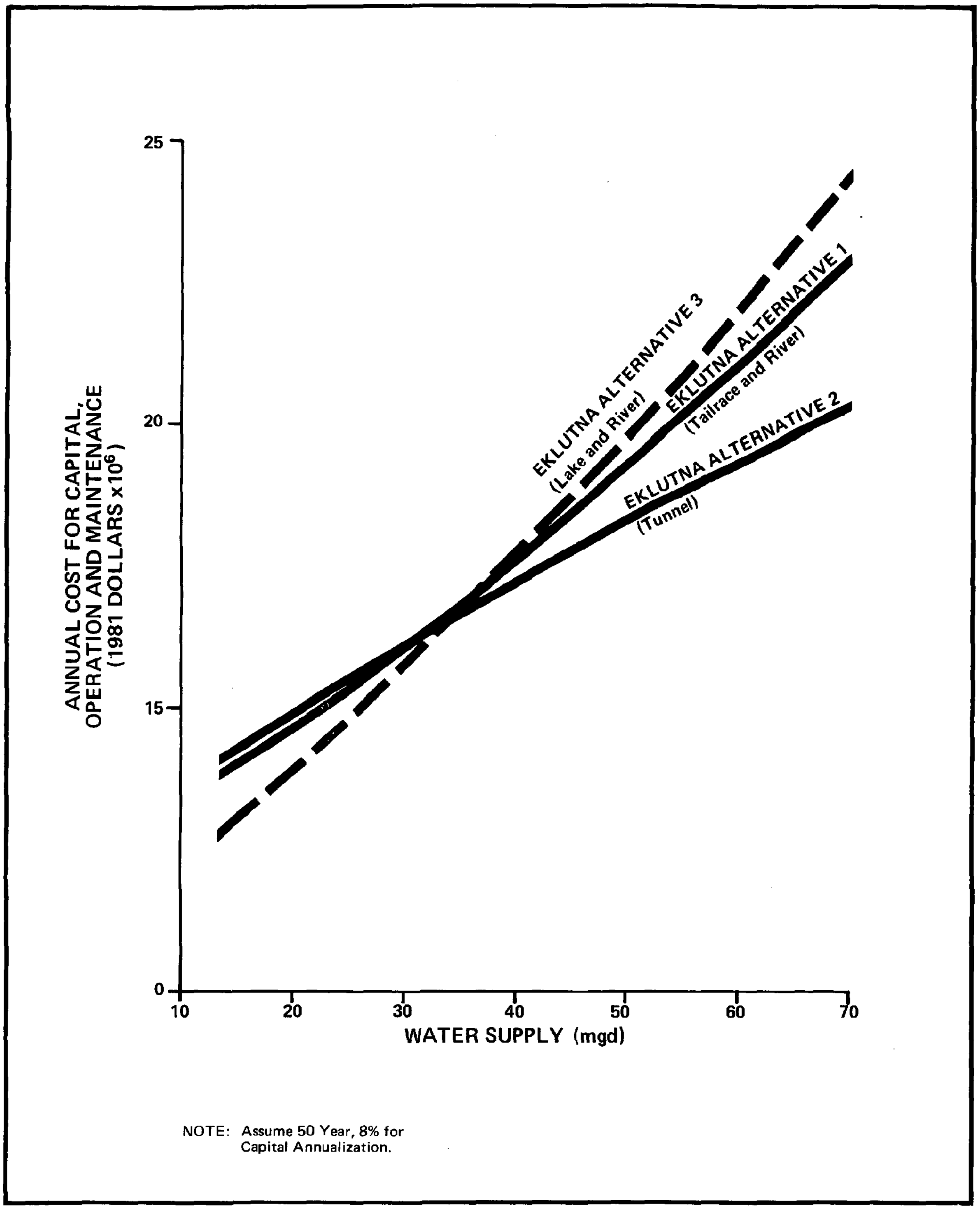


Figure 6-4
Eklutna Alternatives
Total Annual Cost

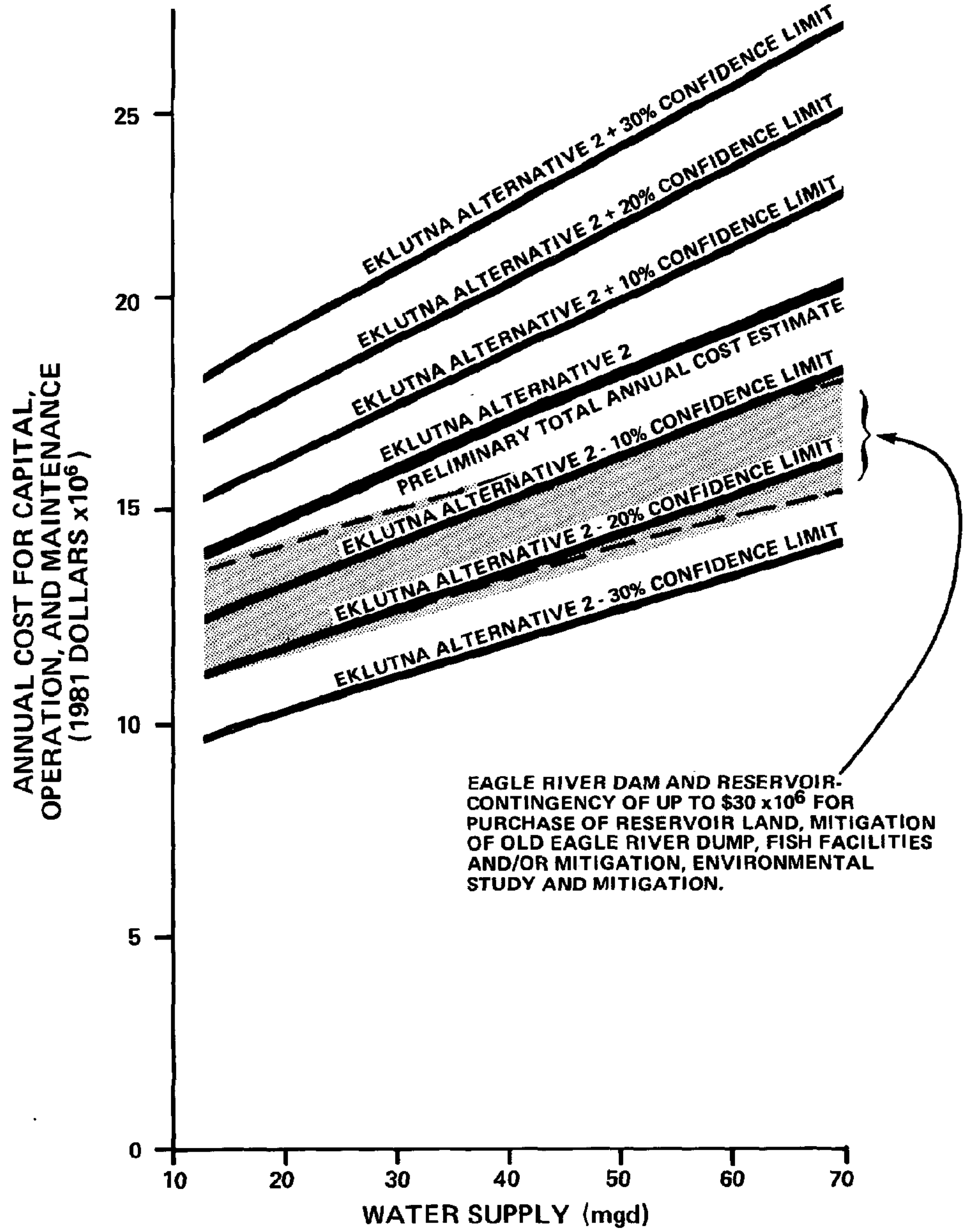


Figure 6-5
Eklutna Alternative 2 vs
Eagle River Dam and Reservoir
Total Annual Cost

