University of Minnesota
St. Anthony Falls Hydraulic Laboratory

Project Report No. 211

FEASIBILITY OF HYDROPOWER CAPACITY ADDITIONS AT THE THIEF RIVER FALLS DAM MN 00502

by

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Prepared for

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ACKNOWLEDGEMENTS

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I. INTRODUCTION

The Thief River Falls Dam MN 00502 is located on the Red Lake River in Thief River Falls, Minnesota. The powerhouse and tailrace are part of the original dam, built in approximately 1890. The present dam was built immediately downstream of the original dam (which remains submerged in the pool upstream). The present hydropower facilities were installed and put into operation in 1927. The output capacity at the present hydroelectric facility is 500 kW at a rated head of 14.0 feet. The purpose of this study is to assess the feasibility of upgrading the total hydropower capacity at the site.

The Thief River Falls Dam was included in an amendment to the grant agreement dated September 22, 1980, between the Minnesota Department of Natural Resources and the St. Anthony Falls Hydraulic Laboratory for hydroelectric feasibility studies on seven municipally owned dam sites in the State of Minnesota. The Minnesota Department of Natural Resources and the City of Thief River Falls subsequently made a cost-sharing agreement for the study. Authorization to begin the Thief River Falls Dam hydropower feasibility study was given on May 21, 1981. On March 29, 1982, an inquiry was made to the Federal Energy Regulatory Commission by the City of Thief River Falls to search for the license for the present installation. If no license is found, the city may apply for an exemption from licensing since their total hydropower capacity is less than 5,000 kW.

This study begins with a hydraulic and hydrologic analysis to determine the available incremental capacity. The core of the study is proposed development alternatives which include preliminary designs, project cost estimates, and the estimated power production of each alternative. Each alternative is then analyzed for its economic feasibility, and the sensitivity of various economic parameters is studied. Finally, the benefits and costs of each development alternative are compared, and the environmental impact of the proposed development is evaluated.

It should be noted that two reconnaissance studies have been prepared and contain useful data. These studies are listed as Refs. [1] and [2].

II. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Thief River Falls Dam MN 00502 is located on the Red Lake River just downstream of the junction of Thief River and Red Lake River and is owned and operated by the City of Thief River Falls. The existing dam consists of a 193-foot wide concrete spillway section comprised of three tainter gate sections, four overflow sections equipped with flashboards, a non-overflow section consisting of parallel walls with an earthen dike between and extending above the walls, and a powerhouse on the right bank. In addition to hydropower, the dam provides limited recreation and serves as a source of water supply for the City of Thief River Falls.

The powerhouse contains both hydroturbine/generator units and diesel generators. The existing hydroturbines are currently oprating and are of the vertical open flume Francis type, installed in 1927 by The James Leffel & Company. and are currently operating. The combined output rating for the hydroturbines is 550 kW at a design head of 14.0 feet. The No. 1 Unit has a nameplate rating of 300 kW, and the No. 2 Unit is rated at 250 kW. A recent field test of overall efficiency indicated that Unit Nos. 1 and 2 are operating at 71 and 77 percent efficiency, respectively. This is excellent for lowhead Francis turbines which are 55 years old. The standby diesel generators are used only during emergencies.

The average annual discharge at the site is 745 cfs, and the drainage area is 3450 mi^2. The design net head is approximately 14 ft. The maximum discharge known to have occurred at the dam site was approximately 9,000 cfs in 1950. During the "dustbowl" years of the early 1930's, zero discharge values were recorded for both Thief River and Red Lake River.

All power and energy produced by a new hydropower facility will be used to offset power and energy currently purchased by the City of Thief River Falls from the the Northern Municipal Power Agency (NMPA). The offset of the one-hour system peak is the source of the greatest benefit of an additional hydropower unit. The city also receives benefit for the reduction in the peak of Western Area Power Administration (WAPA). However, since it is anticipated that WAPA power will be phased out in the near future, the WAPA peak reduction was not considered in this study.

According to a contract between the City of Thief River Falls and NMPA, the demand charge is based upon the peak demand which occurs between November 20 and March 20. The peak usually occurs in the coldest months, e.g. January or February, and is monitored by powerplant operators by means of a Load Management System. During peak season, the flow released from Lower Red Lake is determined by the setting of the Corps of Engineers outlet control gates. Provisions are made to retain as much water in the reservoir at the Thief River Falls Dam as possible in anticipation of the peak load. As the peak approaches, both hydraulic turbines should be operated at their full capacity whenever possible.

The rates effective for the period from March 20, 1982, to March 20, 1983, will be a demand charge of $12.26/kW/month and an energy charge of $0.0108/kWH.

Five project development alternatives were considered. Increasing the capacity at the dam will not obstruct the walkway used by citizens (to cross the river) across the top of the dam. All development alternatives considered in this study are based upon a powerhouse location in the east abutment of the present dam. Alternative A, "Do Nothing," is used as a base for calculating the incremental benefits of adding capacity to the existing facility. The following estimates of energy production and benefits were made for the existing facility (1982 base year):

Average Annual Energy Production	2.87 GWH
Average Annual Energy Benefits	$31,000
Average Annual On-Peak Capacity	388 kW
Average Annual Capacity Credit	$57,100
Average Total Annual Benefits	$88,100

As stated in Section VII.A, the above figures include a long history at the site including low flow years. The computed figure of 2.87 GWH compares well with the average annual energy production of 2.84 GWH computed for the years 1970 through 1980 at the Thief River Falls Dam. Aside from the proposed automatic trash-raking system, there are no real incremental costs associated with Alternative A.

It has been suspected that the cause of a high tailwater is due to downstream river conditions. However, the degree to which this factor affects the powerplant operation should be considered in greater depth in any design phase of the project. Weed accumulation clogs the trashracks to such a degree that powerplant operators must rake the racks continually for 3 to 4 weeks during August and at times forces the powerplant to be shut down. An automatic trash-raking system such as the one described in Section VII.A should alleviate this problem. However, a conveyer system and clearance for the boom must be provided separately.

The combination of cold weather and the system peak means that care must be taken to assure that any mechanical gates or trash raking units be free to move. Heating devices such as "Cal-Rods" may be used for this purpose. They are energy consumers but are considered necessary if water is to be conserved and turbine shutoff is to be guaranteed. A final note on winter operation should be made on the heating of the powerhouse. Currently, the generators in the wheelhouse produce enough heat for a majority of the powerhouse. These savings in heating costs should be considered in an estimate of overall operational scheme with any new turbines.

A summary of average annual incremental on-peak capacity, total initial cost and total average annual benefits for Alternatives B, C, D, and E are given below:

Alternative	Average Annual Incremental On-Peak Capacity (kW)	Total Initial Cost	Total Average Annual Incremental Benefit	35-Year Project Life Benefit-Cost Ratio
B	131	$ 938,000	$27,000	0.57
C	178	1,063,700	36,900	0.68
D	239	1,351,000	50,400	0.73
E	179	900,700	36,900	0.75

Of the four development alternatives considered which increase the existing hydropower capacity, Alternative E has the best economic feasibility. However, all of the cost and benefit streams illustrated in Tables 6, 7, 8, and 9 of Section VIII indicate that the project will not be feasible given the economic assumptions made herein.

An economic sensitivity analysis indicates that variations in project parameters and economic assumptions will not alter the negative feasibility of the proposed development. Variations in project cost; discount and escalation rates; operation, maintenance, and replacement costs; and value of energy were considered.

The storage capability of the dam is not significant enough to cause wide variations in either headwater or tailwater elevations. The present and proposed operational schemes will not interfere with the water supply intake for the City of Thief River Falls (located in the upstream reservoir). The implementation of an automated control system for all hydraulic turbines (present and proposed) should be considered further.

The potential environmental impacts of the proposed development are minor, since no new impoundment will be constructed. The greatest potential impacts would occur during construction of any new powerplant when dredging and other activities may impair water quality or interfere with fish spawning.

RECOMMENDATION:

Given the current financial situation, it is not recommended that additional hydropower facilities be constructed at the Thief River Falls Dam.

III. SITE CHARACTERISTICS AND EXISTING FACILITIES

A. Site Description and Location

The Thief River Falls Dam MN 00502 is located on the Red Lake River and is owned and operated by the City of Thief River Falls. The dam is in Section 33, T154N, R23W of Pennington County. The site location is shown in Fig. 1. The dam consists of a 193-foot wide concrete spillway section comprised of three tainter gate sections, four overflow sections equipped with flashboards, a non-overflow section consisting of parallel walls with an earthen dike between and extending above, and a powerhouse on the right bank. The three tainter gates are operated from a footbridge across the top of the piers [3][1]. In addition to hydropower, the dam provides limited recreation and serves as a source of water supply for the City of Thief River Falls.

A plan view and typical cross sections of the spillways and earth embankment are shown in Figs. 2 through 5. The three tainter gates are each approximately 11.0 ft high by 17'9" wide. The four flashboard overflow sections are each 5.0 ft high by 19'8" wide. (The seasonal height of the flashboards is discussed in Section VI.) The earth embankment has a 12 ft crest and 1 on 2 slopes with a T-wall on the downstream side (approximately 18 ft high).[3]

Photographs of the existing powerhouse and spillway sections are shown in Figs. 6 through 10. The proposed powerhouse location on the east abutment of the spillway is shown in Fig. 11.

The existing turbines, installed in 1927, were supplied by The James Leffel & Company. The original description of the equipment and installation stated that the turbines were installed in an open flume arrangement with steel plate draft tubes. The turbines are rated at a head of 14.0 ft and have a combined output capacity of 550 kW. Each turbine was furnished with turbine and gate shafts for direct connection with the generator and governor. A cross section through the wheelhouse of the powerhouse is shown in Fig. 12. A photo of the generators inside the powerhouse is given in Fig. 13.

The original design criteria for the two open flume Francis turbines are summarized in Tables 1 and 2. A recent field test of overall efficiency indicated that Unit Nos. 1 and 2 are operating at 71 and 77 percent efficiency, respectively. This indicates that the existing units are per-

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[1]Numbers in brackets indicate references on page 73.

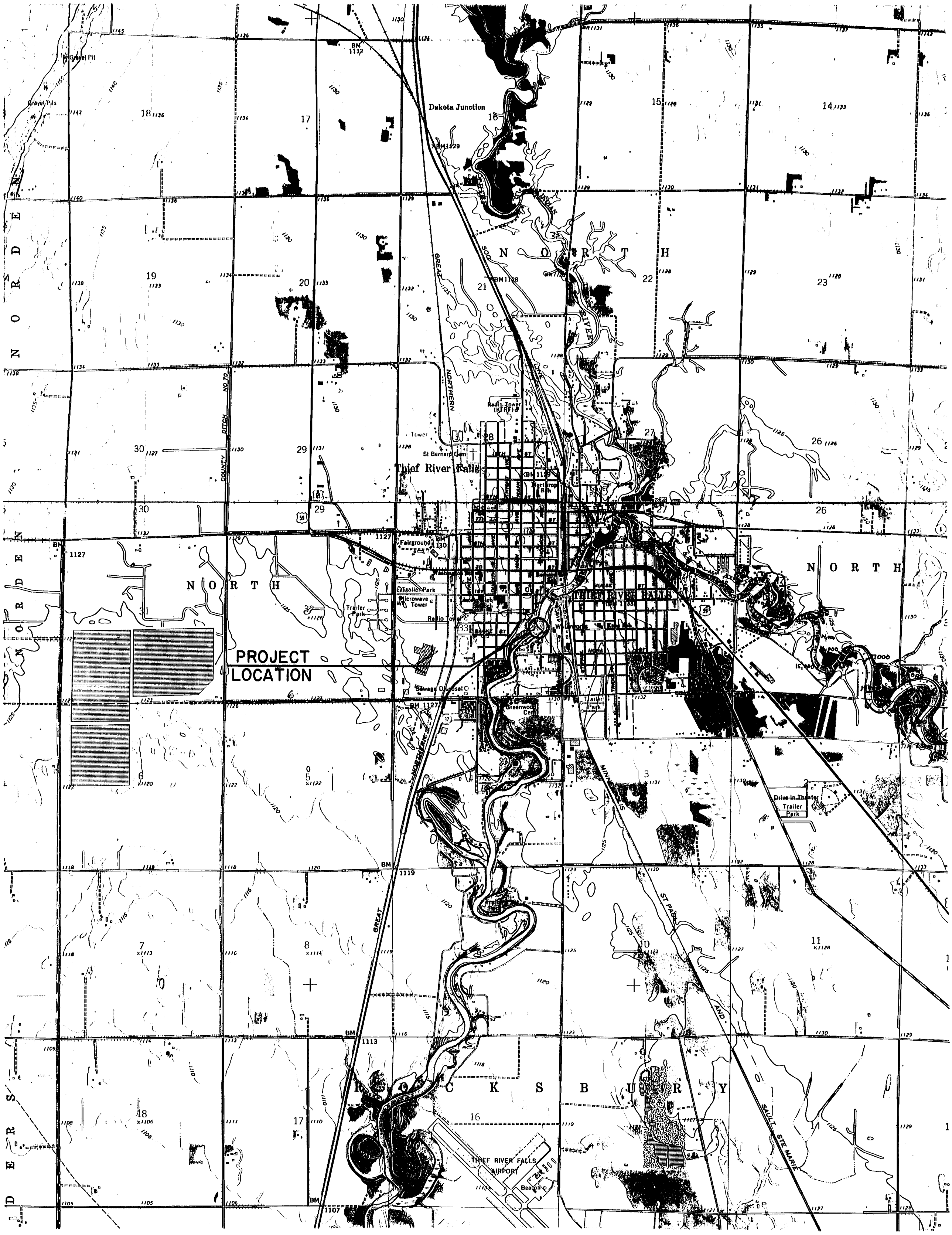

Fig. 1. Project location map of the Thief River Falls Dam.

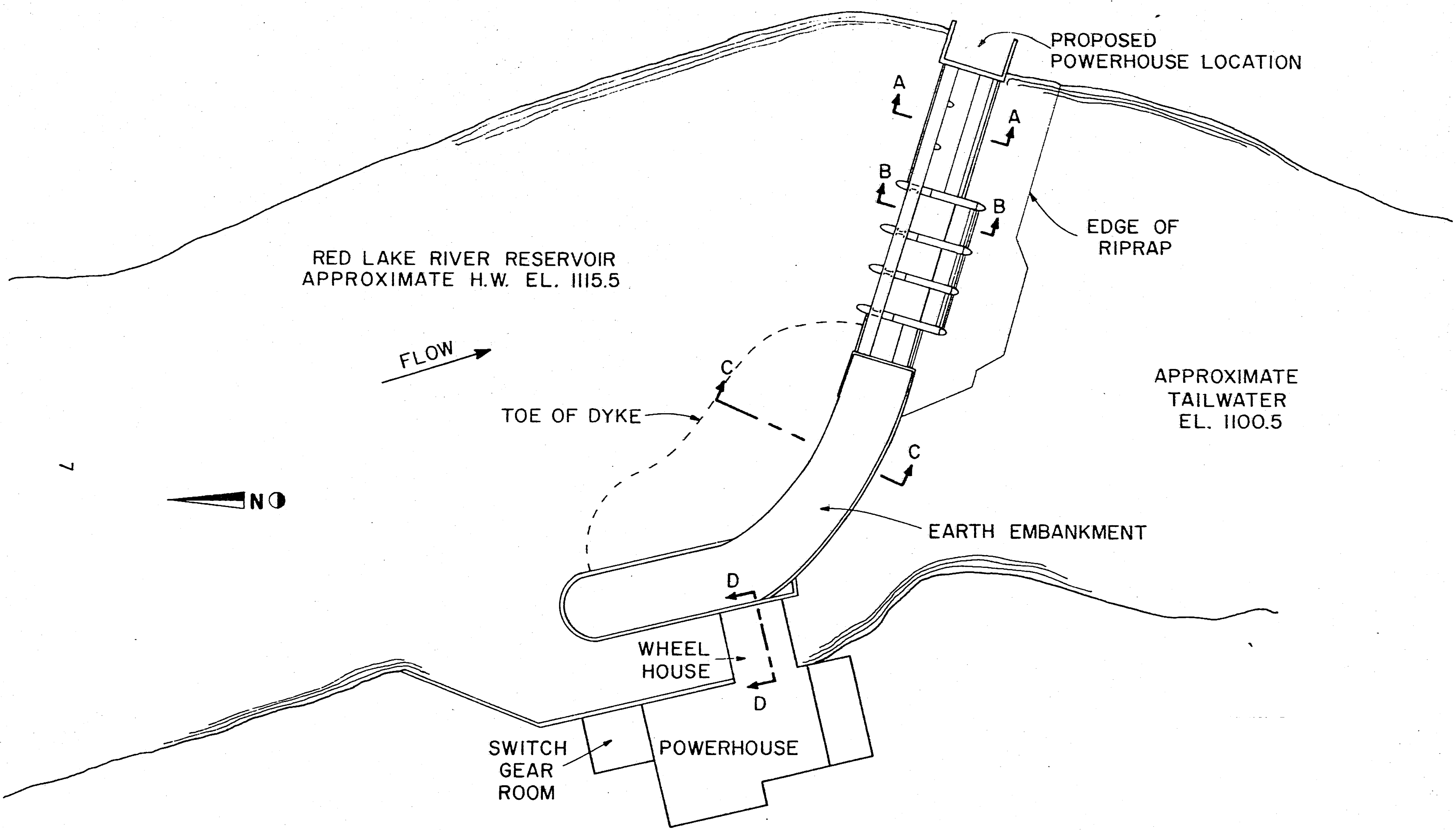

Fig. 2. Plan of the Red Lake River at the Thief River Falls Dam.