Table 6-8
ANNUAL COST SUMMARY
EKLUTNA ALTERNATIVES AND
EAGLE RIVER PROJECT

Alternative	Annual Cost ($)		
	14 mgd[a]	45 mgd	70 mgd
ALTERNATIVE 1			
(Capital Cost = $148,580,000)			
Annual Capital Cost (50 years @ 8%)	12,111,000	12,111,000	12,111,000
Power and Energy Costs	1,136,000	4,754,000	8,486,000
O&M (excluding power)	641,000	1,581,000	2,353,000
Total	13,888,000	18,446,000	22,950,000
$/ac-ft	857.28	365.99	292.73
$/1,000 gallons	2.63	1.12	0.90
ALTERNATIVE 2			
(Capital Cost = $151,140,000)			
Annual Capital Cost (50 years @ 8%)	12,320,000	12,320,000	12,320,000
Power and Energy Costs	1,056,000	3,838,000	5,922,000
O&M (excluding power)	614,000	1,464,000	2,144,000
Total	13,990,000	17,622,000	20,386,000
$/ac-ft	863.58	349.64	260.03
$/1,000 gallons	2.65		
ALTERNATIVE 3			
(Capital Cost = $131,360,000)			
Annual Capital Cost (50 years @ 8%)	10,708,000	10,708,000	10,708,000
Power and Energy Costs	1,464,000	6,383,000	11,257,000
O&M (excluding power)	633,000	1,578,000	2,350,000
Total	12,805,000	18,669,000	24,315,000
$/ac-ft	785.68	368.79	309.09
$/1,000 gallons	2.43	1.14	0.95
EAGLE RIVER[b]			
(Capital Cost = $122,060,000)			
Annual Capital Cost (50 years @ 8%)	9,949,000	9,949,000	9,949,000
Power and Energy Costs	676,000	2,278,000	3,221,000
O&M (excluding power)	691,000	1,631,000	2,393,000
Total	11,316,000	13,858,000	15,563,000
$/ac-ft	698.52	275.96	198.51
$/1,000 gallons	2.14	0.85	0.61

Note: All costs are in 1981 Dollars

[a]Without additional sources developed in the Anchorage Bowl, 14 mgd is needed by 1985, 45 mgd by 2000, and 70 mgd by 2012 (MAUS, 1979). Development of Anchorage Bowl water sources will postpone the need for these average volumes of water from a source outside the Bowl.

[b]Does not include major capital cost items identified in text such as reservoir land and fish facilities.

SUMMARY

The energy impact of a new water source for Anchorage will be considerable. This is especially true for the Eklutna alternatives. Alternative 1 will not impact the energy production at the Eklutna hydroelectric facility, but pumping and treatment energy requirements, at 70 mgd, will be 88 million kWh per year. Alternative 2 will reduce the average energy output of the hydroelectric facility by 40 percent, (62 million kWh per year) and use 6 million kWh per year for treatment. Alternative 3 will reduce the average energy output of the hydroelectric facility by 26 percent (40 million kWh per year) and use 81 million kWh per year for pumping and treatment. The Eagle River water supply project will use 39 million kWh per year for pumping and treatment at 70 mgd.

The capital costs of the alternatives range from $131 to $151 million. The capital cost for the Eagle River dam project is expected to range from $122 to $160 million, depending on the cost for reservoir land, dump water quality impact mitigation, fish facilities and habitat impact mitigation, and other environmental concerns. The Eagle River dam would be a complex structure and proper operation of the reservoir is somewhat complex. Many uncertainties exist regarding the dam construction.

The total annual cost of building and operating a new 70-mgd water supply facility at Eklutna ranges from $20 to $24 million. The partial cost estimate for the Eagle River dam project indicates a total annual cost of $16 million. If additional capital costs should be $30 million, for example, the total annual cost for 70 mgd is over $18 million. As shown in Figure 6-5, refinement of costs for the Eklutna and Eagle River projects may prove that costs for Eagle River are similar to those of at least one of the Eklutna alternatives.

Chapter 7
ENVIRONMENTAL CONSIDERATIONS

This chapter identifies the various environmental concerns of regulatory agencies and interested groups regarding the diversion of water from the Eklutna Watershed. It then compares the three diversion alternatives with each other and the Eagle River Project.

IDENTIFICATION OF ENVIRONMENTAL CONCERNS

Preliminary studies of possible diversion of water from the Eklutna watershed indicated relatively less environmental impact than would be associated with diversion from the Eagle River (Tryck, Nyman, and Hayes, 1973; U.S. Army, Corps of Engineers, 1979). Having identified specific environmental concerns about a reservoir and treatment plant at Eagle River (during Task 2 studies), we contacted the same regulatory agencies and interested parties regarding the three Eklutna diversion alternatives.

From our contacts with these regulatory agencies, interested parties, and the Municipality of Anchorage we derived a list of environmental concerns. Where possible, information from previous reports has been included. The identification process did not include public hearings or meetings, and thus is not fully representative of the sentiments of all people potentially affected by the various water-supply options.

The following agencies and entities were contacted:

Federal Agencies

- Department of the Army
  - Corps of Engineers
  - Fort Richardson Command, Environmental Office and Utilities Division
- Department of Commerce, National Marine Fisheries Service
- Department of Energy, Alaska Power Administration
- Department of Interior, U.S. Fish and Wildlife Service
- Environmental Protection Agency

State of Alaska

- Alaska Department of Environmental Conservation
- Alaska Department of Fish and Game
- Alaska Department of Natural Resources
- Division of Forest, Land and Water Management
- Division of Geological and Geographic Surveys
- Division of Parks
- Eklutna, Inc.

Municipality of Anchorage

- Planning Department
- Water and Sewer Utilities
- Department of Law

ENVIRONMENTAL CONCERNS

The concerns expressed by the agencies and other groups contacted fell within the broad categories of potential impacts on fisheries, wildlife, land use, power production, water quality, and institutional arrangements (rights-of-way) within the project area.

Fisheries

Present fishery resources of the Eklutna watershed are not well known, but are not thought to be extensive. Studies to determine the extent of the fishery resource would be necessary to establish whether instream flow studies would be required and to aid in establishing minimum flow requirements below the project for Alternatives 1 and 2. The proposed hatchery near the existing Eklutna power plant (see Figure 4-5) should not be adversely affected by the water supply project; hatchery design effort should be coordinated with the Municipality of Anchorage to assure that room is provided for future facilities.

Wildlife

Wildlife resources will be impacted only during construction of the project, except possibly in the case of Alternative 3, which will require a powerline to the pump station at Eklutna Lake. The design and construction of the powerline should consider potential impacts on wildlife, particularly raptors.

Land Use

The availability of a reliable water supply is likely to stimulate development in some or all of the affected communities (Eklutna, Peters Creek, Birchwood, Chugiak and Eagle River). Concerns were expressed that deviations from approved land use plans might occur. Attitudes toward enhanced development appear to vary considerably within the area.

Energy Production

The APA expressed concern over the effect of proposed withdrawals of water on the existing Eklutna hydroelectric facility's energy production. This reduction in energy production could be the most significant impact of the project. Any alternative that would minimize or delay withdrawals of water upstream from the facility would be preferred by the APA. The APA would also prefer alternatives that involve as little impact as possible on existing structures. Reduced energy production at Eklutna would have to be offset by energy from other facilities to meet APA contractual obligations. The most likely source of energy might be a thermal plant somewhere in the Anchorage area. Thus, there could be secondary effects of the water supply project from construction and operation of a thermal power plant.

Water Quality

The primary concern over water quality involves disposal of sludge from the water treatment plant. It is unlikely that disposal to a flowing river would be allowed. Disposal to Knik Arm might be possible if it is demonstrated that existing water quality would not be significantly degraded. Land disposal would be required if the use of Knik Arm is not feasible.

Right-of-Way

A considerable amount of public and private land will be crossed by the pipeline. While right-of-way is not a major environmental issue, an opinion was expressed that witholding right-of-way might be used to express opposition to other impacts of the project such as its possible effects on land use.

COMPARISON OF DIVERSION ALTERNATIVES

Alternative 1

Alternative 1, diversion from the Eklutna River and the tailrace of the Eklutna hydroelectric facility, would not affect existing energy production, but would require energy for pump station operation. Existing Eklutna facility structures would not be altered, except the tailrace channel. A new diversion structure would be required in the lower Eklutna River. Prior to diverting river flows, minimum streamflow requirements would have to be determined.

Approximately 7 miles of rights-of-way would be required from public agencies between the hydroelectric facility and the Eklutna

River. Because of geological conditions, special construction techniques might be required, such as pile-supported the pipe, special bedding, cathodic protection, and special pipe joints. Impacts during construction would be greater than those associated with Alternative 3.

The treatment plant would be located near the Glenn Highway crossing of the Eklutna River. Discharge of sludge could be either to Knik Arm or to settling ponds.

Alternative 2

Alternative 2, diverting water from the hydroelectric facility's tunnel, would provide sufficient head for gravity flow to a treatment plant north of the Eklutna Lake Road, thus eliminating the need for a pump station at the tailrace. From the treatment plant south to Anchorage, this alternative follows a route similar to Alternative 1; however, no pump stations would be needed because the treatment plant would be at an elevation allowing gravity flow to Anchorage. This alternative requires a high-pressure pipeline. Although Alternative 2 would reduce energy production of the existing facility the most, its total energy requirements are less than either of the other alternatives because no pumping is necessary.

Alternative 3

Alternative 3 involves the installation of a pump station at Eklutna Lake and diversion from the lower part of the Eklutna River. The existing hydroelectric diversion structures would not be altered. As in Alternative 1, the flows in Eklutna River could also be diverted, reducing the total withdrawals necessary from Eklutna Lake. There would thus be less reduction in energy production from the Eklutna facility than would occur with Alternative 2.