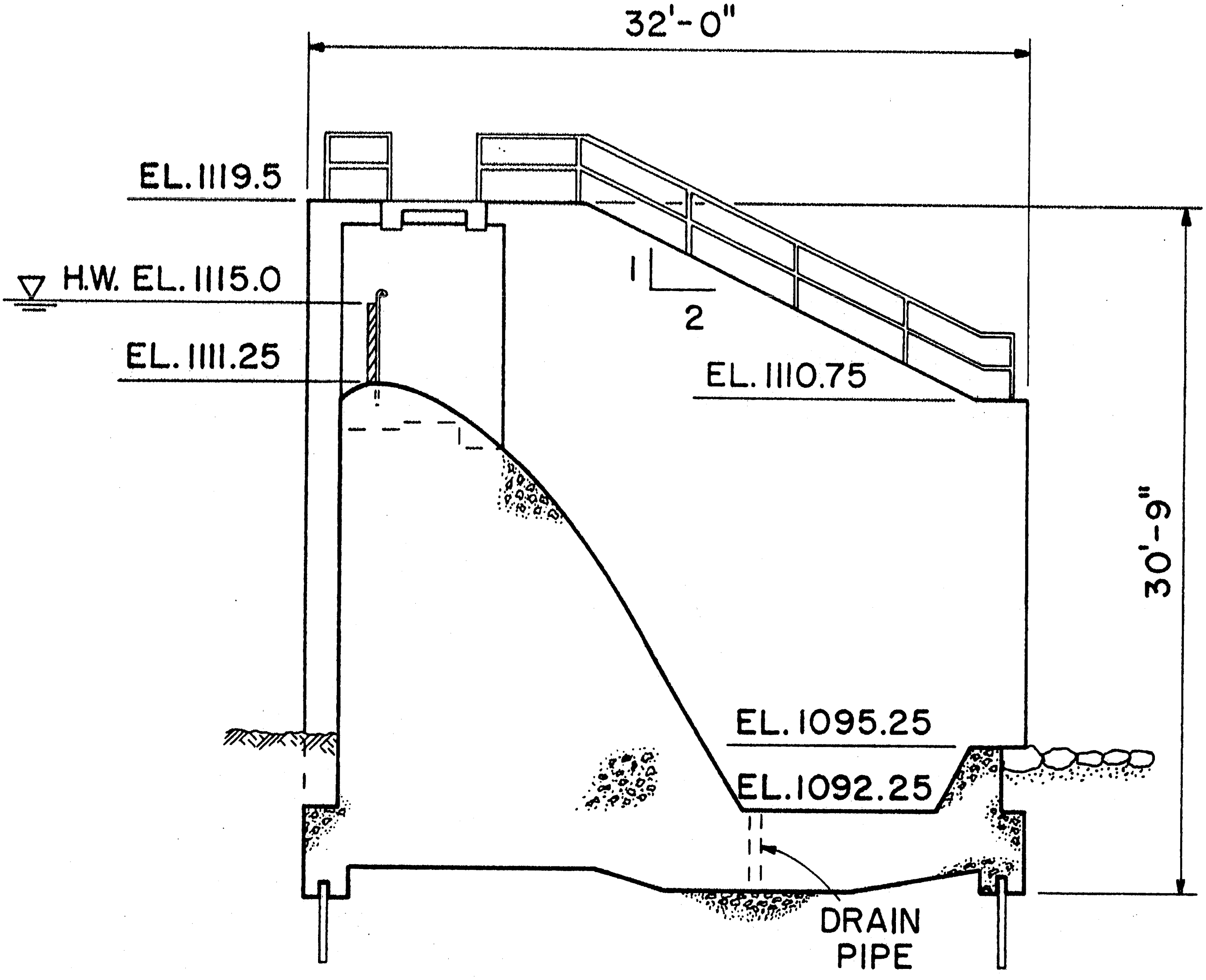

Fig. 3. Section A-A through overflow spillway.

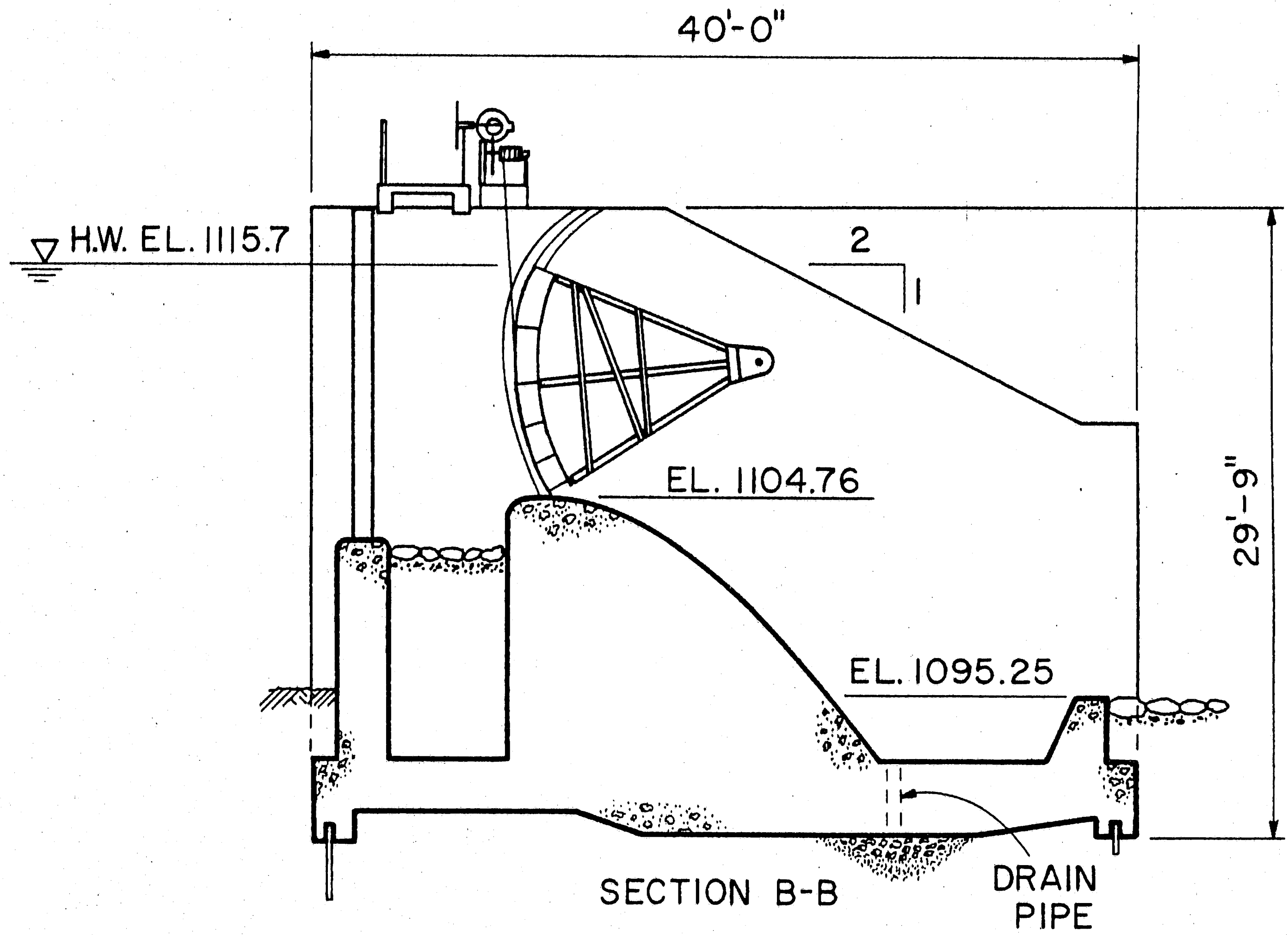

Fig. 4. Section B-B through tainter gate spillway.

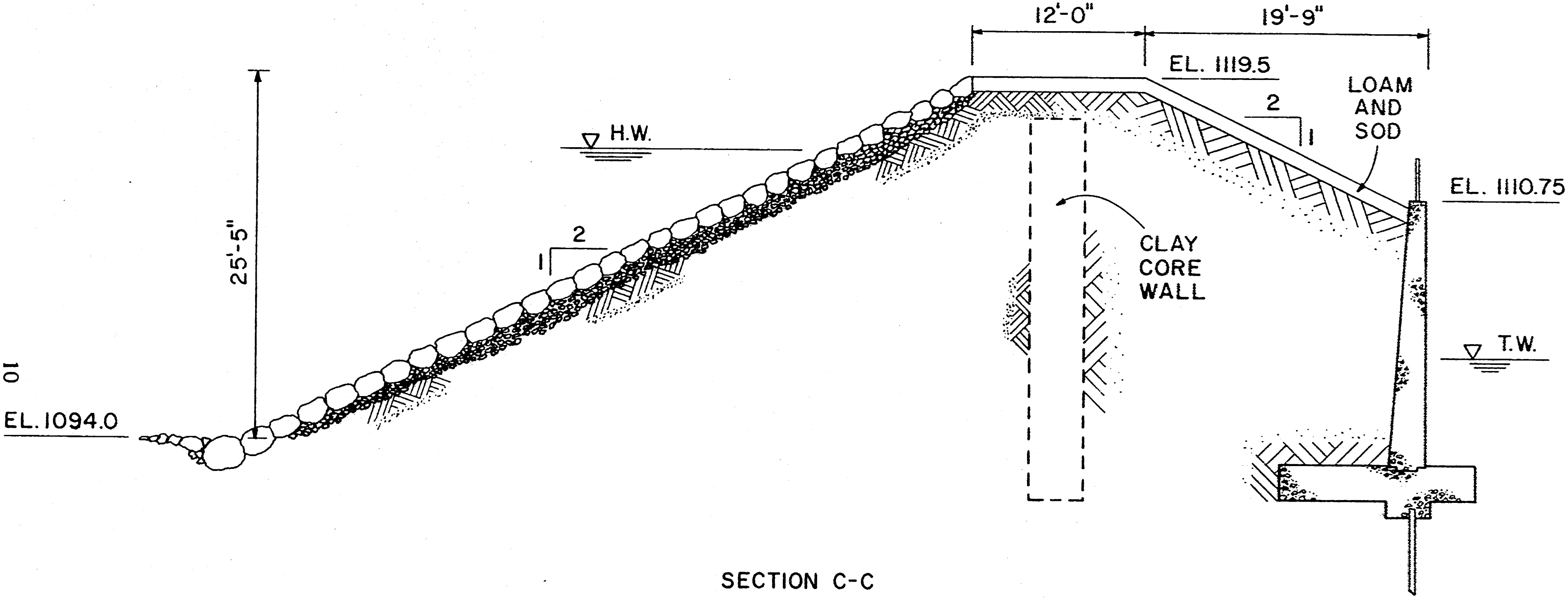

Fig. 5. Section C-C through earth embankment.

Fig. 6. View from downstream indicating (from left to right) powerhouse, earth embankment and spillway sections. Proposed powerhouse location can be seen on the right (east) abutment).

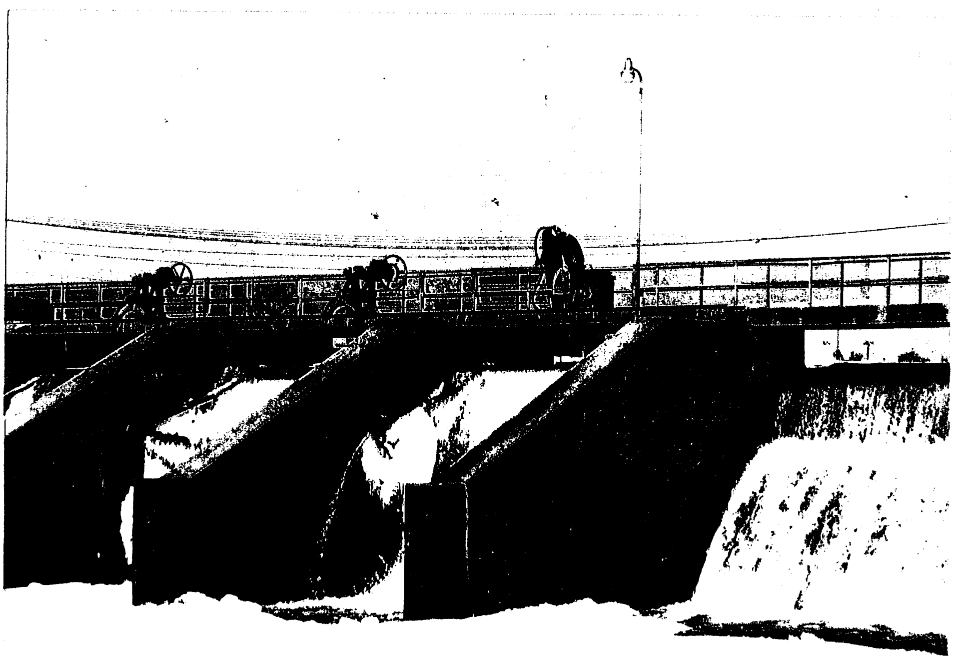

Fig. 7. Detail of tainter gate sections and typical overflow section. Note crew with steam equipment used to thaw the gates prior to spring runoff.

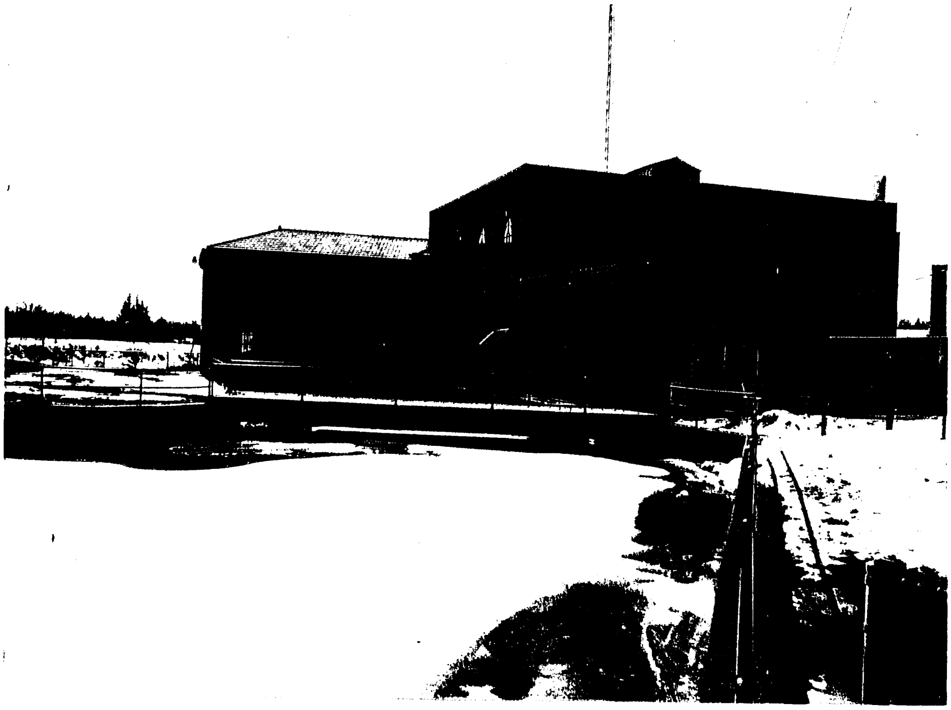

Fig. 8. View of headrace to the turbines. Note access bridge connecting the earthen embankment to the right bank.