During the summer months, water contributed by the Eklutna River might be less turbid than that from Eklutna Lake. Sludge volumes and treatment costs may be the same as for Alternative 1 and lower than those for Alternative 2.

A power line to Eklutna Lake will be required for the pump station. However, if a lake tap should prove feasible, pumping would not be required. If use of the old hydroelectric dam is not feasible, a new diversion structure would have to be built on the Eklutna River below its confluence with Thunderbird Creek. Minimum streamflow requirements will have to be determined prior to diverting water out of the Eklutna River.

From the Eklutna River south to the Eagle River the pipeline would follow the same route as Alternatives 1 and 2. The pipeline for Alternative 3 would be 7 miles shorter than for the other alternatives.

COMPARISON OF ENVIRONMENTAL EFFECTS OF THE EAGLE RIVER DIVERSION AND EKLUTNA ALTERNATIVES

Table 7-1 lists the relative magnitude of possible environmental effects of a dam and reservoir at Eagle River and of the three Eklutna Lake alternatives. Magnitude is based on the frequency with which concerns were expressed or on direct statements from persons consulted.

SUMMARY

The environmental concerns relating to natural resources are less for the three Eklutna alternatives than for a dam and reservoir at Eagle River. Potential fisheries impacts are less, and potential impacts on wildlife are much less. While there might be slightly greater fisheries impacts from Eklutna Alternatives 1 and 3 than from Alternative 2, those are not expected to be great.

The impacts on water quality and potential effects of water quality on human health are much less with the Eklutna options, than with Eagle River, particularly in regard to sediment and sludge disposal. The old Eagle River dump also poses potential water quality problems for the Eagle River dam and reservoir project.

Eklutna Alternatives 2 and 3 would reduce the total energy generation at the existing Eklutna facility. The Eagle River project would have the lower energy requirements than the Eklutna alternatives.

Visual impacts are not a problem at Eklutna compared to the impacts of the proposed reservoir on the Eagle River. Projects in either watershed would have similar impacts on land use northeast of Anchorage, because water would be provided to this area from both.

The Eklutna alternatives would require fewer rights-of-way and less land acquisition than the Eagle River project. Of the Eklutna options, Alternative 3 requires a shorter pipeline than Alternatives 1 and 2.

Table 7-1
MAGNITUDE OF ENVIRONMENTAL EFFECTS
EAGLE RIVER PROJECT AND EKLUTNA ALTERNATIVES

Impact	Eagle River	Eklutna Alt. 1	Eklutna Alt. 2	Eklutna Alt. 3
Fisheries				
Loss of Habitat	H	L	0	L
Fish Passage Facilities	H	0	0	0
Minimum Flow Requirements	H	L	0	L
Sediment (from reservoir flushing)	H	0	0	0
Requirement for Mitigation of Losses	H	L	0	L
Changes in Microclimate (including downstream temperature)	L	0	0	0
Wildlife				
Loss of Habitat for Big Game Species	H	0	0	0
Loss of Habitat for Nongame Species	H	L	L	L
Management of Pipeline Right-of-Way	H	H	H	H
Groundwater				
Shallow Aquifers Near Eagle River	L	0	0	0
Water Quality				
Leachate from Dump	H	0	0	0
Septic Systems in Drainage Area	H	L	0	L
Recreational Use of Watershed	H	H	0	H
Dilution of Existing Sewage Outfalls	L	0	0	0
Power Production				
Effect on Eklutna Hydroelectric Facility	0	L	H	H
Energy Requirements	H	H	0	H
Land Use				
Effects on Land Use Options	H	H	H	H
Location of Treatment Plant	L	L	L	L
Powerlines	L	0	0	L
Dam Safety	H	0	0	0
Aesthetic Effects				
Historic and Archeological Sites	L	L	L	L
Visual Impacts	H	0	0	L
Right-of-Way and Difficulty of Reservoir Land Acquisition	H	L	L	L

L = Low
H = High
0 = Zero

Chapter 8
CONCLUSIONS AND RECOMMENDATIONS

Task 5 has demonstrated the technical feasibility of three alternative projects for developing a 70-mgd water supply in the Eklutna watershed. Figure 8-1 rates the three Eklutna alternatives and the Eagle River project in terms of the potential impact of a number of important aspects. The chart suggests that costs appear higher for the Eklutna alternatives. However, the development of a water supply project at Eklutna will have considerably less environmental impact than the Eagle River project. Potential delays of the Eagle River project for land acquisition, environmental studies, and old Eagle River dump mitigation lead to the conclusion that the Eklutna project can be implemented in a more timely manner. Additionally, inflation effects of such delays could severely impact final construction costs of the Eagle River project.

It is projected that a new water source will be needed within the next ten years to supplement Anchorage Bowl sources. (The Eagle River-Chugiak-Eklutna area needs a new source of water now.) We conclude that only the Eklutna water source can be developed in time to meet projected Anchorage Bowl demands.

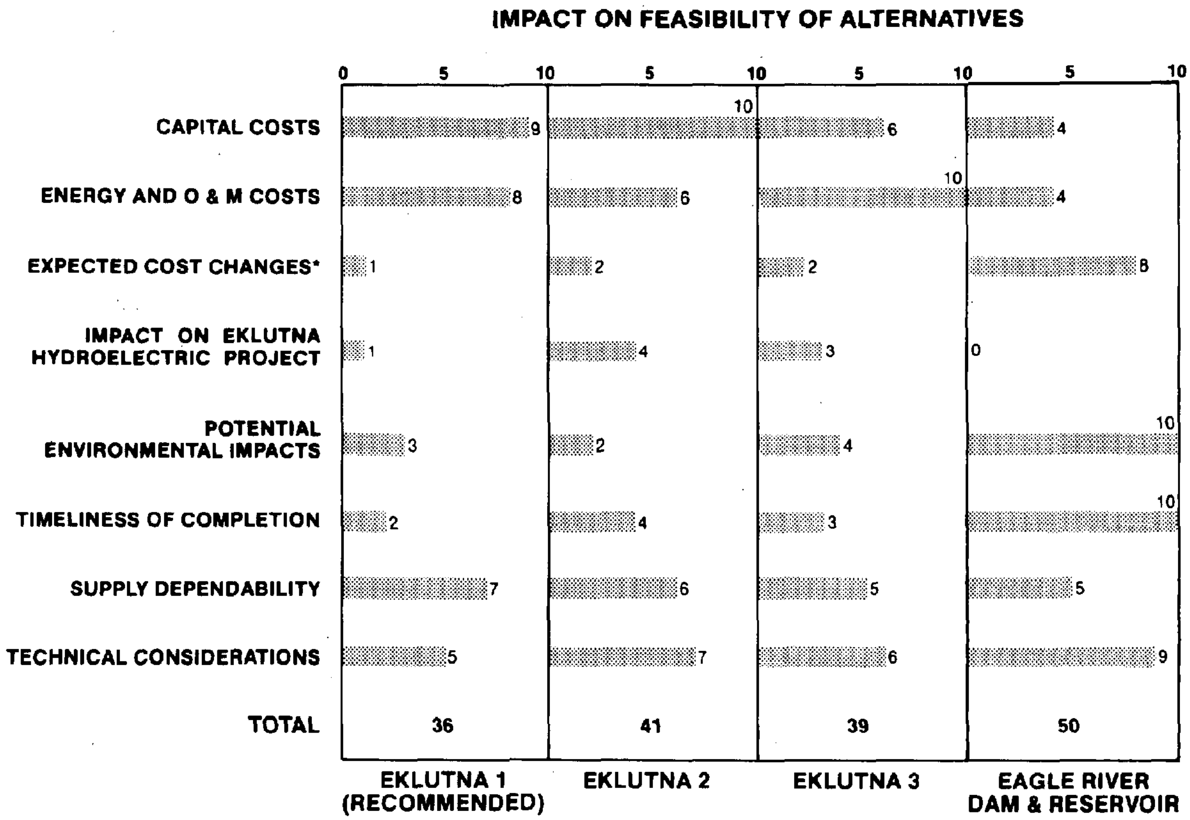
The following eight factors were used in ranking each alternative:

1. Capital Costs: The projects were ranked on a straight-line basis. Eklutna Alternative 2 was rated 10, because it is estimated to be the most expensive ($151 million). A project costing $100 million would have rated 0.

2. Energy and O&M Costs: The projects were ranked on a straight-line basis. Eklutna Alternative was rated 10, since it is estimated to have the highest costs ($13.6 million per year at 70 mgd). A project with no annual cost would have rated 0.

3. Expected Cost Changes due to design improvements, staged construction, land purchase requirements, and other unknowns and uncertainties: As shown in Figure 6-5, costs could easily be comparable for Eagle River and Eklutna. Therefore, Eagle River was given a rating of 8 to reflect this. Energy conservation and staged construction is expected to improve Eklutna Alternative 1 the most; it is rated at 1.