Fig. 9. View of powerhouse outlet. Note riprap (on left) and 10 inch plank carried by two powerplant operators (on right) subsequently placed in the overflow spillway section.

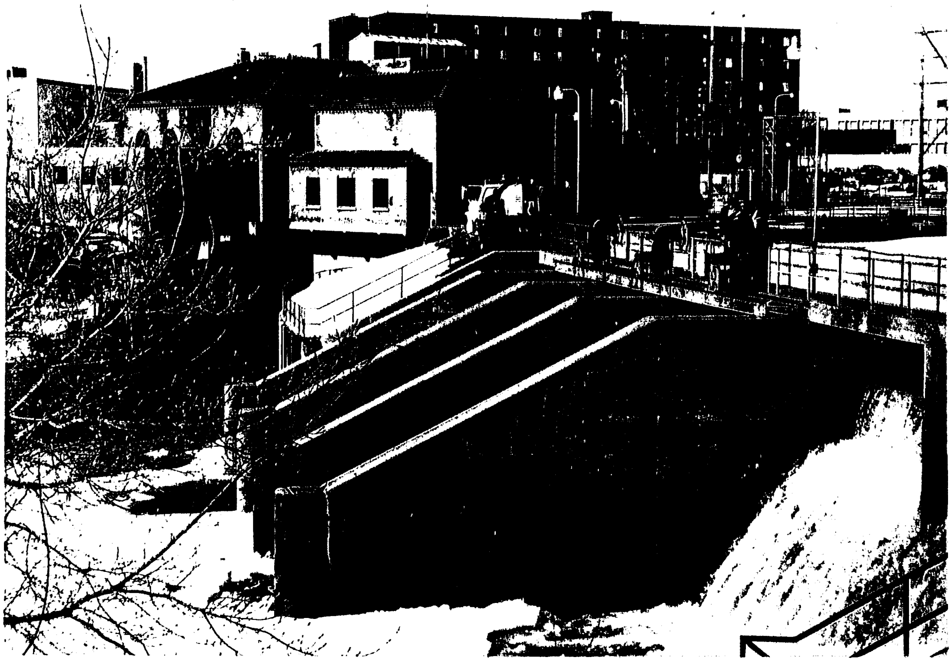

Fig. 10. View from left bank of powerhouse and spillway. Note steam truck (used to thaw gates prior to spring runoff) parked on earth embankment, and switchyard located on the right.

Fig. 11. View of proposed powerhouse location on the east abutment of the existing dam.

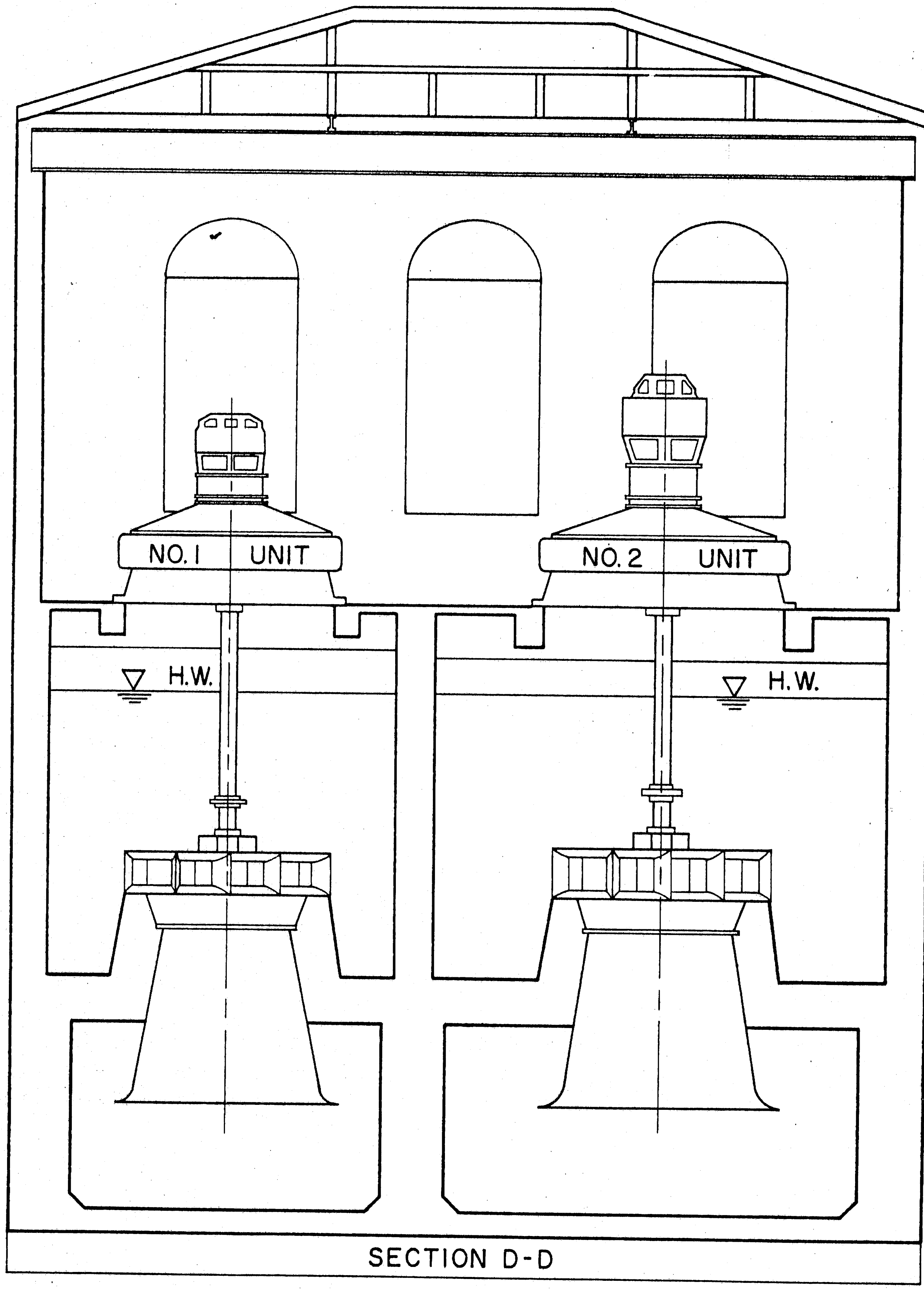

Fig. 12. Cross Section D-D through the existing wheelhouse indicating the existing open flume vertical Francis turbines with wicket gates. Generators are directly coupled and located on the floor above the turbines.

TABLE 1. Characteristics of Existing Turbine No. 1 Supplied by The James Leffel & Co. in 1927

Turbine No. 1 - Open Flume Francis (Leffel) 36" Z-Turbine - 14 ft head - 150 RPM - Field Test Efficiency @ Full Gate: 71 percent for turbine and generator.

Power	Horsepower	Turbine Test Efficiency	Guaranteed Turbine Efficiency	Discharge (cfs)
Full	325	83.6	82.6	245
.95	309	91.7	90.7	213
.90	292	91.4	90.4	202
.80	260	88.0	87.0	187
.70	228	83.7	82.7	172
.60	195	79.6	78.6	155
.50	163	75.3	74.3	136

Installation Date: 1927
Rated Output: 250 kW
Generator: 312 KVA (G.E.)
Volts: 4160

TABLE 2. Characteristics of Existing Turbine No. 2 Supplied by The James Leffel & Co. in 1927

Turbine No. 2 - Open Flume Francis (Leffel) 42" Z-Turbine - 14 ft head - 128 RPM - Field Test Efficiency @ Full Gate: 77 percent for turbine and generator.

Power	Horsepower	Turbine Test Efficiency	Guaranteed Turbine Efficiency	Discharge (cfs)
Full	445	83.6	82.6	336
.95	423	91.7	90.7	291
.90	400	91.5	90.5	276
.80	356	88.1	87.1	255
.70	312	83.9	82.9	235
.60	267	79.7	78.7	212
.50	223	75.3	74.3	187

Installation Date: 1927
Rated Output: 300 kW
Generator: 375 KVA (G.E.)
Volts: 4160

forming well since the maximum full gate efficiency which may be expected from these units is 78 percent, assuming 95 percent generator efficiency.

In addition to the two hydraulic turbines, powerplant operators are also responsible for the operation and maintenance of stand-by diesel generators which comprise the majority of the space in the entire powerhouse layout. The diesels are operated only in cases of emergency or complete power failure. The use of the diesel generators are described in a contractural agreement between the City of Thief River Falls and the Minnkota Power Cooperative, Inc.

Also located at the powerplant is a Load Management System used by the City of Thief River Falls and described in more detail in Section VI. A photograph of the monitoring equipment utilized by powerhouse operators (to determine the occurrence of the peak load) is shown in Fig. 14.

The existing facilities also consist of all necessary switchgear to connect both the hydraulic and diesel generators onto the electrical distribution system. There is no automatic trash-raking system at the site. The cost of a typical system currently available in the market is given in Section VII.A.

B. Historical Background

The original dam at Thief River Falls was built by Kretszchmar for operating a flour mill later known as the Hanson-Barzen Milling Co. The existing powerhouse and tailrace are part of the original dam constructed around 1890. This dam was replaced by the current dam which was built by Hitchcock and Estabrook in 1946. However, the original dam remains submerged in the upstream pool and is presently effective in breaking up ice during the spring runoff period.

According to plans available for the site, most of the original dam was removed to Elevation 1104.0 However, according to Mr. Morris Owen, former Utility Superintendent, parts of the dam are located only three to four feet below the normal reservoir water surface elevation. Parts of the original dam were observed protruding from the reservoir during the field survey. However, ice cover presented a check of the exact configuration of the original dam in the upstream pool.

The city installed some hydroelectric equipment in 1908. The two present open flume Francis turbines were intalled and put into operation in 1927. Around 1928 the city acquired flowage rights over many upstream properties to Elevation 1117.0 [3]. However, according to Mr. Morris Owen there were two properties for which rights were acquired only to Elevation 1115.0 (which is approximately equal to the normal operating pool elevation). The city acquired the property via a deed from Wenzel A. Schreiter, Lena Schreiter, and Anna Kretszchmar, dated June 24, 1924, filed on August 1, 1924 and recorded in Pennington County Board of Deeds No. 6, page 296.

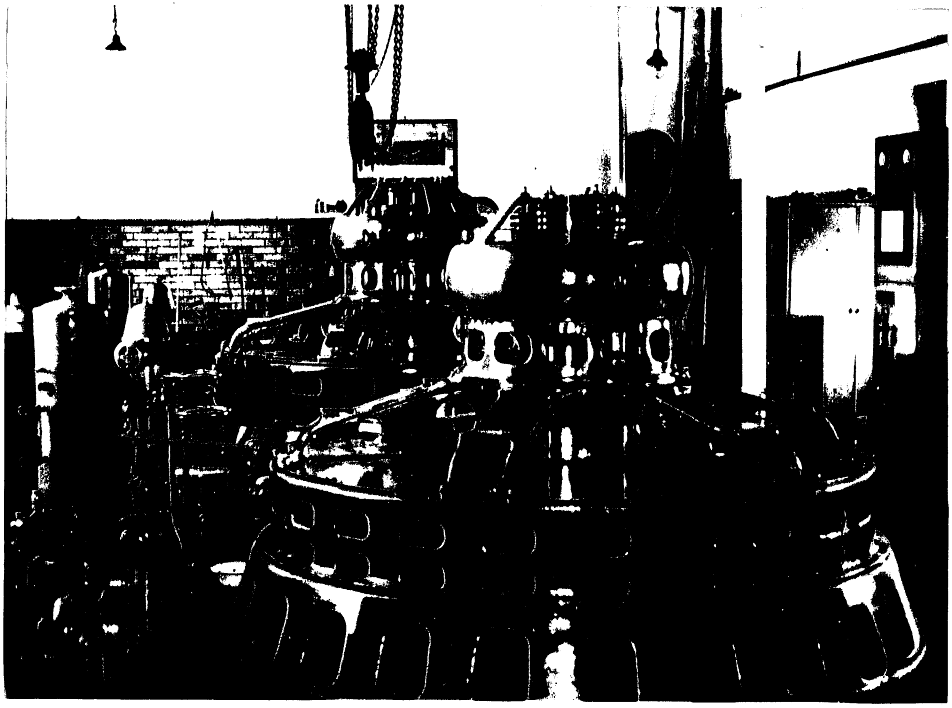

Fig. 13. View of existing generators located inside the wheelhouse of the powerplant. Unit No. 2 is located on the left and Unit No. 1 is located on the right.

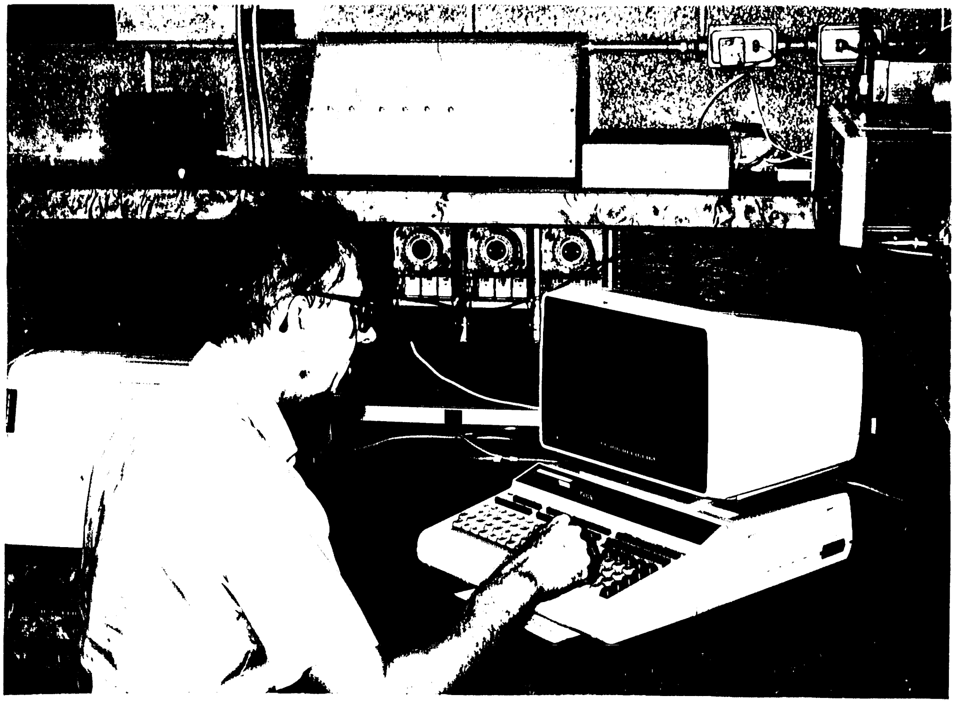

Fig. 14. View of the Load Management System located within powerhouse and used by powerplant operators to monitor the occurrence of the peak load.

The historical average annual production of two hydraulic turbines from 1928 to 1955 as well as utility production records [4] are summarized in Fig. 15. A comparison of the early 1930's of Fig. 15 and the time record of flow in the Red Lake River, given in Fig. 19 (Section IV), indicates that at times of low flow, power production from these turbines may be equal to zero.