4. Impact on Eklutna Hydroelectric Project: The projects were ranked on a straight-line basis, no impact to 100 percent impact. Eagle River has no impact and is rated 0; Eklutna Alternative 2 (tunnel tap) has an average annual impact of 40 percent at 70 mgd, and is rated 4; Eklutna Alternative 3 (lake diversion and



0 = NO IMPACT
10 = MAXIMUM IMPACT

* DUE TO DESIGN IMPROVEMENTS, STAGED CONSTRUCTION, AND LAND PURCHASE REQUIREMENTS

Figure 8-1
Comparison of Water Supply Alternatives

river diversion) has an average annual impact of 26 percent at 70 mgd, and is therefore rated 3 (the closest whole number). Alternative 1, tailrace diversion and river diversion, was given a rating of 1 instead of 0 because the operation and maintenance of the Eklutna hydroelectric facility may have to be modified to ensure that adequate water is flowing through the tailrace at all times.

5. Potential Environmental Impacts: The projects were ranked on a relative basis, no impact to the level of impact expected at Eagle River, rated at 10. Eklutna Alternative 2 (tunnel tap) was rated lowest at 2, since its only impact is that associated with the pipeline. This level of impact was felt to be considerably less than that of the Eagle River project. Eklutna Alternative 1 (tailrace and river) rated one point higher because of the Eklutna River diversion and tailrace pump station. Eklutna Alternative 3 (lake and river) was rated the highest of the Eklutna projects at 4. The Alternative 3 factors that resulted in the extra point over Alternative 1 include:

   - The pump station at Eklutna Lake (semi-remote)
   - The power line to the pump station at Eklutna Lake
   - The change in river flows

6. Expected Timeliness of Project Completion: As discussed above, the Eagle River-Chugiak area needs a new source of water now. The Anchorage Bowl is expected to need a new source of water from outside the bowl within ten years. We believe there is high probability that the Eagle River dam project cannot be completed within ten years, principally because of environmental and land ownership questions; hence it is rated 10. Ideally, a project should be ready for start of construction next year to serve the Eagle River-Chugiak area. (Increased supplies are also needed now in the Anchorage Bowl.) The project that should encounter least agency and environmental resistance is the Eklutna Alternative 1. Alternative 3 (rated 3) may incur agency and environmental delays because of the work required in and around the lake. Alternative 2 is rated 4, the highest of the Eklutna projects, because of the delays expected from by the U.S. Department of Energy.

7. Supply Dependability: The Eagle River project offers a relatively reliable supply and is rated at 5. Long pipelines are involved, with medium-length lines going both

north and south. The dependence of the project on a somewhat complex reservoir operation reduces its overall reliability. Eklutna Alternative 3 has the shortest pipeline of the three Eklutna projects, about 22 miles versus about 30 miles for the other two. It is rated 5. Eklutna Alternative 2, with 30 miles of pipeline, has very few mechanical features (no pump stations); however, the water supply can be interrupted by loss of tunnel water. It is rated 6. Infrequently the tunnel is dewatered for inspection, for example after the 1964 Alaska earthquake caused debris to enter the tunnel and disrupt the hydroelectric project. The tunnel was dewatered for inspection, cleaning, and repair. Eklutna Alternative 1 is rated the highest at 7 because of the long pipeline (30 miles), because the tailrace pump station is subject to damage from an earthquake due to poor ground conditions, and because the water supply is totally dependent on the operation and integrity of the hydroelectric project.

8. Technical Considerations: The Eagle River project has many perceived technical considerations, and is rated 9. Many technical considerations are noted in Appendix II for the dam, winter operations of the facility, and sedimentation considerations. Eklutna Alternative 1 rates a 5 because of the geotechnical considerations at the tailrace and along the pipeline route from the tailrace to the Village of Eklutna. Additionally, the river diversion may experience frazil ice and other winter operations problems. Eklutna Alternative 3 avoids the tailrace and pipeline geotechnical problems, but may have similar or worse problems at the Eklutna Lake shoreline. Technical considerations for Eklutna River frazil ice are more important for Alternative 3 because all of this alternative's water is diverted from the lower portion of the steep and turbulent river. It is rated 6. Eklutna Alternative 2 is rated 7 principally because of the poor geology and very steep slopes near the tunnel adit. Additionally, this alternative requires very-high-pressure pipe. In addition, the treatment plant for this alternative must be at an altitude of over 600 feet to allow gravity flow to Anchorage.

With this rating method we conclude that Eklutna Alternate 1 is the most viable project for the Municipality of Anchorage's future water supply. This project diverts water from the Eklutna hydroelectric project's tailrace and the lower Eklutna River.

RECOMMENDATIONS

Task 5 has with limited time and data addressed many considerations for a water supply project at Eklutna. Significant improvements in the recommended alternative are needed prior to design. Additional studies should be concluded in the near future to ensure timely project implementation.

The following areas of study are recommended:

- Facility Combination. Combining facilities from the Eklutna alternatives and the Eagle River project could result in a more cost-effective project. For example, a nonwinter diversion pump station upstream of the old dump on the Eagle River could reduce energy demands enough to justify its construction. This addition would face less land and environmental concerns than the dam and reservoir project.

- Revised Population Projections. The size and timing of the water supply facilities depend on population projection. New projections should be made. The Municipal Planning Department has indicated that new data will possibly decrease the existing population projections. This would lead to a subsequent reduction in anticipated water demands.

- Evaluation of Existing Annual Demand Variations. Low, average, and peak demands should be estimated. Once estimated, we recommend that revisions be made in facility sizing to reflect these demand variations.

- Integration of the Municipal Water Treatment Plant Expansion and New Water Well Plans with the Eklutna Water Source Project. We recommend that Anchorage Bowl projects be integrated with plans for the Eklutna project to allow for staging and timing of construction considerations.

- Energy Conservation Consideration. Pipeline size optimization and integration and combination of alternatives should make the recommended project more cost-effective.

- Winter Regime Studies. An analysis should be conducted to determine methods of minimizing frazil and other ice impacts.

- Geotechnical Investigations. Complex geological conditions exist at pump station and treatment plant sites and on pipeline routes. Field data and testing should be conducted during preliminary design.

- Water Treatment Pilot Plant. A pilot plant of at least 1-mgd capacity should be operated for 1 year to determine design parameters, to identify potential operational problems, and to establish operational and chemical costs.

- Preliminary Facilities Design. Preliminary plans and specifications should be prepared for the pipeline, pump stations, diversion structures, and treatment plant, along with a detailed cost estimate. The design should take advantage of the results of the recommended areas of study listed above.

Chapter 9
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Exhibit A
Transmission Pipeline Criteria

Exhibit A
TRANSMISSION PIPELINE CRITERIA

Certain criteria were used in the preliminary design of the pipeline route from the Eagle River to the Municipal Water Treatment Plant in Anchorage (Appendix IV, Transmission Main Design). This exhibit is a summary of some these criteria as they relate to the proposed pipeline routes from an Eklutna Lake diversion to the Eagle River.

VELOCITIES

The minimum velocity for untreated water is recommended to be 2 feet per second (fps). No minimum velocity is required for treated water. The maximum velocities should be held to 5 to 7 fps except for that section of the pipeline from the diversion point to the water treatment plant. A higher maximum velocity in this section of the main may be required in order to meet the minimum desired velocity during initial flow conditions.