Maintenance records indicate that bearings, bushings, links, bolts, upper shaft couplings, and pins have either been replaced or repaired for both turbines. The shaft on the smaller unit has been machined because it had become oblong. Normal maintenance has been performed on both machines. One powerplant operator indicated that one runner may have a slight pitting. However, overall efficiency indicates that the machines are performing quite well to date.

C. Dam Integrity

The Red Lake River Dam is classified in the small size category as defined in the "Recommended Guideline for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers. The dam has been given a high hazard classification since a significant threat of loss of life would result from failure at a discharge exceeding spillway capacity. The threat of failure would be reduced if the following recommendations of a consulting engineering company in the Dam Safety Report [3] are followed:

1. The informal operating procedures be developed into a documented operating plan, defining responsibility and procedures for operation.

2. A periodic documented program of inspection be implemented as a necessary part of a maintenance program.

3. The scour downstream of the westerly tainter gate bay be repaired. (If scour is not arrested, undermining is possible.)

4. The downstream edge of the aprons be periodically checked for future scouring.

5. A detailed stability analysis be performed as required by the National Dam Safety Guidelines for high hazard dams.

In addition, the Dam Safety Report [3] had the following comments related to the powerhouse structure:

1. The bulkhead slot on the left side of the tailrace is severely fractured and needs repair if it is to be usable in the future. Complete fracture has occurred, and the concrete block is tied together.

2. There are no observed signs of instability of the powerhouse (e.g. sliding, overturning, bearing), which is part of the dam.

3. There is no evidence of erosion upstream or downstream of the powerhouse (soundings were taken upstream and downstream).

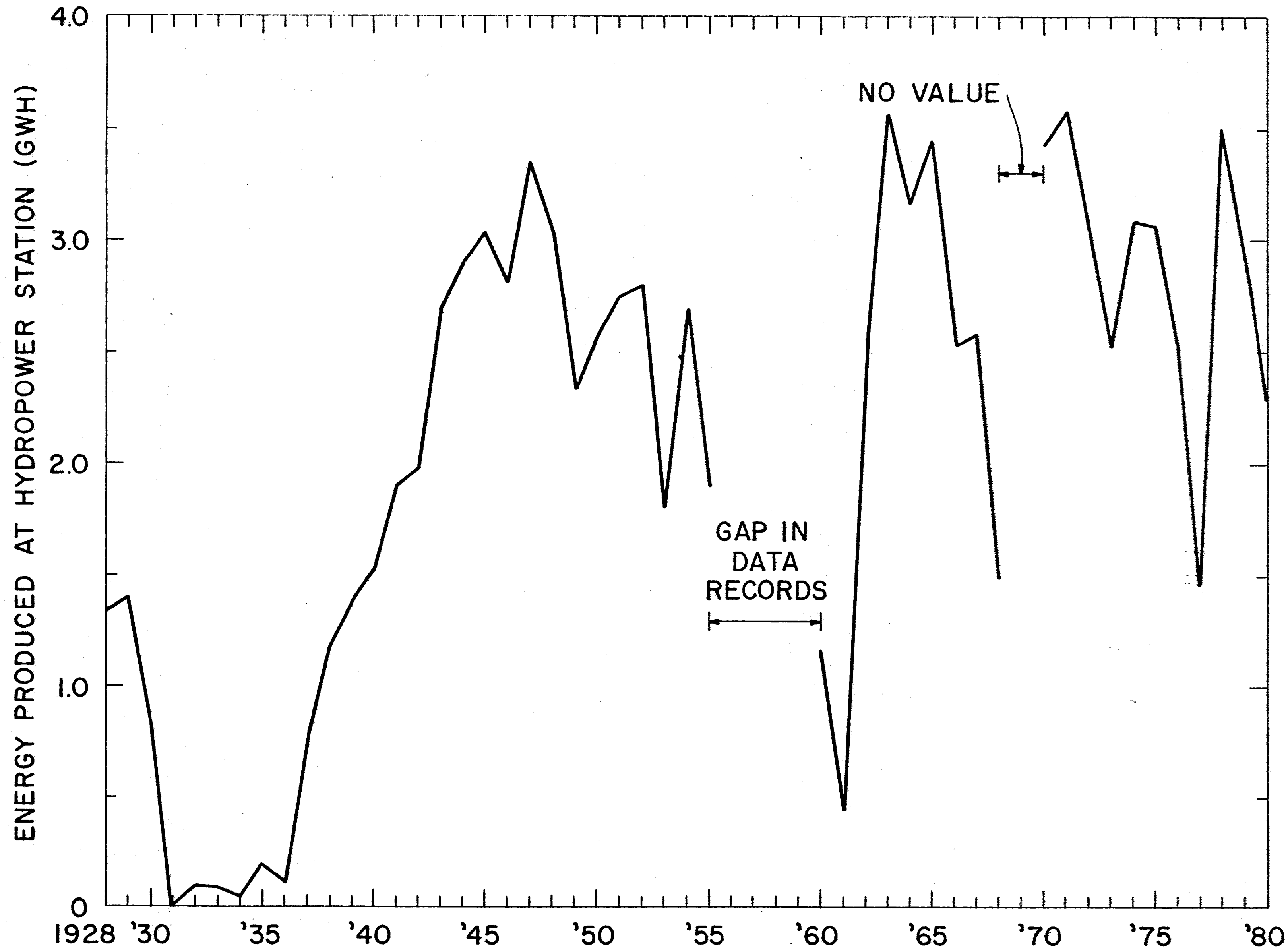

Fig. 15. Historical average annual energy production at the Thief River Falls Dam.

4. An abnormally large powerhouse discharge is not expected to have a tendency to erode the embankment. There is no obstruction to flow through the powerhouse.

5. The right tailrace wall has spalled at some joints, and the second monolith from the powerhouse has a diagonal crack with some leaching. The horizontal construction joints in the powerhouse have some minor leaching.

6. The structure has no visible structural strength problems. There are no observed signs of seepage.

The following additional observations were also made in the Dam Safety Report [3]:

1. Failure of the Red Lake River Dam at Thief River Falls could generate up to an 8-ft high flood wave immediately downstream from the dam for the condition of normal pool and low discharge. Urbanization has taken place in the river reach 2,500 feet downstream from the dam. No homes would be flooded for this case in the urban area since all are more than 8 feet above the normal low flow water level downstream from the dam, and the flood wave would be attenuated in traveling down the river. Because of the observed use of riverbank areas within the urban area for recreational purposes, it is believed that a failure under such conditions would present a significant threat to loss of life.

2. Failure due to overtopping could occur at a discharge of about 17,400 cubic feet per second. This is dependent on the adequacy of the downstream erosion protection including riprap and concrete walls. If sudden failure occurred, the flood wave generated would be about 5-1/2 feet in height immediately downstream from the dam and could have an attenuated height of about 3 feet in the downstream urbanized area. Some homes would be flooded. Dam failure at discharges exceeding existing spillway capacity could present a significant hazard to loss of life.

3. The structure requires manipulation of gates in order to pass high flows. Peak runoff rates are normally snowmelt related and ice flows in the river may present a problem. Operational methods related to passage of ice flows through the structure are critical to the safety of the structure. The dam could be overtopped at flows much less than the above cited existing design capacity if ice would prevent gate manipulation, flashboard removal, or would jam above the structure. For such cases, there would be a similar case for loss of life potential as cited above.

4. The probable maximum flood and the standard project flood greatly exceed the capacity of the dam. If either flood occurred, the dam would be overtopped. The overtopping probability of occurrence is approximately 0.4 percent or slightly greater than the 200 year flooding event.

IV. HYDRAULICS AND HYDROLOGY

A. Flow Duration and Reservoir Storage

The Thief River Falls Dam MN 00502 is located on the Red Lake River which is part of the Red River of the North Basin. The dam itself is situated just downstream of the junction of Thief River and Red Lake River. Two U.S. Geological Survey gages were used in the development of a flow duration curve. One gage is located near Goodridge, Minnesota (U.S.G.S. Gage No. 05075000) with a drainage area of 2300 mi^2 and the other gage is located on Thief River approximately five miles upstream from the City of Thief River Falls (U.S.G.S. Gage No. 05076000) with a drainage area of 959 mi^2. The combined drainage area for the two gages is 3259 mi^2. The total drainage area for the Thief River Falls Dam is 3450 mi^2. To obtain the flow duration curve for the Thief River Falls Dam, 54 years of U.S.G.S. records for the two gages were combined and adjusted for the difference in drainage area. The resulting curve is given in Fig. 16. Average annual discharge at the Thief River Falls Dam was similarly established to be 745 cfs. The reservoir length was estimated from U. S. Army Corps of Engineers' records to be 4.4 miles. The average annual precipitation in Thief River Falls is approximately 21.22 inches.

Flow duration curves were also computed for each month over the period of record and are summarized in Fig. 17. As described in Section V, the most critical period of operation of the turbines is in the months of January and February. A flow duration curve for February is shown in Fig. 18. The flow duration curve for the month of January is almost identical to the one shown for February. The data indicated on the figure are described in more depth in Section VII.

The maximum discharge known to have occurred at the dam site was approximately 9,000 cfs in 1950 [3]. During the "dust-bowl" years of the early 1930's, zero discharge values were recorded for both Thief River and Red Lake River. An indication of the fluctuations of flow in the Red River is shown in Fig. 19. The ratio to mean is computed by dividing a five year moving average (of the mean annual discharge) by the average discharge over the entire historical record.

The operational plan in Section VI indicates that the reservoir cannot be used for extended peaking purposes. The hydropower plant should therefore be considered as a run-of-river installation with the possibility for daily peaking.

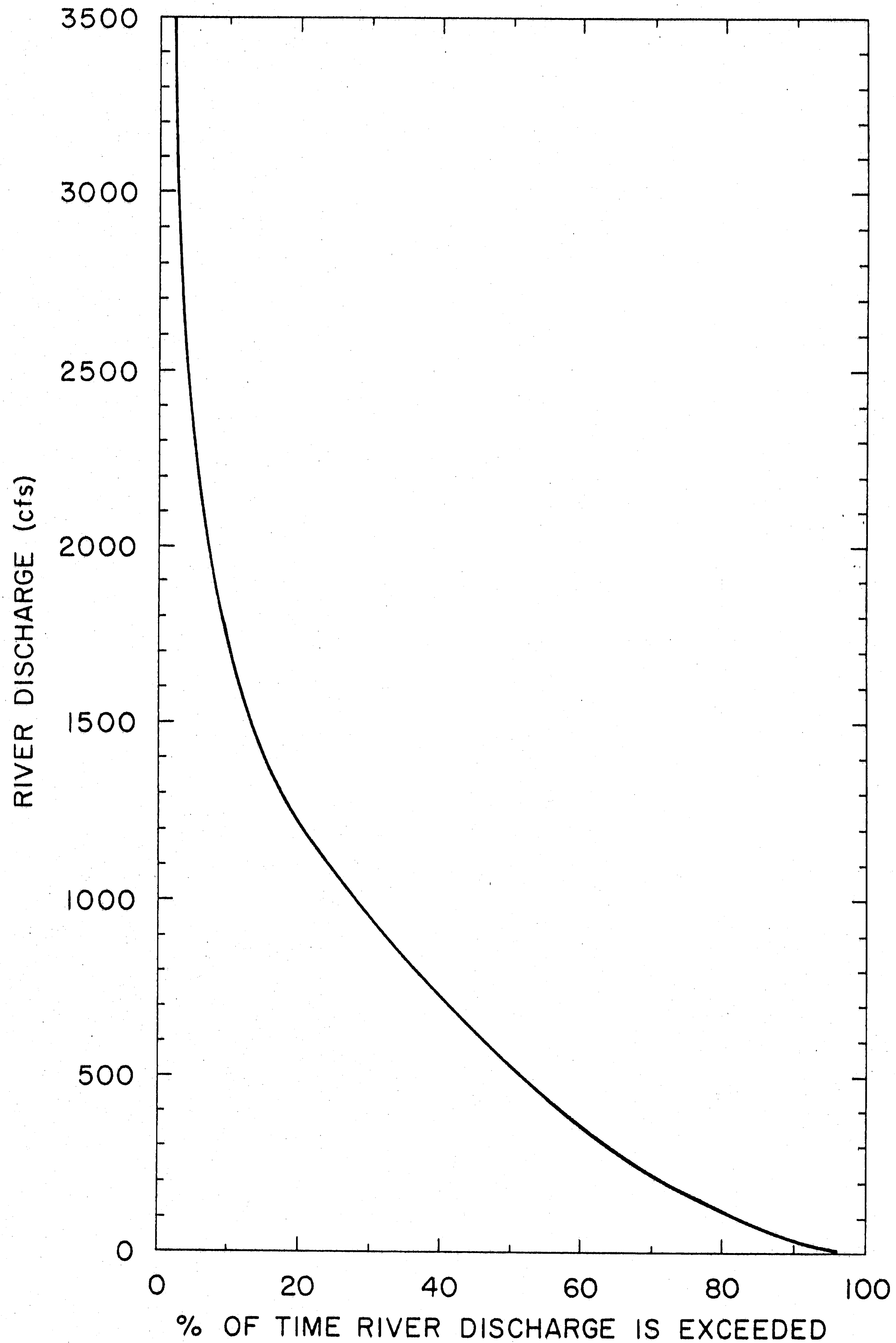

Fig. 16. Flow duration curve for the Thief River Falls Dam.

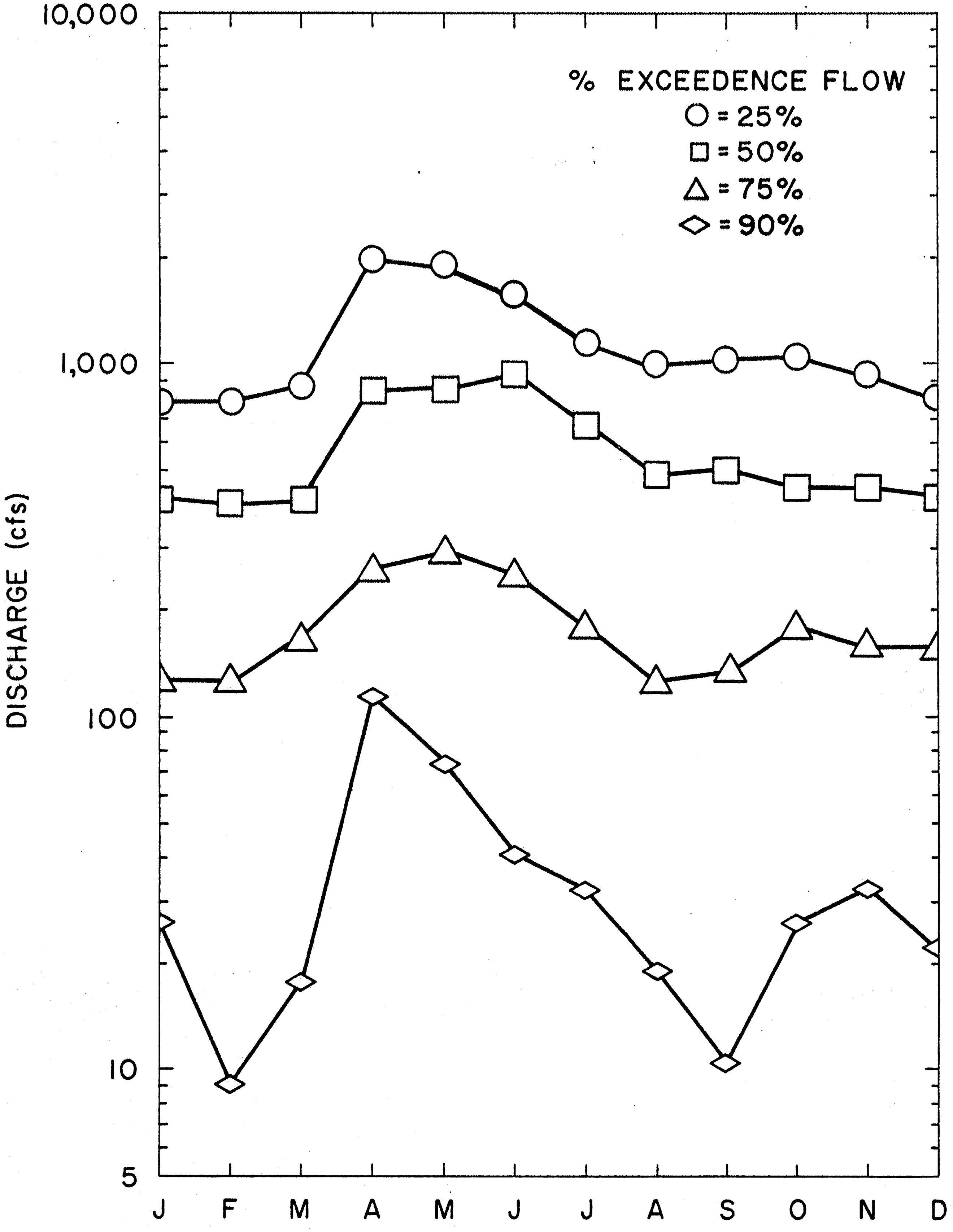

Fig. 17. Summary of monthly flow duration curves for the Thief River Falls Dam.