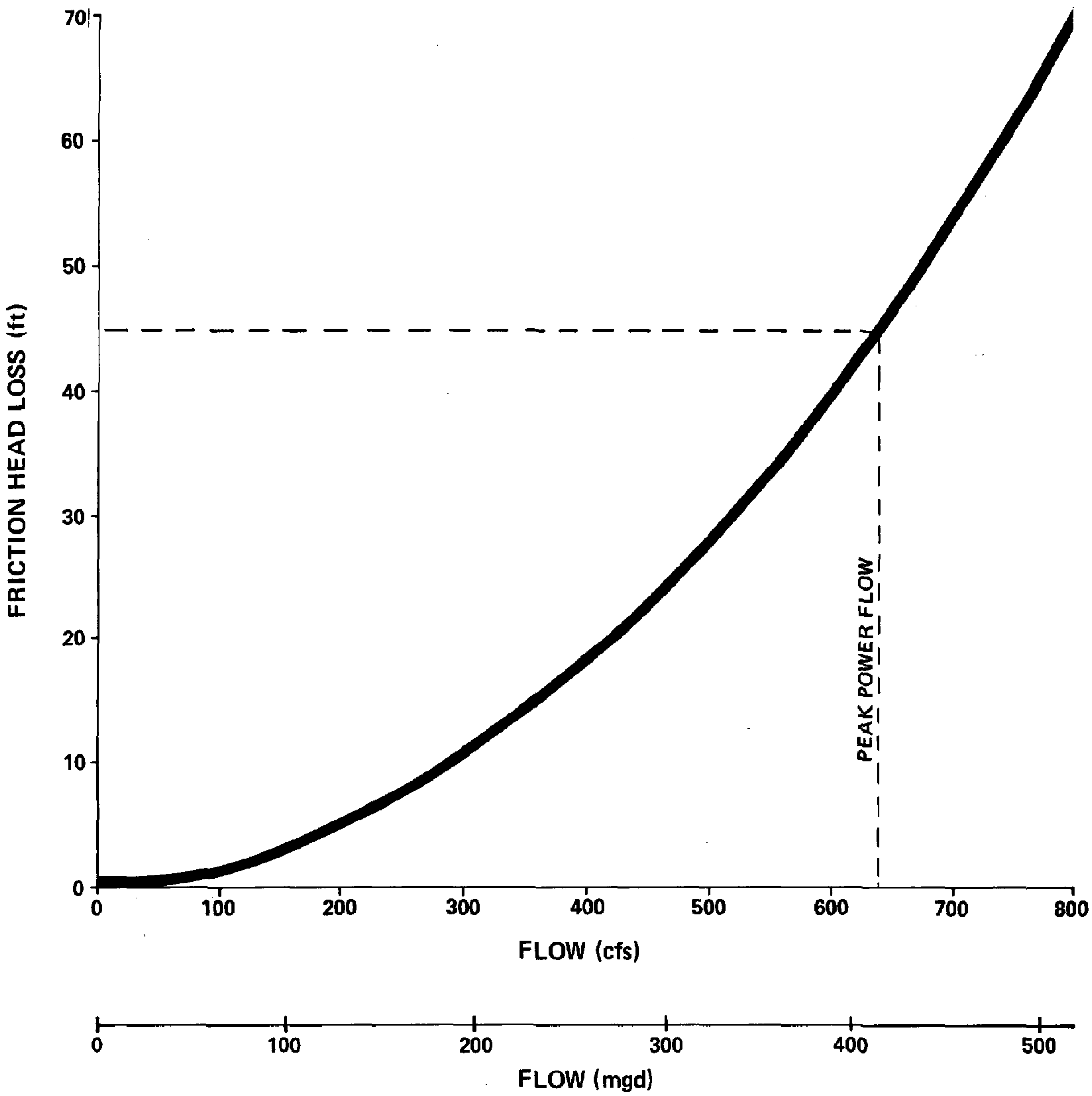
PRESSURES

The pressures in the pipeline may vary from 15 to 355 pounds per square inch (psi), depending on the alternative project selected and the operating flow condition. Alternative 2, diversion of water from the Eklutna Lake tunnel will involve high heads of up to 355 psi in order for the water to flow by gravity to Anchorage. Numerous pressure-reducing stations will be required along the pipeline for the distribution systems connecting to this supply main.

The alternatives whereby water is diverted from the Eklutna power plant tailrace or the Eklutna River were tentatively designed so that the pressures between the communities of Eagle River and Eklutna would range from a minimum of 40 psi to a maximum of 120 psi. Thus, the pipeline would provide for normal service without the addition of numerous pressure-reducing stations to the various distribution systems served by the main.

FRICTION LOSSES

A Hazen-Williams coefficient "C" of 120 will be used to size the pipelines. Friction factors for the Eklutna Lake tunnel were determined from 1960 field measurements (U.S. Bureau of Reclamation. Friction Factors for Large Conduits Flowing Full. 1977). The tunnel is 23,550 feet long and 9 feet in diameter, and is concrete-lined. Figure A-1 shows the relationship between flow and tunnel head loss.



NOTES: 1. DOES NOT INCLUDE THE FOLLOWING ADDITIONAL LOSSES:

- Intake Structure
- Age Beyond 1960
- Penstock
- Earthquake Changes

2. TUNNEL LENGTH: 23,500 ft.
3. DIAMETER: 9.04 ft.

DATA SOURCE: U.S. Bureau of Reclamation. 1977.

Figure A-1
Eklutna Lake Tunnel
Head Loss vs Flow

SURGE ANALYSIS

No surge analysis was made during the preparation of this report. For the purpose of selecting pipe classes, a surge allowance of 50 psi is assumed. During the preliminary or final design of the selected alternative, a computer analysis of the surge conditions will be required to solve the hydraulic transient problems.

EXTERNAL LOADS AND RESTRAINTS

Alternative pipeline alignments from the Eklutna hydroelectric facility to the Eklutna River must be designed to withstand live loads from trains. Concentrated pressures on tunnel liners and casing should be calculated using Cooper E80 loadings.

ADDITIONAL PIPELINE DESIGN CONSIDERATIONS

In evaluating the costs of the various alternatives, the requirement for pipe access manholes, isolation valves, blowoff/drain valves, and hydrostatic testing must be considered. This task does not include evaluations of the existing adit tunnel of the Eklutna Lake tunnel and the old Eklutna River diversion dam and tunnel. However, some assumptions have been made so that an order-of-magnitude cost estimate can be made of each alternative.

No geotechnical investigation or corrosion survey has been made on that section of the pipeline from the Eagle River north to the Eklutna hydroelectric facility.

For the purpose of estimating costs, it has been assumed that all the pipeline from the Eklutna River north to the Eklutna hydroelectric facility will require an impressed-current cathodic protection system. Approximately 25 percent of that section of pipeline between the Eagle River and the Eklutna River will need an impressed-current cathodic protection system.

During final design, a corrosion investigation should be performed on the selected alignment. The study would include soil resistivities, chemical analysis of the soils and water, measurement of stray electrical currents, and recommendations for the design of a cathodic protection system, including pipe coatings and linings.

Exhibit B
USGS Water Quality Data

WATER QUALITY DATA

DATE	TIME	SURFACE AREA (SQ MI) (00049)	STREAM-FLOW (CFS) (00060)	STREAM-FLOW, INSTAN-TANEOUS (CFS) (00061)	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)
OCT , 1948									
18...	1350	119	--	126	--	117	--	--	45
19...	0935	119	--	126	--	214	--	--	90
APR , 1949									
22-29	--	119	111	--	--	133	7.1	7.8	50
MAY									
02-30	--	119	116	--	--	130	7.1	7.8	50
JUN									
03-20	--	119	362	--	--	142	7.1	8.0	52
JUL									
01-29	--	119	817	--	--	135	7.2	6.2	50
AUG									
01-29	--	119	926	--	--	130	7.1	7.2	47
SEP									
02-30	--	119	680	--	--	128	7.0	9.0	46
OCT									
03-31	--	119	185	--	--	125	6.9	11	44
NOV									
04-29	--	119	122	--	--	127	7.0	8.6	44
DEC									
02-30	--	119	133	--	--	130	7.5	2.9	48
JAN , 1950									
03-30	--	119	133	--	--	134	7.4	3.8	48
FEB									
03-27	--	119	125	--	--	138	7.7	2.0	51
MAR									
03-31	--	119	120	--	--	138	7.7	2.0	52
APR									
03-28	--	119	109	--	5	134	7.2	7.1	57
MAY									
01-29	--	119	94	--	5	128	7.4	3.8	48
JUN									
02-30	--	119	349	--	5	139	7.6	2.3	48
JUL									
03-31	--	119	976	--	10	128	7.6	2.3	48
AUG									
04-29	--	119	877	--	10	119	7.5	2.7	43
SEP									
01-25	--	119	472	--	5	124	7.1	6.9	44
DEC									
01-26	--	119	126	--	5	136	7.0	9.4	48

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY
15280000 - EKLUTNA C NR PALMER AK

PROCESS DATE 09/29/81
DISTRICT CODE 02

WATER QUALITY DATA

DATE	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM+ POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
OCT , 1948									
18...	55	0	.14	56	10	18	2.6	5.8	1.0
19...	110	0	.25	--	--	--	--	--	.5
APR , 1949									
22-29	61	0	.09	64	14	19	3.9	1.2	.8
MAY									
02-30	61	0	.18	62	12	19	3.5	1.8	.9
JUN									
03-20	63	0	.20	64	13	20	3.5	2.5	1.1
JUL									
01-29	61	0	.16	62	12	20	3.0	2.8	1.0
AUG									
01-29	57	0	.20	58	12	18	3.3	2.8	.6
SEP									
02-30	56	0	.14	58	12	18	3.0	2.8	.9
OCT									
03-31	54	0	.18	58	14	18	3.2	1.6	1.2
NOV									
04-28	54	0	.16	58	14	18	3.1	2.3	1.0
DEC									
02-30	58	0	.18	58	11	19	2.6	3.3	.9
JAN , 1950									
03-30	59	0	.16	62	13	20	2.9	2.0	.8
FEB									
03-27	62	0	.20	65	14	21	3.1	2.0	.8
MAR									
03-31	63	0	.16	63	11	20	3.1	3.7	.5
APR									
03-28	70	0	.18	74	17	24	3.5	1.4	1.5
MAY									
01-29	59	0	.18	66	18	21	3.3	1.1	1.5
JUN									
02-30	58	0	.09	63	15	19	3.8	1.9	1.1
JUL									
03-31	58	0	.11	56	9	18	2.8	4.3	.9
AUG									
04-28	53	0	.09	53	10	16	3.2	3.5	.9
SEP									
01-25	54	0	.09	61	17	20	2.8	2.1	.4
DEC									
01-26	59	0	.11	62	14	20	3.0	1.8	.5