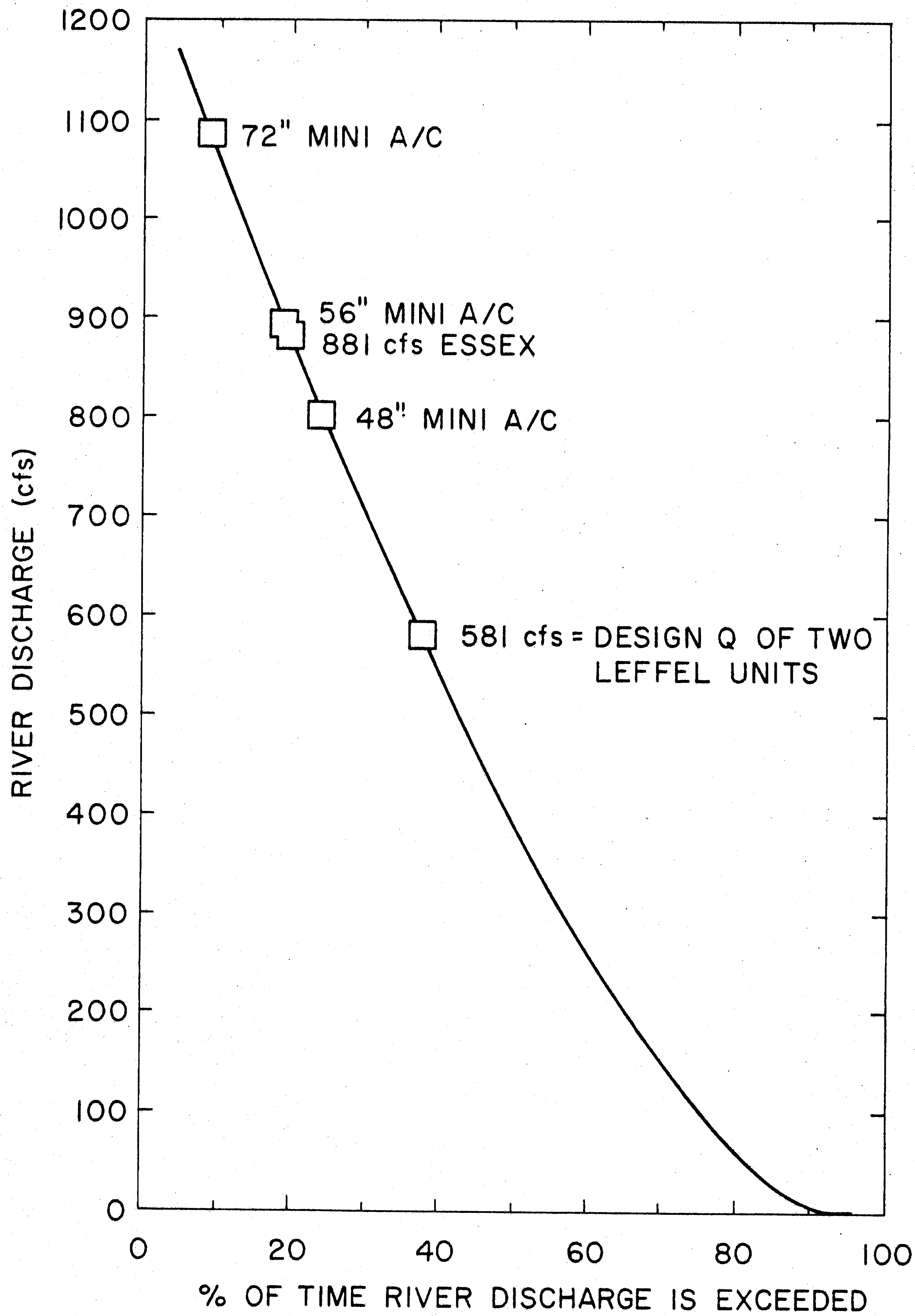

Fig. 18. Flow duration curve at the Thief River Falls Dam for the month of February.

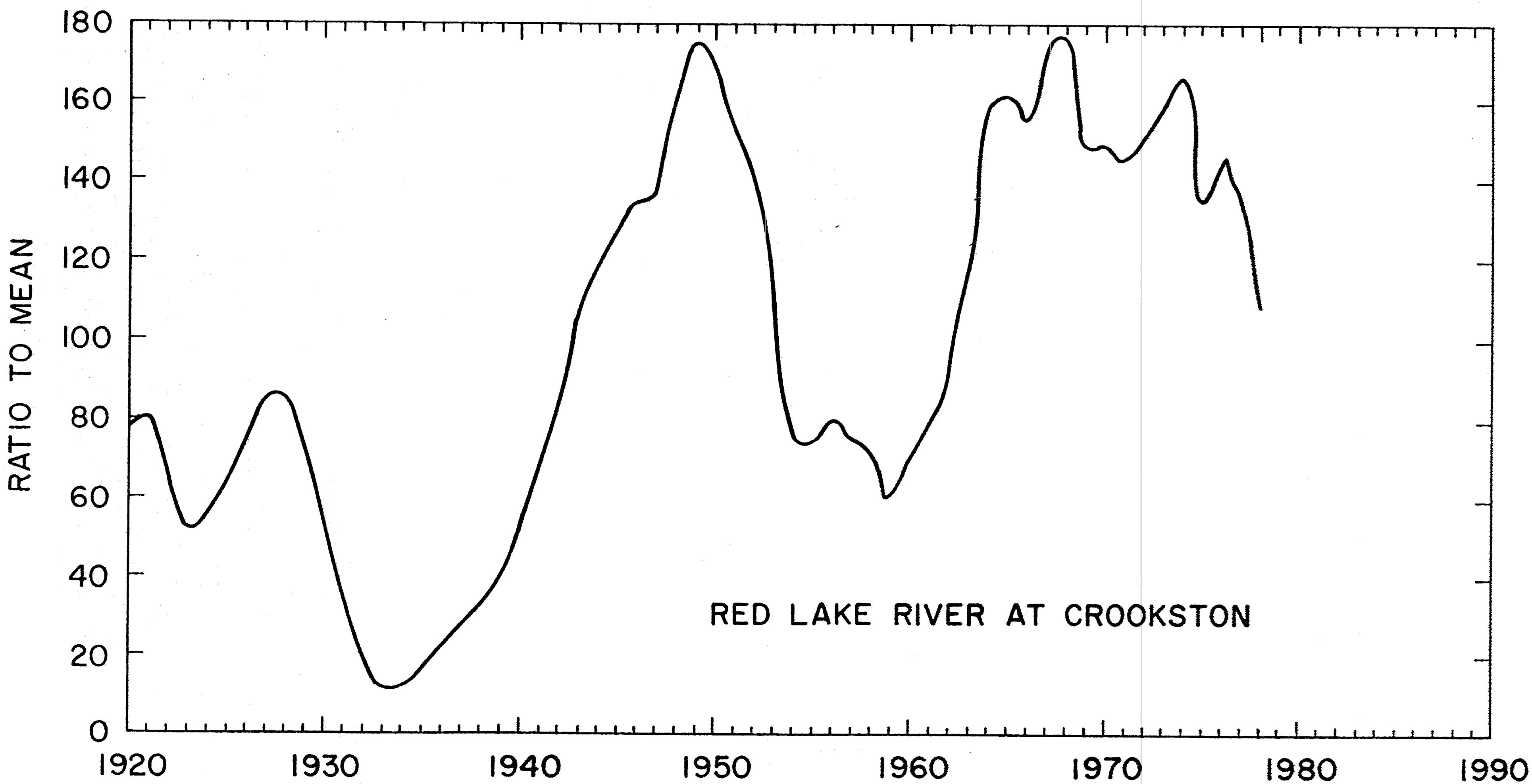

Fig. 19. Ratio of five year moving average discharge to mean discharge over period of record for the Red Lake River at Crookston.

B. Description of the Watershed

The Red Lake Watershed District, a territory which includes all of the land of the Red Lake Watershed, is authorized to operate under and express all rights and authorities contained in the Minnesota Watershed Act. The area of the Red Lake Watershed is approximately 5,990 mi^2. It lies between range 28 west and range 50 west and township 146 north and township 158 north [5].

The Red Lake Watershed is divided into three distinct physiographic areas, namely the Glacial Moraine, Glacial Lake Plain, and the Glacial Lake-Washed Till Plain. The watershed for the Thief River Falls Dam is located almost entirely in the Lake-Washed Till Plain. Located within this area are large sections of shallow bogs and peat areas as well as the Upper and Lower Red Lakes (which are remnants of the old glacial Lake Agassiz). [5]

The flow in the Red Lake River, which contributes a major portion of the flow to the dam in Thief River Falls, is determined by a U.S. Army Corps of Engineers dam located at the outlet of the Lower Red Lake. The operation of this outflow structure is discussed in further detail in Section VI.

According to Ref. [5], the Red Lake River originates at the dam at the outlet of Lower Red Lake and flows approximately 196 miles in a westerly direction to its confluence with the Red River of the North. The slope of the Red Lake River above Crookston is about 2.0 feet per mile.

"The peak periods of flow occur in April or May, depending upon the spring breakup and snowmelt, and again in May, June, or July when heavy spring or summer rains occur. A low flow period generally occurs in the late summer or early fall because of low precipitation. During the winter months, when the rivers and lakes are frozen over, another low flow occurs.

"The Red Lake River contributes greater flood flow volumes than any other tributary to the Red River. The Red Lake River flow usually synchronizes closely with the arrival of the Red River flood crest and aggravates flooding at Grand Forks, East Grand Forks, and the area downstream along the Red River. Several large lakes and extensive marsh areas in the basin also tend to extend the duration of flood recessions. Ice jams on the Red Lake River often increase flood crests several feet.

"The Red Lake River remains a natural river from the junction of Thief River to its mouth at East Grand Forks. It flows within a well defined valley which has very litle flood plain storage for flood peak attenuation. The result is a hydrograph which has characteristically high peaks and short duration.

"Thief River originates at the outlet of Thief Lake and flows in a southerly direction to its junction with Red Lake River at Thief River

Falls. The upper part of the basin is drained by Moose River which empties into Thief Lake. Mud and Little Rivers drain the central area and flow through Mud Lake to Thief River. The Thief Lake Wildlife Management Area contains approximately 12 sq. mi. of water which serves as a temporary reservoir during high water. Mud Lake and the pools in Agassiz National Wildlife Refuge also provide temporary storage for runoff water. These natural reservoirs help sustain the flow of water in Thief River during periods of low rainfall. Although these refuges are operated primarily for wildlife benefits, they can provide up to 90,000 acre feet of gate controlled spring flood storage and 67,000 acre-ft of summer flood storage." [5]

During January and February, U.S.G.S. records indicate that the contribution of flow from Thief River is minimal. Also, the flow in the river during the year is a function of the control of many retention areas located within its watershed. Flooding on the Thief River affects a large area of agricultural land, and the floods are of long duration.

C. Headwater and Tailwater Elevations

The normal operating pool at the Thief River Falls Dam is at Elevation 1115.5 feet above MSL [3]. The top of the tainter gate crest is at Elevation 1115.7. At low flows, the gates are closed and flashboards are added to maintain the pool. At high flows, the flashboards are removed and the existing hydropower plant is operating at full capacity. Normally, the flow during the winter months is specified by the setting of the outflow dam at Lower Red Lake. Therefore, the reservoir elevation at the Thief River Falls Dam is normally set in October and remains fixed until just prior to spring runoff (usually late March). The setting of the reservoir in the Winter of 1981 was maintained at approximately El. 1116.2 (including ice cover) with an outflow discharge at Lower Red Lake equal to approximately 675 cfs. According to Ref. [6], the flashboards along the overflow spillway have a height equal to 38-1/2 inches in the summer (El. 1114.5) and a height equal to 50 inches in the winter (El. 1115.5). The actual pool elevation may be different depending upon the river discharge and powerplant operation. Given the above constraints, an average reservoir elevation was used in calculation of both incremental average capacity and incremental average annual energy which would result from hydropower capacity additions.

A tailwater rating curve shown in Fig. 20 was developed utilizing recorded gage readings and flow data. Forty years of recorded gage readings were obtained from the Water Control Center at the St. Paul District Office of the U.S. Army Corps of Engineers. These were correlated with actual U.S.G.S. river discharge measurements. The discrepancy of data points shown are probably due to the fact that these data are from a representative sampling which includes winter months (during which accurate discharge and tailwater measurements are more difficult to obtain).

Reference [3] indicates that at normal pool elevation and low tailwater the differential head at the dam is 18.0 feet. It should be noted

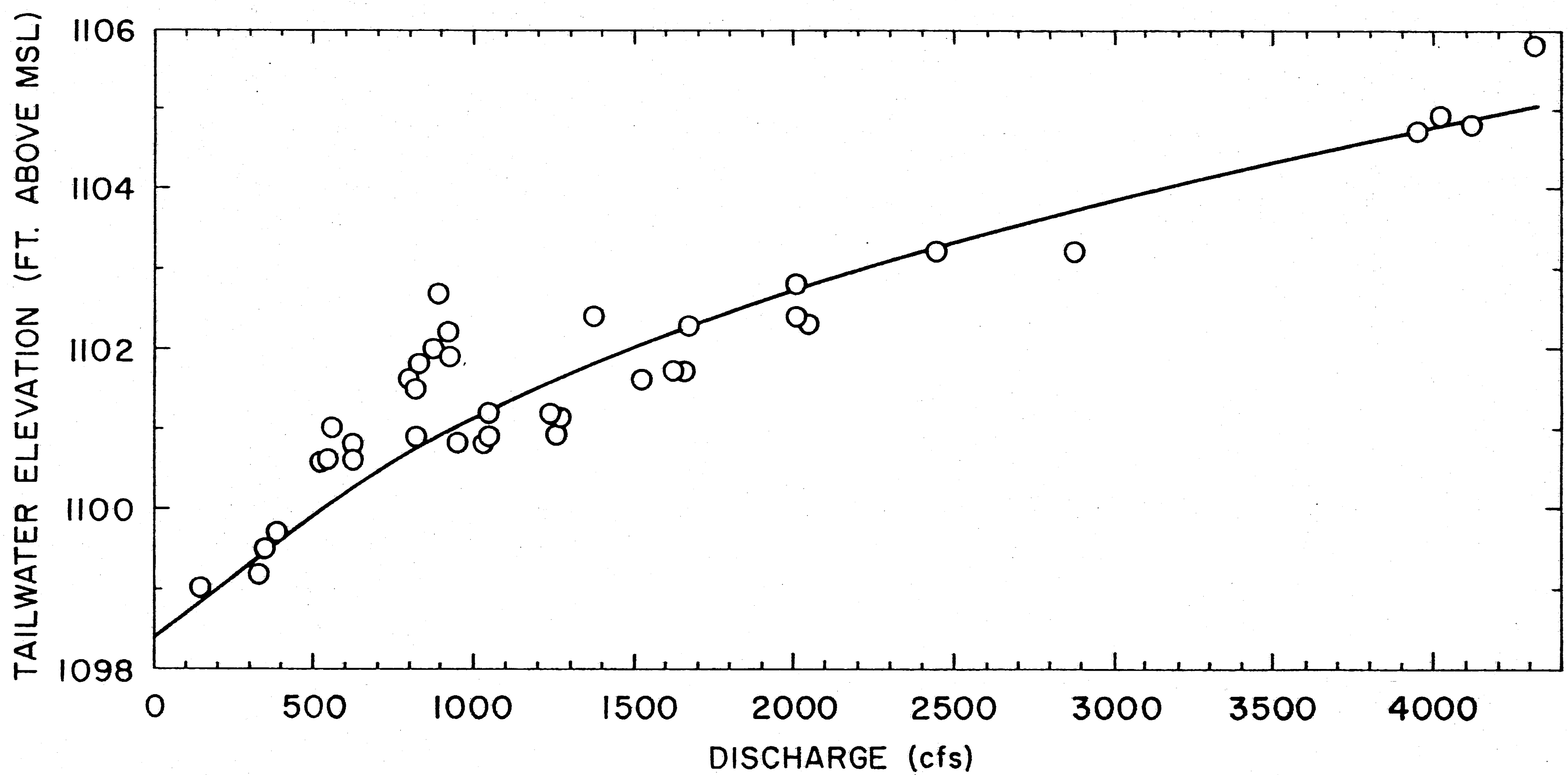

Fig. 20. Tailwater elevation versus river discharge for the Thief River Falls Dam.

that during normal operations, the gross head at the dam is between 14.0 and 15.0 feet.