WATER QUALITY DATA

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)	ELEV. OF LAND SURFACE DATUM (FT. NGVD) (72000)
OCT , 1948									
18...	20	--	3.0	78	26.5	.11	.60	--	856.53
19...	35	--	6.4	--	--	--	1.1	--	856.53
APR , 1949									
22-29	14	--	3.0	72	21.6	.10	.40	--	856.53
MAY									
02-30	13	.1	2.8	72	22.6	.10	.80	--	856.53
JUN									
03-29	16	--	3.5	78	76.2	.11	.90	--	856.53
JUL									
01-29	16	--	3.3	77	170	.10	.70	--	856.53
AUG									
01-29	16	--	3.8	74	185	.10	.90	--	856.53
SEP									
02-30	15	--	2.9	71	130	.10	.60	--	856.53
OCT									
03-31	15	--	2.8	69	34.5	.09	.80	--	856.53
NOV									
04-28	16	--	2.8	70	23.1	.10	.70	--	856.53
DEC									
02-30	15	.1	3.8	74	26.6	.10	.80	40	856.53
JAN , 1950									
03-30	15	.2	4.1	75	26.9	.10	.70	40	856.53
FEB									
03-27	16	.1	5.0	79	26.7	.11	.90	30	856.53
MAR									
03-31	17	.1	5.9	82	26.6	.11	.70	20	856.53
APR									
03-28	16	.2	3.7	86	25.3	.12	.80	20	856.53
MAY									
01-29	16	.2	3.9	77	19.5	.10	.80	20	856.53
JUN									
02-30	17	.0	3.6	76	71.6	.10	.40	100	856.53
JUL									
03-31	16	.0	3.4	75	198	.10	.50	100	856.53
AUG									
04-28	15	.0	2.6	68	161	.09	.40	100	856.53
SEP									
01-25	20	.0	3.4	76	96.9	.10	.40	70	856.53
DEC									
01-26	16	.0	3.2	74	25.2	.10	.50	40	856.53

WATER QUALITY DATA

DATE	TIME	TEMPER-ATURE, WATER (DEG C) (00010)	SURFACE AREA (SQ MI) (00049)	STREAM-FLOW (CFS) (00060)	STREAM-FLOW, INSTAN-TANEOUS (CFS) (00061)	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)
JAN , 1951											
01-29	--	--	119	122	--	5	138	7.1	7.6	49	60
FEB											
02-26	--	--	119	71	--	5	136	7.4	3.8	49	60
MAR											
02-30	--	--	119	56	--	5	137	7.4	3.9	50	61
APR											
02-30	--	--	119	49	--	5	129	7.6	2.3	46	56
MAY											
04-28	--	--	119	46	--	5	134	7.5	3.0	49	60
JUN											
01-15	--	--	119	357	--	5	128	7.3	4.6	47	57
18-29	--	--	119	369	--	5	126	7.4	3.6	46	56
JUL											
02-16	--	--	119	1240	--	5	123	7.3	4.3	44	54
20-30	--	--	119	1350	--	5	110	7.3	3.8	39	48
AUG											
03...	1000	13.0	119	--	999	5	109	7.3	4.0	41	50
06...	1000	13.0	119	--	950	10	107	6.6	20	41	50
SEP											
25...	--	--	119	--	538	5	116	6.6	18	38	46
NOV											
20...	1430	--	119	--	133	5	122	7.4	3.6	46	56
DEC											
27...	--	--	119	--	136	10	125	7.6	2.3	48	58
JAN , 1952											
28...	1500	2.0	119	--	138	10	124	7.5	2.8	46	56
FEB											
20...	1000	.0	119	--	118	5	125	7.5	2.9	48	58
MAR											
11...	1100	.5	119	--	120	5	121	7.2	5.5	44	54
APR											
16...	1330	.5	119	--	48	5	121	7.2	5.4	43	53
MAY											
08...	1400	8.5	119	--	36	5	119	7.4	3.4	44	54
JUN											
10...	1500	--	119	--	100	5	126	7.6	2.4	49	60
JUL											
02...	1430	--	119	--	835	5	120	7.5	12	39	48
AUG											
22...	1600	10.5	119	--	404	5	112	6.8	12	39	48

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY
15280000 - EKLUTNA C NR PALMER AK

PROCESS DATE 09/29/81
DISTRICT CODE 02

WATER QUALITY DATA

DATE	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	SODIUM+ POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)
JAN , 1951											
01-29	0	.14	62	13	20	2.9	--	--	--	3.7	--
FEB											
02-26	0	.20	63	14	20	3.1	--	--	--	2.4	--
MAR											
02-30	0	.20	62	12	20	2.9	--	--	--	3.2	--
APR											
02-30	0	.25	60	14	19	3.1	--	--	--	1.8	--
MAY											
04-28	0	.20	64	15	20	3.5	--	--	--	1.4	--
JUN											
01-15	0	.09	65	18	20	3.7	--	--	--	.6	--
18-29	0	.11	63	17	19	3.7	--	--	--	1.7	--
JUL											
02-16	0	.14	59	15	18	3.4	--	--	--	2.0	--
20-30	0	.09	53	14	16	3.2	--	--	--	2.0	--
AUG											
03...	0	.18	52	11	16	2.9	--	--	--	5.1	--
06...	0	.05	50	9	16	2.5	--	--	--	4.7	--
SEP											
25...	0	.11	55	17	18	2.4	--	--	--	.6	--
NOV											
20...	0	.14	56	10	18	2.6	--	--	--	4.2	--
DEC											
27...	0	.16	58	11	19	2.7	--	--	--	4.8	--
JAN , 1952											
28...	0	.14	62	16	19	3.6	--	--	--	.7	--
FEB											
20...	0	.11	62	15	19	3.6	--	--	--	3.2	--
MAR											
11...	0	.11	58	14	19	2.6	--	--	--	2.8	--
APR											
16...	0	.11	53	10	17	2.6	--	--	--	4.0	--
MAY											
08...	0	.09	58	13	18	3.1	--	--	--	3.6	--
JUN											
10...	0	.14	63	14	20	3.1	--	--	--	3.7	--
JUL											
03...	0	.14	59	13	19	2.9	--	--	--	3.6	--
AUG											
23...	0	.29	51	12	16	2.9	1.8	.1	7	--	.9

WATER QUALITY DATA

DATE	CHLO- RIDE, DIS- SOLVED (MG/L AS CL) (00940)	SULFATE DIS- SOLVED (MG/L AS SO4) (00945)	FLUO- RIDE, DIS- SOLVED (MG/L AS F) (00950)	SILICA, DIS- SOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L) (70301)	SOLIDS, DIS- SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS- SOLVED (TONS PER AC-FT) (70303)	NITRO- GEN, NITRATE DIS- SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)	ELEV. OF LAND SURFACE DATUM (FT. NGVD) (72000)
JAN , 1951											
01-29	.8	18	.1	3.3	--	79	26.0	.11	.60	30	856.53
FEB											
02-26	1.0	16	--	3.0	--	76	14.6	.10	.90	40	856.53
MAR											
02-30	1.0	16	--	3.2	79	77	11.9	.11	.90	30	856.53
APR											
02-30	.5	16	--	4.0	76	73	10.1	.10	1.1	40	856.53
MAY											
04-28	.6	16	--	4.1	--	76	9.44	.10	.90	70	856.53
JUN											
01-15	1.5	16	.2	5.1	76	76	73.3	.10	.40	30	856.53
19-29	2.0	16	.2	4.3	--	75	74.7	.10	.50	30	856.53
JUL											
02-16	2.0	15	--	4.3	79	72	265	.11	.60	60	856.53
20-30	2.2	14	--	4.6	--	66	241	.09	.40	40	856.53
AUG											
03...	2.0	18	--	5.1	--	74	200	.10	.80	--	856.53
06...	1.0	17	--	6.1	--	72	185	.10	.20	--	856.53
SEP											
25...	2.2	14	.1	3.5	72	64	105	.10	.50	10	856.53
NOV											
20...	2.5	14	.1	3.3	72	73	25.9	.10	.60	60	856.53
DEC											
27...	3.5	15	.1	3.2	76	78	27.9	.10	.70	110	856.53
JAN , 1952											
28...	.5	16	.0	3.1	66	71	24.6	.09	.60	30	856.53
FEB											
20...	1.8	18	.0	3.2	75	78	23.9	.10	.50	10	856.53
MAR											
11...	2.0	16	.0	2.8	71	72	23.0	.10	.50	20	856.53
APR											
16...	1.5	15	.1	2.6	70	69	9.07	.10	.50	10	856.53
MAY											
08...	.8	19	.0	2.9	--	74	7.19	.10	.40	40	856.53
JUN											
10...	2.2	17	.1	3.3	--	80	21.6	.11	.60	20	856.53
JUL											
07...	2.2	15	.0	2.7	--	76	149	.10	.60	30	856.53
AUG											
22...	1.5	15	.0	2.9	--	66	72.0	.09	1.3	30	856.53