D. Spillway Design Flood

The probable maximum flood, as determined in Ref. [3], is 154,000 cfs at the Thief River Falls Dam. The standard project flood is approximately one-half of the P.M.F. or 77,000 cfs. From the headwater curve and discharge frequency curve of Ref. [3], it is apparent that the dam would be overtopped at a discharge of approximately 17,400 cfs. This would have a probability of occurrence of approximately 0.4 percent or would be slightly greater than the 200-year flooding event. If sudden failure occurred, the flood wave generated would be about 5-1/2 feet in height immediately downstream from the dam and could have an attenuated height of about 3 feet in the downstream urbanized area. Discharges exceeding existing spillway capacity could present a significant hazard to loss of life. Peak runoff rates are normally snowmelt related and ice flows in the river may present a problem. The dam could be overtopped at flows much less than the existing design capacity if ice would prevent gate manipulation, flashboard removal, or would jam above the structure.

V. CURRENT POWER PRODUCTION AND DEMAND

A. Current Demand

The City of Thief River Falls has a municipal utility with its own distribution system. The city currently purchases power from two sources: the Department of Energy through the Western Area Power Administration (WAPA) and the Northern Municipal Power Agency (NMPA). Minnkota Power Cooperative, Inc. is the power distribution agent for NMPA. Minnkota owns the load management equipment located at the powerhouse for monitoring of the system peak. Through contracts with Minnkota, NMPA owns 15 percent of Minnkota's power distribution system. NMPA has the same rates for its members as Minnkota has for the City of Thief River Falls. NMPA owns 30 percent of the Coyote Power Plant near Beulah, N. D.

All power generated by the hydropower facilities is used to offset the peak demand. The peak will generally occur in either January or February, corresponding to the maximum demand for electrical heat. The 1982 peak demand of 16,013 kW occured in early February. Powerplant operators monitor the one-hour NMPA peak (as discussed in Section VI) by means of the Load Management System.

B. Current Production

The capacity of the existing turbines at Thief River Falls is rated at 550 kW. The rated head for this output is 14.0 feet. During a field survey on March 22, 1982, the gross head at the site was measured to be 15.2 feet (due to a higher reservoir elevation of 1116.55). The output of both turbines were monitored at full gate discharge. The combined output was 535 kW. Utilizing the original design information supplied by the manufacturer[2] and adjusting for the difference in head, the efficiencies of both turbines was computed. The overall efficiencies of the No. 1 unit and the No. 2 unit were 71 and 77 percent, respectively. These efficiencies are excellent for open flume Francis turbines which are 55 years old.

The average annual energy production for the years 1970 through 1980 is 2.84 GWH. However, by referring to Fig. 15 one can notice that during droughts the average annual energy can drop to zero. The flow duration curve in Fig. 16 also indicates that the flow is not always dependable. Reference [4] stated that a review of the years of operation of the hydroplant indicated that in the years of low water the plant may not contribute appreciably to the firm power. This report concurs with the

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[2] James Leffel and Co.

statement, except that the ability of the hydroplant to reduce peak demand charges should, and will, be considered.

C. Value of Power and Energy

All power and energy produced by a new hydropower facility will be used to offset power and energy currently purchased by the City of Thief River Falls from NMPA. The current rate structure for the City of Thief River Falls is based upon Schedule A-1, Firm Power of the Wholesale Power Rate from Minnkota, and is the same rate that NMPA charges its members (e.g., City of Thief River Falls)[6]. The demand portion of the rate structure is determined as follows:

1. The demand charge is based upon peak demand between November 20 and the following March 20. This demand is the value used until the following November 20.

2. If a higher demand is set after November 20, Thief River Falls does not have to pay the higher demand. The demand will remain at the value set during the previous November 20 to March 20 period.

3. If a higher demand is set after November 20, it will be used as that month's demand, i.e. a higher demand in December will become the new demand, and again higher in January will be another new demand and so on until the next March 20.

At this point the highest demand recorded between November 20 and March 20 will be the demand until the next November 20.

The rates effective for the period from March 20, 1982, to March 20, 1983, will be a demand charge of $12.26 (1982) per month per kW ($147.12/kW/yr) and an energy charge of $0.0108/kWH (1982). The above demand charge is the source of the greatest benefit of an additional hydropower unit since it would offset the system peak. The city also receives benefit for the reduction in the peak of the Western Area Power Administration (WAPA). However, since it is anticipated that WAPA power will be phased out in the near future, the WAPA peak reduction was not considered in this study.

VI. CURRENT AND PROPOSED OPERATIONAL SCHEME

The operation and maintenance of the Thief River Falls Dam and powerhouse is the responsibility of the City of Thief River Falls. There are no formal operation and maintenance plans.[3]

Currently, five full-time employees man the power plant on a 24-hour rotating shift basis. According to the utility distribution engineer, the duties of the employees are:

1. Maintain hydro and diesel power production equipment.

2. Operate hydro equipment at an optimum output for a given river discharge.

3. Operate the diesel equipment as needed. This equipment is leased to Minnkota Power Co-op at $1.00 per kW of producible output per month. Presently this is 5300 kW which is $5300 per month. Should the city lose its normal power source, the city has first priority on the use of the diesel plant.

4. Monitor the city's loads during peak times and control load as needed with the city's Load Management System and hydropower output. The Load Management System displays the total demand of purchased power, not including output of the hydraulic turbines. By monitoring this, the city can reduce its peak demand by assuring that the turbines are on-line and that the Load Management System shuts off load at the peak time. The Load Management system is a ripple system using the power lines for transmitting signals to control electric heat and electric water heater loads.

5. Each spring, for approximately five days duration, all gates are opened to pass ice debris. A steam truck, as shown in Fig. 10, is used by city personnel for this purpose.

As mentioned in Section IV, the flow at the Thief River Falls Dam is governed to a large degree by the discharge released at the U.S. Army Corps of Engineers dam at the outlet of the Lower Red Lake. The availability of an adequate discharge during the winter months is crucial to the prospect of developing additional hydropower facilities at the site. The economics of additional facilities is judged primarily by the margin by which the new turbines reduce the peak electrical demand (see Section VII). The operating plan followed by the Corps of Engineers at Lower Red Lake is summarized as follows:

- The minimum release of flow from the Lower Red Lake is 60 cfs. (Under drought conditions, the outflow can be reduced to 5 cfs.)

- The maximum release from the Lower Red Lake is 900 cfs.

- The normal pool at Lower Red Lake is maintained at Elevation 1174.0. (Prior to spring runoff, the pool is lowered to Elevation 1173.5.)

- The flow for the period from September 15 to April 1 is determined by the recent history of inflow and outflow to the lake.

- The final setting is usually made on November 15 and no change in gate setting occurs after the gates freeze. This allows a relatively constant discharge in the order of 100-900 cfs to be released during the winter months. The discharge released from the Lower Red Lake during the winter of 1981 was between 650 and 700 cfs.

The City of Thief River Falls is informed by the Corps of Engineers each winter of the flow anticipated to be released from the outlet dam at Lower Red Lake.

The flashboards on the spillway are currently maintained at a height of 38-1/2 inches in the summer [7]. The informal plan or objective is to maintain the pool at Elevation 1115.5 [3]. At low flows, the gates are closed and flashboards are added to maintain pool elevation. A minimum flow is released through the powerhouse and through leaks in spillway gates (see Section IX) during this period. At higher flows, the gates are opened and the hydraulic turbines are turned on. In the fall, an additional 11-1/2 inches of planking is added to the spillway [7]. In the spring the gates are thawed early in preparation for higher flows. The submerged dam upstream aids in breaking the large ice sheets in the early ice flows. The broken ice is then able to pass through the existing spillway sections. The operational methods related to the passing of ice flows are critical to the safety of the structure. (Ice jams preventing operation of the gates could cause the dam to be overtopped.) Reference [3] indicates that a plan of operation and maintenance for the dam gates should be developed and a periodic documented inspection program should be initiated.

During the off-peak season, the present and proposed hydraulic turbines will be operated entirely on a non-peaking basis and will have an output determined by the run-of-river flow. At very low flows, the units cannot be run. However, the turbines can be run at the minimum operating discharge. Otherwise, minimum flow releases may be obtained (as in the past) by leakage through existing gates and by opening the wicket gates slightly on the present No. 1 turbine unit.

During the peak season (e.g. winter months, primarily the months of January and February), the flow released from Lower Red Lake is established as discussed earlier. By means of the installed Load Management System, the powerplant operator can observe the occurrence of the peak load. Provisions are made to retain as much water in the reservoir as possible in anticipation of the occurrence of the peak load. As the peak load approaches, all units should be operated at their full capacity whenever possible in order to offset the peak demand (and thus reduce the demand charges assessed to the city during the next rate period). It is assumed that the total peaking time for the reservoir is three hours. The next peak is assumed to occur in nine hours. (This implies that the possibility exists for a peak to occur twice in any 24-hour period.) During these nine hours, only the minimum flow will be released and limited storage will take place until the next peaking period.

There are three limiting constraints to the amount of power the hydroplant may generate during this peaking period. These constraints are as follows:

- Capacity of the hydroturbine units. The units obviously cannot operate at greater than full capacity.

- Available reservoir storage. During the three-hour peaking period, the reservoir water level will be drawn down. This drawdown will be only 1 ft or less. Sufficient river discharge must be available to refill the reservoir and supply a minimum discharge downstream in the nine-hour off-peak period.

- Minimum downstream discharge. Even when there is sufficient reservoir storage, the upstream river discharge must be sufficient to allow for minimum discharge release during off-peak periods, as well as peak period power generation. If this is not the case, peak power generation will be restricted to allow for minimum downstream discharge during off-peak periods. A minimum downstream discharge of 80 cfs was used herein, corresponding to the operation of Lower Red Lake.

It should be noted that the peak period is assumed to occur the coldest day of the year. Therefore, long-term environmental effects of such an operational scheme are assumed to be minimal. Also, the storage capability at the dam is not significant enough to cause wide variations in either headwater or tailwater elevations.

The three largest cities which obtain their water from the Red Lake River are Thief River Falls, Crookston and East Grand Forks. Red Lake Falls has a groundwater supply but uses the Red Lake River as as backup source. Peaking, as discussed above, should not interfere with those water supplies. The water supply intake for the City of Thief River Falls is located in the upstream reservoir. Present and proposed operational schemes will not interfere with the intake structure.

The implementation of an automated control system for all hydraulic turbines (present and proposed) should be considered further in the design phase of the project.

VII. PROJECT DEVELOPMENT ALTERNATIVES

In this section the costs and expected annual incremental energy production of four development alternatives for the Thief River Falls hydropower facility are considered. These alternatives were assessed by using the "Do Nothing" alternative as a base. The increase in benefits supplied by each alternative has been defined as incremental. Project development alternatives were formulated in the following manner:

- Once the hydraulic and hydrologic analysis was performed, the first step in choosing development alternatives was to determine which types of hydroturbines are most applicable to the site. Turbine and generator manufacturers were then contacted to obtain cost estimates of specific turbine/generator units and electrical equipment since they are the major equipment item in a hydropower facility. Turbine performance characteristics were also obtained.

- The expected annual energy production was computed for each of the five development alternatives using flow duration, headwater, tailwater information, and turbine performance curves.

- The income generated by displacing energy to be bought from NMPA was computed by determining the average annual energy which may be expected of each development alternative and multiplying it times the value of energy determined in Section V.C.

- The average annual income generated by displacing peak demand and reducing NMPA's demand charge was determined from the flow duration curve for the month of February, given in Fig. 18, which incorporates 54 years of record. The three constraints listed in Section VI were used in Fig. 18 to compute the maximum on-peak power corresponding to river discharge at 5 percent exceedance increments. The mean of these on-peak power values is the average annual capacity credit given to the installation. Incremental capacity credit is the difference between an installation which includes new units and the existing installation.

- Construction costs were estimated on the basis of unit costs applied to preliminary layout drawings. Construction cost estimates included facility structural costs as well as diversion, removal, and excavation costs. A 25 percent contingency allowance was added to cover smaller items and possible omissions.

- When electrical equipment costs were not included in the turbine/generator costs estimates, these costs were estimated based upon information obtained from a well-known generator/switchgear/

controls manufacturer. Electrical equipment costs include switchgear, transformer, control switchboard, wire and cable system, and conduit, grounding, and lighting.

- Freight and installation estimates for turbines and generators were based upon manufacturer's recommendations.

- Miscellaneous powerplant equipment costs were estimated according to guidelines in Ref. [8]. Equipment for ventilation, fire protection, communication, and turbine/generator bearing cooling water are included in this category. The cost estimates include 15 percent for freight and installation. The July 1978 cost base was escalated to July, 1981, according to the Consumer Price Index.

- A multiplier of 20 percent was applied to the final project cost for engineering, construction management, and other costs [8]. These costs include expenditures for license and permit application, preliminary and final design, construction management, and administration.

Several options were considered during the selection of the location of an additional unit. Since the performance of the existing turbines was considered satisfactory, replacement of the existing turbines with an additional unit in the existing wheelhouse was not considered to be a feasible alternative. After a site visit, it was evident that utilizing the rest of the powerhouse structure would require extensive civil works construction.

Only two other powerhouse locations were considered potentially feasible. The first option would be to construct a small concrete powerhouse with inlet and outlet works in the earth embankment of the present dam. However, after interviews with utility personnel, the purpose for constructing the dam in two sections (earth and concrete) was determined. Namely, if an ice jam developed behind the dam which threatened overtopping of the structure, the earth embankment would be utilized as a relief valve (removed with explosives) in an effort to save the rest of the structure. This location, therefore, was no longer considered a viable alternative.

The second option would be to utilize the east abutment of the existing dam. This option would require a smaller cofferdam and less excavation than a location in the earth embankment, as well as eliminating potential problems with access of heavy equipment to the site and potential problems in working around the earth embankment. All development alternatives considered in this study are based upon a powerhouse location in the east abutment of the present dam. This location has easy access for heavy equipment. The potential for sediment accumulation as well as the degree to which silting takes place in the reservoir should be considered in any design phase of the project.

A. Alternative A: Do Nothing

This alternative implies that no new turbine/generator units will be considered. The turbines presently operating are assumed to be in good operating condition. The validity of this assumption was strengthened by the field verification test for overall powerplant efficiency as described in Section III.A.