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY — PROCESS DATE 09/29/81

612235149011200 - FIVE MILE C AT EKLUTNA LK NR EKLUTNA AK — DISTRICT CODE 02

WATER QUALITY DATA

DATE	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)
MAY , 1953											
01...	10	219	7.4	7.0	90	110	0	.32	114	24	30

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 09/29/81
612235149011200 - FIVE MILE C AT EKLUTNA LK NR EKLUTNA AK DISTRICT CODE 02

WATER QUALITY DATA

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)
MAY , 1953											
01...	9.1	3.6	.1	6	1.0	.0	30	5.9	135	.18	1.4

WATER QUALITY DATA

DATE	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)
MAY , 1953											
01...	10	264	7.7	4.5	115	140	0	.38	138	23	34

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 09/29/81

612328149033200 - THREE MILE C AT EKLUTNA LK NR EKLUTNA AK DISTRICT CODE 02

WATER QUALITY DATA

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)
MAY , 1953											
01...	12	4.5	.2	7	.9	.0	30	6.7	159	.22	1.7

WATER QUALITY DATA

DATE	TIME	TEMPER-ATURE, WATER (DEG C) (00010)	STREAM-FLOW, INSTAN-TANEOUS (CFS) (00061)	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)
JUN , 1949												
24...	1720	8.5	574	--	161	6.8	20	63	77	0	.27	79
JUN , 1951												
06...	--	11.5	323	5	167	6.9	15	62	76	0	.16	77

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY

612701149220800 - EKLUTNA R AT GLENN HWY AT EKLUTNA AK

PROCESS DATE 09/29/81

DISTRICT CODE 02

WATER QUALITY DATA

DATE	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM+ POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
JUN , 1949												
24...	16	23	5.2	2.5	1.4	18	4.9	94	146	.13	1.2	--
JUN , 1951												
06...	15	23	4.7	3.4	1.0	19	4.3	94	82.0	.13	.70	30

WATER QUALITY DATA

DATE	TEMPER-ATURE, WATER (DEG C) (00010)	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)
APR , 1949												
22-29	--	--	145	7.1	8.8	57	69	0	.20	70	13	21
MAY												
02-30	--	--	158	7.6	3.1	63	77	0	.18	76	13	23
JUN												
03-20	--	--	146	7.5	3.4	56	68	0	.18	70	14	22
JUL												
01-29	--	--	140	7.3	5.1	52	63	0	.16	64	12	20
AUG												
01-29	--	--	136	7.0	9.9	51	62	0	.14	64	13	20
19...	11.5	--	187	7.1	12	80	98	0	--	93	13	--
SEP												
02-09	--	--	131	7.1	7.5	48	59	0	.14	61	13	19
OCT												
10-31	--	--	146	7.2	7.0	57	69	0	.18	70	13	21
NOV												
04-28	--	--	148	7.3	5.7	58	71	0	.16	72	14	22
DEC												
02-30	--	--	148	7.5	3.5	57	70	0	.16	71	14	22
JAN , 1950												
07-30	--	--	152	7.6	2.9	59	72	0	.16	71	12	22
FEB												
03-27	--	--	151	7.6	2.9	58	71	0	.14	71	13	22
MAR												
03-31	--	5	150	7.8	1.6	53	65	0	.18	73	20	22
APR												
03-29	--	5	153	7.7	2.4	62	76	0	.18	73	11	22
MAY												
01-29	--	5	160	7.7	2.6	66	81	0	.20	80	14	23
JUN												
02-30	--	5	150	7.7	2.3	58	71	0	.23	75	17	23
JUL												
03-28	--	5	129	7.4	3.6	46	56	0	.14	56	10	18
AUG												
04-31	--	5	121	7.4	3.4	44	54	0	.16	57	13	17
SEP												
01-29	--	5	130	7.7	1.9	48	59	0	.11	51	3	16
OCT												
20-30	--	5	144	7.7	2.2	56	68	0	.11	65	9	20
NOV												
03-27	--	5	141	7.7	2.0	52	63	0	.14	61	9	19

WATER QUALITY DATA

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM+POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
APR , 1949											
22-29	4.4	1.2	.5	15	--	3.5	--	80	.11	.90	--
MAY											
02-30	4.5	2.1	.8	15	.1	4.6	--	89	.12	.80	--
JUN											
03-20	3.6	1.8	1.1	16	--	4.2	--	83	.11	.80	--
JUL											
01-29	3.4	2.8	.9	16	--	3.8	--	79	.11	.70	--
AUG											
01-29	3.4	2.3	.7	16	--	4.2	--	78	.11	.60	--
19...	--	--	--	--	--	--	--	--	--	--	--
SEP											
02-09	3.3	2.3	.5	16	--	3.8	--	75	.10	.60	--
OCT											
10-31	4.2	2.3	.9	16	--	4.2	--	83	.11	.80	--
NOV											
04-28	4.2	1.8	.9	16	--	3.7	--	84	.11	.70	--
DEC											
02-30	3.9	2.3	.8	16	.1	5.7	--	86	.12	.70	40
JAN , 1950											
07-30	3.9	3.7	1.0	17	.1	5.3	--	89	.12	.70	60
FEB											
03-27	3.9	2.7	.9	16	.1	4.9	--	86	.12	.60	30
MAR											
03-31	4.4	1.3	1.9	18	.2	5.8	--	86	.12	.80	30
APR											
03-28	4.5	4.5	1.6	17	.1	5.1	91	93	.12	.80	40
MAY											
01-29	5.4	2.6	1.6	15	.1	6.4	--	95	.13	.90	30
JUN											
02-30	4.2	.6	1.6	14	.1	4.5	88	84	.12	1.0	40
JUL											
03-28	2.6	4.1	1.1	16	.0	3.4	--	73	.10	.60	70
AUG											
04-31	3.5	2.8	1.0	16	.0	3.3	--	71	.10	.70	80
SEP											
01-29	2.8	7.5	1.8	15	.3	6.1	--	79	.11	.50	50
OCT											
20-30	3.6	6.3	1.0	20	--	6.5	--	91	.12	.50	60
NOV											
03-27	3.4	6.0	2.1	18	.2	6.1	--	86	.12	.60	50

WATER QUALITY DATA

DATE	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS (MG/L AS CACO3) (00900)
DEC , 1950									
01-15	5	146	7.8	1.6	52	64	0	.14	64
MAR , 1951									
30...	--	158	--	--	62	75	0	.18	73
APR									
02-30	5	157	7.6	3.1	62	76	0	.20	70
MAY									
04-28	5	148	7.8	1.7	57	69	0	.16	68
JUN									
01-15	5	142	7.5	3.3	54	66	0	.14	69
JUL									
02-13	5	129	7.3	4.7	48	58	0	.14	64
16-30	5	116	7.3	4.3	43	53	0	.11	57
AUG									
03-13	5	113	7.2	5.2	43	52	0	.16	57
17-31	5	112	7.4	3.2	42	51	0	.16	55
SEP									
03-14	5	120	7.4	3.6	46	56	0	.14	56
17-28	5	120	7.5	2.8	45	55	0	.11	61
OCT									
01-15	5	130	7.5	3.2	52	63	0	.11	67
19-29	5	136	7.4	4.1	52	64	0	.11	67
NOV									
02-12	5	138	7.6	2.7	55	67	0	.14	70
16-30	5	136	7.6	2.6	53	65	0	.11	65
DEC									
03-28	5	133	7.1	8.9	57	70	0	.14	66
JAN , 1952									
07-29	0	136	7.1	8.1	52	64	0	.14	69
FEB									
01-29	0	135	7.1	8.3	53	65	0	.14	72
MAR									
03-31	5	134	7.2	6.7	54	66	0	.14	66
APR									
04-29	5	148	7.3	5.9	60	73	0	.09	78
MAY									
02-19	5	157	7.5	4.2	68	83	0	.11	80

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WATER QUALITY DATA

DATE	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	SODIUM+ POTAS-SIUM DIS-SOLVED (MG/L AS NA) (00933)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
DEC , 1950									
01-15	11	20	3.5	--	--	--	4.9	--	1.5
MAR , 1951									
30...	11	--	--	--	--	--	--	--	2.0
APR									
02-30	8	21	4.3	--	--	--	4.0	--	.8
MAY									
04-28	11	21	3.8	--	--	--	2.0	--	.5
JUN									
01-15	15	21	4.0	--	--	--	3.0	--	2.5
JUL									
02-13	16	20	3.5	--	--	--	3.0	--	4.2
16-30	14	18	3.0	--	--	--	2.5	--	2.8
AUG									
03-13	14	18	2.9	--	--	--	4.3	--	5.8
17-31	13	17	3.0	--	--	--	3.4	--	2.8
SEP									
03-14	10	16	3.9	--	--	--	7.9	--	7.0
17-28	16	19	3.4	--	--	--	3.3	--	5.2
OCT									
01-15	15	20	4.1	--	--	--	5.1	--	4.8
19-29	14	20	4.1	--	--	--	5.0	--	4.8
NOV									
02-12	15	22	3.7	--	--	--	3.7	--	5.0
16-30	12	21	3.1	--	--	--	5.2	--	4.2
DEC									
03-29	9	20	3.9	--	--	--	6.9	--	2.8
JAN , 1952									
07-28	16	21	4.1	--	--	--	2.8	--	2.5
FEB									
01-29	19	22	4.1	--	--	--	1.5	--	2.5
MAR									
03-31	12	20	3.8	--	--	--	5.0	--	2.2
APR									
04-29	18	24	4.3	2.1	.1	6	--	.7	1.2
MAY									
02-19	12	23	5.6	2.7	.1	7	--	.7	1.0

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WATER QUALITY DATA

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
DEC , 1950								
01-15	19	--	4.6	--	86	.12	.60	40
MAR , 1951								
30...	--	--	7.0	--	--	--	.80	--
APR								
02-30	14	--	5.4	--	88	.12	.90	10
MAY								
04-28	14	--	4.3	--	80	.11	.70	30
JUN								
01-15	16	.2	7.5	--	87	.12	.60	40
JUL								
02-13	16	.1	4.6	--	81	.11	.60	10
16-30	14	.1	4.7	--	72	.10	.50	30
AUG								
03-13	14	.1	3.7	--	75	.10	.70	30
17-31	15	.1	4.0	--	71	.10	.70	70
SEP								
03-14	16	.1	3.6	--	83	.11	.60	--
17-28	15	.1	3.8	--	77	.10	.50	40
OCT								
01-15	18	.1	5.3	--	89	.12	.50	110
19-29	17	.1	4.2	--	87	.12	.50	50
NOV								
02-12	15	--	4.1	--	87	.12	.60	60
16-30	16	.1	1.9	--	84	.11	.50	90
DEC								
03-28	18	--	6.8	--	94	.13	.60	--
JAN , 1952								
07-23	18	.0	5.6	83	86	.11	.60	30
FEB								
01-29	17	.0	6.1	84	86	.11	.60	30
MAR								
03-31	18	--	4.4	83	87	.11	.60	60
APR								
04-28	17	.1	6.0	90	92	.12	.40	40
MAY								
02-13	17	.1	8.7	98	100	.13	.50	20

WATER QUALITY DATA

DATE	TIME	TEMPER-ATURE, WATER (DEG C) (00010)	STREAM-FLOW, INSTAN-TANEOUS (CFS) (00061)	TUR-BID-ITY (JTU) (00070)	COLOR (PLAT-INUM COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	OXYGEN, DIS-SOLVED (MG/L) (00300)	PH FIELD (UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY (MG/L AS CACO3) (00410)	BICAR-BONATE (MG/L AS HCO3) (00440)	CAR-BONATE (MG/L AS CO3) (00445)
OCT , 1972												
06...	1420	6.5	371	25	0	126	10.9	7.9	1.1	44	54	0
DEC												
18...	1300	2.5	438	9	6	141	--	7.8	1.6	51	62	0
FEB , 1973												
01...	1010	.0	10	--	3	144	--	7.7	2.0	51	62	0
15...	1400	3.0	236	4	--	143	--	--	--	--	--	--
APR												
17...	1520	3.0	193	7	5	143	--	7.5	3.3	54	66	0
JUL												
17...	1145	11.5	145	20	30	144	9.9	7.7	2.2	57	69	0
31...	1015	12.5	159	40	10	138	10.6	8.1	.9	55	67	0
AUG												
13...	1500	10.0	220	--	20	135	--	7.8	1.5	48	59	0
27...	1115	10.5	275	35	9	131	11.0	8.0	1.0	52	63	0
SEP												
26...	1100	9.0	331	15	--	120	10.4	--	--	45	55	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY
612336149084800 - EKLUTNA R AL POWER PLANT NR EKLUTNA AK

PROCESS DATE 09/29/81
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WATER QUALITY DATA

DATE	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	PHOS-PHORUS, ORTHOPH OSPHATE DISSOL. (MG/L AS PO4) (00660)	PHOS-PHORUS, ORTHOPH OSPHATE DISSOL. (MG/L AS P) (00671)	HARD-NESS (MG/L AS CACO3) (00900)	HARD-NESS, NONCAR-BONATE (MG/L CACO3) (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)
OCT , 1972												
06...	.11	--	--	--	57	13	18	2.7	2.5	.1	9	.2
DEC												
18...	--	.04	.03	.010	62	11	20	3.0	3.0	.2	9	.5
FEB , 1973												
01...	--	.07	.00	<.010	65	14	21	3.1	2.8	.2	8	.4
15...	--	--	--	--	--	--	--	--	--	--	--	--
APR												
17...	--	.13	.00	<.010	65	11	21	3.1	2.7	.1	8	.4
JUL												
17...	--	.18	.00	<.010	66	9	21	3.2	2.8	.2	8	.5
31...	--	.13	.00	<.010	74	19	25	2.8	2.9	.1	8	.4
AUG												
13...	--	.13	.00	<.010	59	11	19	2.9	3.3	.2	11	.6
27...	--	.12	.03	.010	59	7	19	2.7	2.6	.1	9	.3
SEP												
26...	--	.14	.00	<.010	59	14	19	2.8	2.5	.1	8	.7

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 09/29/81

612836149084900 - EKLUTNA R BL POWER PLANT NR EKLUTNA AK DISTRICT CODE 02

WATER QUALITY DATA

DATE	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)
OCT , 1972											
06...	1.0	13	<.1	6.3	--	--	--	--	--	110	--
DEC											
18...	4.2	19	.1	2.8	--	--	--	--	--	80	--
FEB , 1973											
01...	.8	20	.1	2.8	--	--	--	--	--	20	--
15...	--	--	--	--	--	--	--	--	--	--	--
APR											
17...	1.3	17	<.1	2.8	--	--	--	--	--	50	--
JUL											
17...	.9	18	<.1	2.8	--	--	--	--	--	50	--
31...	2.7	18	<.1	2.7	--	--	--	--	--	--	--
AUG											
13...	.9	17	<.1	2.9	<1	<100	2	ND	11	<10	<2
27...	1.5	18	.1	2.6	--	--	--	--	--	80	--
SEP											
26...	3.4	16	1.0	3.8	--	--	--	--	--	50	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY
612836149084800 - EKLUTNA R BL POWER PLANT NR EKLUTNA AK

PROCESS DATE 09/29/81
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WATER QUALITY DATA

DATE	MANGANESE, DISSOLVED (UG/L AS MN) (01056)	SILVER, DISSOLVED (UG/L AS AG) (01075)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	COLIFORM, TOTAL, IMMED. (COLS. PER 100 ML) (31501)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	SOLIDS, DISSOLVED (TONS PER DAY) (70302)	SOLIDS, DISSOLVED (TONS PER AC-FT) (70303)	NITROGEN, NITRATE DISSOLVED (MG/L AS NO3) (71851)	SEDIMENT, SUSPENDED (MG/L) (80154)	SEDIMENT DISCHARGE, SUSPENDED (T/DAY) (80155)
OCT , 1972											
06...	20	--	--	--	B0	71	71.1	.10	.50	17	17
DEC											
18...	<10	--	--	--	B0	83	98.2	.11	--	10	12
FEB , 1973											
01...	<10	--	--	--	--	82	2.21	.11	--	--	--
15...	--	--	--	--	--	--	--	--	--	4	2.5
APR											
17...	<10	--	--	--	--	81	42.2	.11	--	3	1.6
JUL											
17...	<10	--	--	--	B14	84	32.9	.11	--	20	7.8
31...	--	--	--	--	B17	88	37.8	.12	--	13	5.6
AUG											
13...	<10	ND	50	<1	B0	76	45.1	.10	--	--	--
27...	20	--	--	--	B8	79	58.7	.11	--	11	8.2
SEP											
26...	120	--	--	--	--	77	68.8	.10	--	5	4.5