The major problems encountered with the current facility include weed accumulation on the trashracks and a suspected high tailwater. It has been suspected that the cause of the high tailwater is due to the downstream river conditions [9]. However, the degree to which this factor affects the powerplant operation should be considered in greater depth in any design phase of the project. The weed accumulation reportedly occurs around the beginning of August and clogs the trashracks to such a degree that power-plant operators must rake the racks continually. The problem persists for 3 to 4, weeks and at times the powerplant is forced to be shut down.

It has been suggested that the installation of an automatic trash raking system would alleviate this problem. However, it must be understood that most systems have a minimum clearance required for proper installation and that a separate means of ultimate disposal of the trash is still required (e.g. a conveyor system). Both of these criteria may pose a problem at the Thief River Falls Dam and increase the cost of a unit. Given these constraints, a manufacturer (see Appendix A) has been contacted for a cost estimate. These machines have been in operation in North American since 1977 and in Europe since the early 1960's. Currently there are three installations in Wisconsin using this system. The owners of these sites are:

(1) Consolidated Papers, Wisconsin Rapids, WI (2 sites)

(2) Kaukauna Electric & Water, Kaukauna, WI

The 1982 installed cost estimate is quoted at $52,000 for the existing hydropower facilities. Heating of the unit is required for successful operation in the winter. According to the manufacturer, head losses should be kept to a minimum during the high trash season if the units is installed correctly.

The proposed operational plan for Alternative A is very similar to that currently in use, as described in Section V. Using this operational plan the estimated average annual energy production and benefits are (1982 base year):

Average Annual Energy Production	2.87 GWH
Average Annual Energy Benefits	$31,000
Average Annual On-Peak Capacity	388 kW
Average Annual Capacity Credit	$57,100
Total Average Annual Benefit	$88,100

As stated in Section V.C, the above figures include a long historical record at the site including low flow years. The computed figure of 2.87 GWH compares well with the average annual energy production of 2.84 GWH computed for the years 1970 through 1980 at the Thief River Falls Dam.

Alternative A is included to provide a base for estimating the incremental benefits of the other development alternatives, i.e. the actual benefits of each alternative beyond what is already provided by Alternative A. All income and energy production values given in Alternatives B through E will be the incremental amount above that of Alternative A.

B. Alternatives B, C, and D: Addition of ONe Mini-Tube Unit

Alternatives B, C, and D all consider the utilization of a Mini-Tube[3] turbine. Each unit has a fixed-blade propeller with fixed guide vanes. For each value of net head, the unit has only one operating flow. The design discharge runner diameter and output for each unit at a rated head of 14.0 feet are given in Table 3.

TABLE 3. Design Discharge, Runner Diameter, and Rated Output at 14.0 ft Net Head for the Mini-Tube Units of Alternatives B, C, and D.

Alternative	Runner Diameter (inches)	Design Discharge (cfs)	Rated Output (kW)
B	48	222	213
C	56	312	300
D	72	499	480

These units are installed on an incline and are a relatively attractive development alternative because of their simplicity and significantly lower cost. A typical plan and section view of a preliminary layout are given in Figs. 21 and 22.

The equipment package for the Allis-Chalmers Units consists of the following:

- intake gate
- hydraulic power unit for intake gate

[3]Allis-Chalmers trade mark.

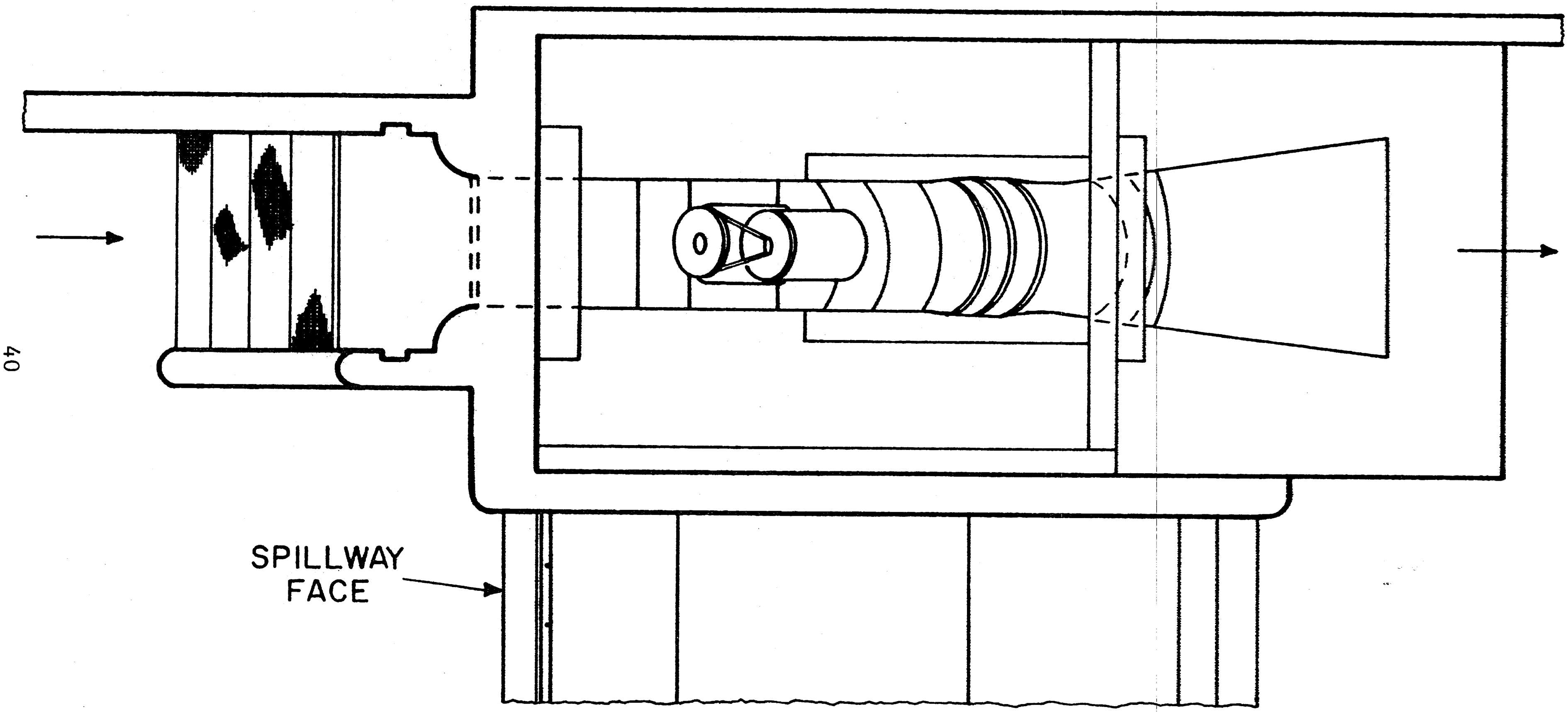

Fig. 21. Plan view of typical Mini-Tube installed in the east abutment of the existing dam for Alternatives B, C, and D.

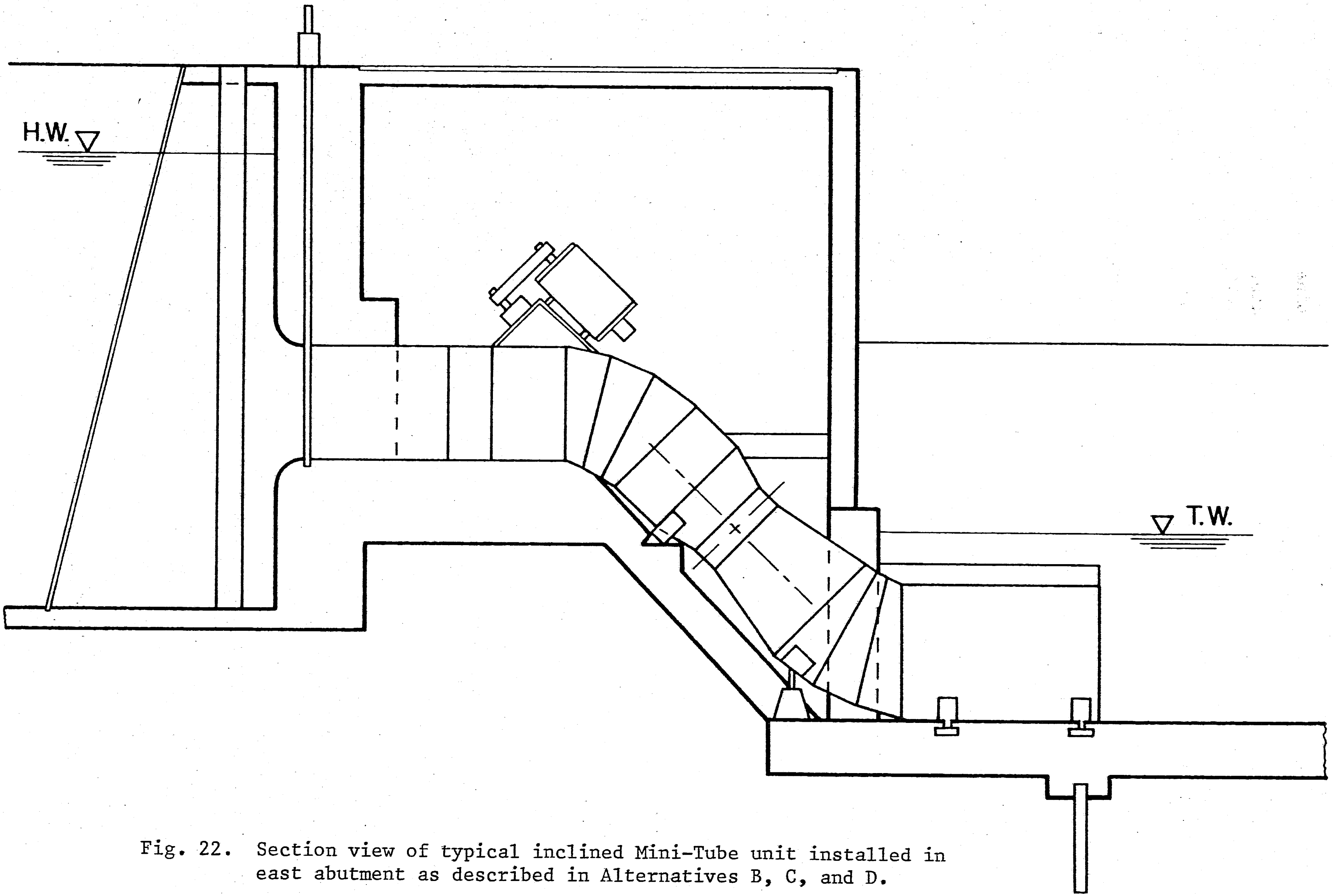

Fig. 22. Section view of typical inclined Mini-Tube unit installed in east abutment as described in Alternatives B, C, and D.

- inclined Mini-Tube turbine
- speed increaser
- 2300 v induction generator
- lighting arrestor and surge capacitor
- 2300 v switchgear
- transformer, high voltage switch, and metering cubicle

The cost estimates (1982 base year) for Alternatives B, C, and D are summarized in Table 4.

TABLE 4. Cost Estimates (1982) for Development Alternatives B, C, and D

Description	Alternatives B	Alternatives C	Alternatives D
1. Construction Costs	$423,400	$ 463,800	$ 545,000
2. Turbine/Generator Package (including Electrical Equipment)	263,000	312,000	437,000
3. Miscellaneous Plant Equipment	43,000	48,500	56,600
4. Installation	52,800	62,400	87,400
5. Engineering, Construction Management, etc.	156,000	177,000	225,000
Total Initial Cost:	$938,000	$1,063,700	$1,351,000

The incremental energy production and benefits, as well as incremental operation, maintenance and replacement costs for Alternatives B, C, and D are (1982 base year) are summarized in Table 5.

The sensitivity analysis of Section VIII.C considers the operation, maintenance, and replacement costs in greater depth.

The City of Thief River Falls has indicated that it has some equipment which could possibly be used to defray total overall equipment costs. However, most of the components selected by the manufacturer have been specifically matched to insure compatibility and to allow a quotation of an overall efficiency value. Therefore, the manufacturer's components as quoted in the preliminary cost estimate are to be used in this study.

TABLE 5. Average Annual Incremental Energy Production, On-Peak Capacity, Incremental Energy Benefits, Capacity Credits and Incremental Operation, and Maintenance and Replacement Costs for Alternatives B, C, and D

	Alternatives		
	B	C	D
Average Annual Incremental:			
Energy Production	0.71 GWH	0.99 GWH	1.41 GWH
Energy Benefits	$ 7,700	$10,700	$15,200
On-Peak Capacity	131 kW	178 kW	239 kW
Capacity Credit	$19,300	$26,200	$35,200
Total Benefits	$27,000	$36,900	$50,400
Incremental Operation, Maintenance and Replacement Costs	$11,220	$13,520	$17,140

C. Alternative E: Addition of Two Bulb-Type Units

Alternative E is the addition of two packaged bulb-type turbine/generator units in the east abutment of the existing dam. Each turbine will operate at a plant discharge of 150 cfs and an output of approximately 146 kW at 14 ft of head. The turbines are manufactured by Essex Turbine Company, Inc. of Magnolia, Massachusetts. Each package (Model No. ET-1352) comes complete with turbine/gear/generator assembly, 54 inch inlet reducer with Dresser coupling, approximately 0 degree angle 1/3 draft tube, tachometer drive, vibration transducer, and oil level site gauge. The size of the runner diameter is 1352 mm (4.436 ft). The generator is a Westinghouse or General Electric 1200 rpm, 480 volt, 150 kW induction generator.

The associated equipment includes a General Electric generator control panel. The panel contains all control functions required to operate the Essex series packaged turbines, including the turbine control computer and penstock gate controllers. The control computer uses a multi-read switch sensor to provide a dynamic pond range of 2.5 feet. The control functions are integrated to the generator control system and gate mechanisms. Three pole mount transformers (single phase with lighting arrestors), two 3-phase motor capacitors with switched resistor network, two 54" steel vertical gates complete with guides, inlet ball, 54" outlet pipe, and one integrated hydraulic gate actuation package (including 30 gallon reservoir, filtration and site gages, 3 hp hydraulic pump, hand backup pump and necessary solenoid operated and manual valves) are all included in the turbine/generator package. The hydraulic pump operates on demand for raising the gates and pressuring the accumulators and is operated either by the control computer or manually.

According to the manufacturer and field observations, freezing of the tailwater should not be a major problem. However, the manufacturer recommends that the system be vented so that the inlet reducer, turbine, and draft tube are evacuated of water when not operating. In addition, the perimeter of the inlet gates must be heated. This is done typically by using units such as "Cal-rods" imbedded in the concrete. They are energy consumers, but are considered necessary if water is to be conserved and turbine shut-off is to be guaranteed. The costs of this heating unit was not supplied by the manufacturer but should be considered as an essential item in any design phase of the project.

Each turbine has as a fixed blade reaction runner with fixed guide vanes. The turbines are called bulb-type units since the generator and planetary gear are contained in a bulb-shaped housing in the water passageway just upstream of the runner and fixed guide vanes.

A plan and section view of Alternative E installed in the east abutment of the present dam are shown in Figs. 23 and 24. The breakdown of the cost estimate for Alternative E is as follows (1982 base year):

1.	Construction Costs	$435,000
2.	Turbine/Generator Package	194,000
3.	Electrical Equipment and Automatic Controls	31,100
4.	Installation	44,600
5.	Miscellaneous Plant Equipment	45,900
6.	Engineering, Construction Management etc.	150,000
	Total Initial Cost	$900,700

The incremental energy production and benefits for Alternative E are (1982 base year):

Average Annual Incremental Energy Production	0.97 GWH
Average Annual Incremental Energy Benefits	$10,500
Average Annual Incremental On-Peak Capacity	179 kW
Average Annual Incremental Capacity Credit	$26,400
Total Average Annual Incremental Benefit	$36,900

The incremental annual operation, maintenance, and replacement costs for this alternative are estimated to be $14,380. This parameter is analyzed in greater depth in the sensitivity analysis of Section VIII.C.

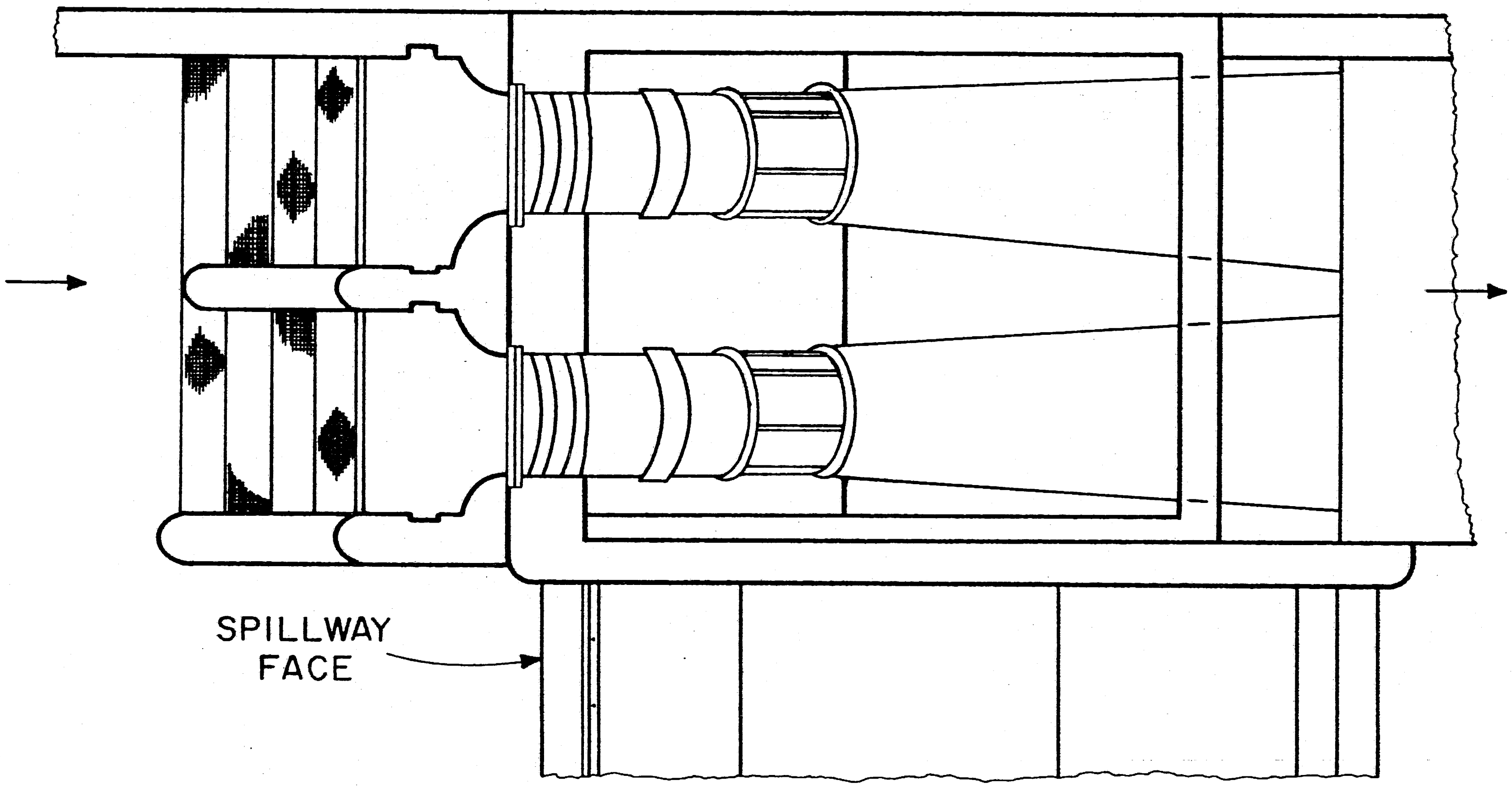

Fig. 23. Plan view of Alternative E: two Essex turbines installed in the east abutment of the existing dam.

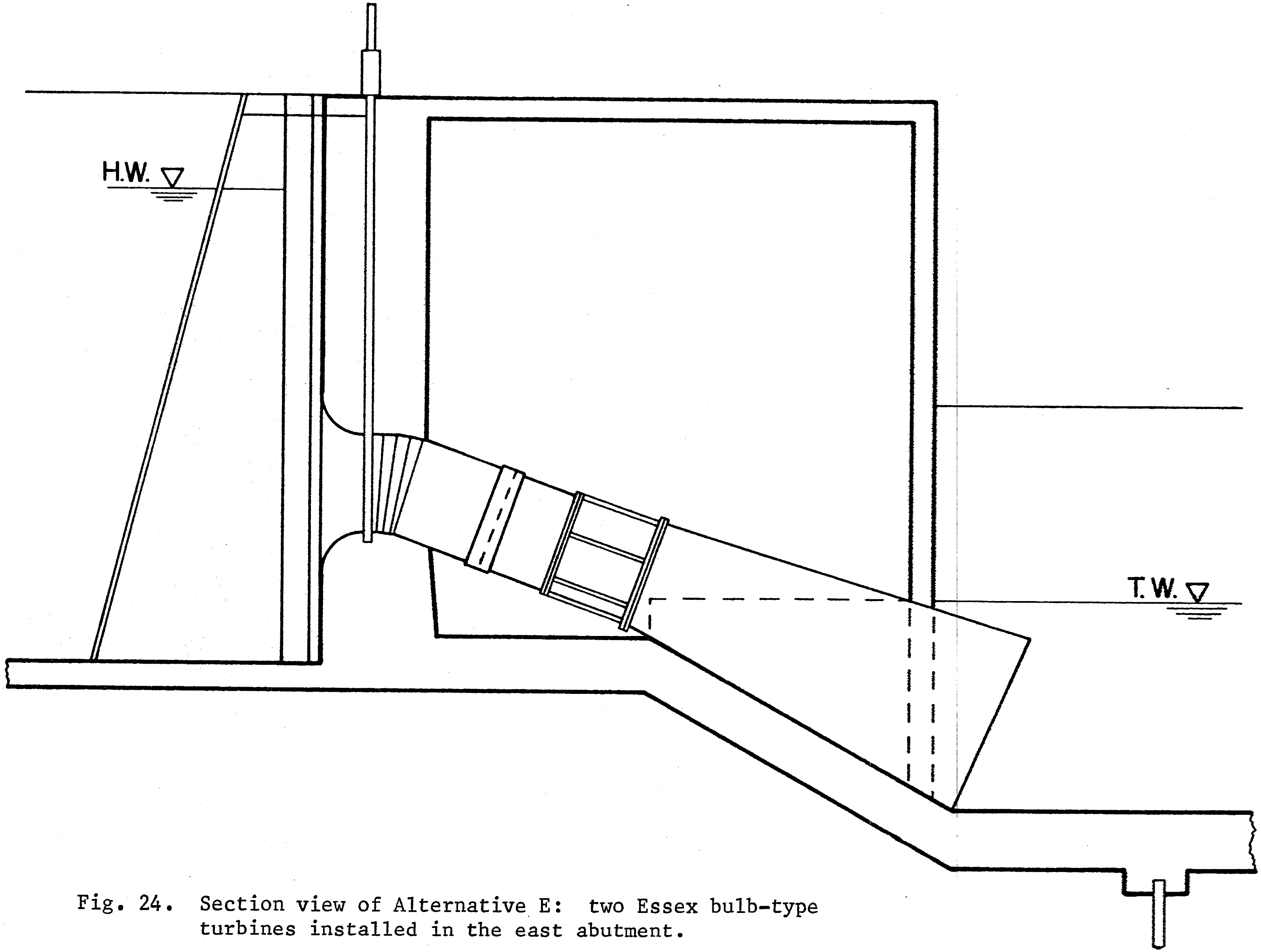

Fig. 24. Section view of Alternative E: two Essex bulb-type turbines installed in the east abutment.

The turbine units selected for Alternative E were developed and manufactured by a recently founded and relatively small company. A smaller version of this hydroturbine, a 1000 mm diameter model, has been independently tested by Alden Research Laboratory at Worcester Polytechnic Institute. The results of the test illustrate good performance characteristics. The larger unit specified herein has not been tested. The ET-1352 has a different number of blades and a larger diameter than the tested ET-1000. Similar performance characteristics are expected and assumed herein but as of yet they have not actually been verified.

As of this writing, two of the ET-1352 units are proposed for installation at a site in Goffstown, N. H. Requests for information on performance of installed units from the site owners have not been answered.

D. Other Development Alternatives

There are other turbine manufacturers marketing turbines in the United States which are applicable to the Thief River Falls Dam. The Neyrpic right-angle drive units, marketed in the United States by Hydro Energy Systems, Inc., are a fixed-blade propeller turbine designed to fulfill the same market as the Allis-Chalmers Mini-Tube turbine. The right-angle drive units can also be installed on an incline. The Worthington Pump Company and the Cornell Pump Company also manufacture turbines which are applicable to the Thief River Falls site.

E. Summary of Development Alternatives

There is a significant difference between the total initial project cost of the four development alternatives which included new turbine/generator units. These differences are illustrated in Table 5. Also given in Table 6 is the ratio of annual benefit to total initial project cost (not to be confused with the "benefit-cost ratio"). Choosing the alternative with the largest value of this ratio is the same as choosing the largest benefit-cost ratio or the minimum payback period. It is a relatively conservative feasibility indicator, however, since it does not always correspond to the maximum benefits minus costs.

The design flow of Alternatives A through E are compared with the February flow duration curve in Fig. 18, Section IV. Figure 18 indicates that the existing installation is already sized at the 40 percent exceedance level for February. This is also true for the composite flow duration curve given in Fig. 16.

TABLE 6. Comparison of the Incremental Benefits and Energy Production and of Total Initial Project Costs for Development Alternatives B, C, D, and E (1982 Base Year).

	Development Alternative			
Average Annual Incremental:	B	C	D	E
Energy Production (GWH)	0.71	0.99	1.41	0.97
Total Benefits ($)	27,000	36,900	50,400	36,900
Total Initial Cost ($)	938,000	1,063,700	1,351,000	900,700
Annual Incremental Benefit/ Total Initial Cost	0.0288	.0347	.0373	.0410

VIII. ECONOMIC ANALYSIS

A. Background and Assumptions

This section of the report will compare the benefits and costs of hydropower development at the Thief River Falls Dam. Certain basic assumptions, which are required in a benefit/cost analysis, will be outlined before describing the results of the economic analysis. The sensitivity of the benefit/cost comparisons to these basic assumptions is investigated in Section VIII.C.

1. Economic Feasibility Indicators

A number of economic feasibility indicators will be given herein to provide interested parties with a choice of decision rules and outline the economic advantages and disadvantages of each option. These indicators are:

The first year cost of power is the cost of debt service, operation and maintenance, and other costs divided by the average annual energy production.

The benefit-cost ratio is the present worth of project benefits divided by the present worth of initial project costs and annual costs.

$$B/C = \frac{\sum_{i=0}^{n} B_i/(1+d)^i}{C_i + \sum_{i=0}^{n} OM_i/(1+d)^i} \qquad (1)$$

where B/C = benefit-cost ratio for a project economic life of n years,

B_i = benefits in year i,

C_i = initial project cost,

OM_i = operation, maintenance, and replacement cost in year i,

d = discount rate, and

n = project economic life

The net present value is the present worth of project benefits minus the present worth of project costs:

$$NPV = \sum_{i=0}^{n} NB_i/(1 + d)^i \qquad (2)$$

where NPV = net present value for a project economic life of n years, and

NB_i = net project benefits in year i (benefits minus costs).

Payback period is the number of years of power generation required to reach a zero net present value. Internal rate of return is the discount and interest rate required to give zero net present value at the end of project economic life.

2. Assumptions

The following assumptions are incorporated into the economic analysis:

- Long-term tax-exempt bonds are typically for a 20-year period. For this reason the initial project cost will be amortized over a 20-year period.

- Nine percent annual escalation in the value of energy and power. Power producing utilities in the State of Minnesota (see Ref. [10]) have projected that the value of electricity will increase at or near the rate of inflation over the next 20 years.[4] The annual increase in the consumer price index between 1977 and 1981 has averaged 9.9 percent. The CPI is currently moderating; however, most economic forecasters are still predicting inflation rates near 9 percent over the next 5 to 10 years.[5]

- Eleven percent interest and discount rates. Interest rates on tax-exempt bonds have been climbing since the beginning of 1980.

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[4]Minnesota Energy Agency.

[5]Data Resources, Inc.

Historically, A-rated tax-exempt bonds have been near the rate of inflation. The recent tax cuts, however, have diminished the attractiveness of tax-exempt bonds. Many economic analysts believe the difference between long-term rates for tax-exempt bonds and non-tax-exempt financing rates will decrease by approximately 1.5 percent.[6] For this reason, a two percent spread between interest rate and escalation rate will be used.

- Incremental annual operation, maintenance and replacement costs for base year 1982. These costs were figured over and above present operation, maintenance, and replacement costs using Ref. [8].
- Nine percent annual escalation in operation, maintenance and replacement costs. This rate was chosen to coincide with the predicted inflation rate.
- A two-year construction period [8].
- A linear expenditure of capital during project construction.

The sensitivity of the benefit/cost analysis to discount rate and escalation rates will be described in Section VIII.C.

B. Comparison of Project Development Alternatives

The cost and benefit streams for development Alternatives B, C, D, and E are given in Tables 7, 8, 9, and 10.

The economic indicators of Section VIII.C indicate that Alternative E has the most potential. However, all of the cash flows indicate that the project will not be feasible given the economic assumptions made herein.

C. Sensitivity Analysis

The sensitivity analysis investigates the impact of variations in project parameters and economic assumptions on the feasibility indicators. The analysis will determine the sensitivity of the feasibility indicators to important project parameters and assumptions.

1. Variation of Project Cost

Because the scope of this study is to assess the feasibility of developing a site and is not a final design, variation of costs should be considered. Figure 25 illustrates the changes in the benefit cost ratio as a function of variation in total project cost for Alternative E. It should be noted that even a 20 percent reduction in total project cost yields a benefit cost ratio of just over 1.0 for a proposed 50 year project. This

[6]Donald Porter. First Boston Corporation, New York, N. Y.

TABLE 7. Cost and Benefit Streams for Development Alternative B, at the Thief River Falls Dam. Base Year for Present Worth - 1982. Two-year construction period. 11 percent interest rate. 9 percent escalation rates. All figures are in dollars.

Annual Incremental Operation, Maintenance and Replacement Cost$ (1982 Base Year) = $11,220.

Year	Debt Service	OM & R Costs	Gross Income	---------- Present Worth Benefits	Costs	Cash Flow ----------	Net Present Value
1	58895	0	0	0	53059	-53049	-53059
2	117790	0	0	0	95601	-95601	-148659
3	117790	14530	34924	25536	96751	-71215	-219874
4	117790	15838	38068	25076	88025	-62949	-282823
5	117790	17263	41494	24624	80148	-55523	-338346
6	117790	18817	45228	24181	73036	-48855	-387201
7	117790	20511	49299	23745	66614	-42869	-430070
8	117790	22357	53735	23317	60813	-37496	-467566
9	117790	24369	58572	22897	55573	-32676	-500242
10	117790	26562	63843	22485	50838	-28354	-528596
11	117790	28952	69589	22079	46559	-24479	-553075
12	117790	31558	75852	21682	42690	-21008	-574084
13	117790	34398	82679	21291	39191	-17900	-591983
14	177790	37494	90120	20907	36025	-15118	-607101
15	117790	40869	98230	20531	33160	-12630	-619731
16	117790	44547	107071	20161	30567	-10406	-630137
17	117790	48556	116708	19797	28218	-8420	-638557
18	117790	52926	127211	19441	26089	-6648	-645206
19	117790	57689	138660	19090	24160	-5069	-650275
20	117790	62881	151140	18746	22409	-3663	-653938
21	58895	68541	164742	18409	14240	4169	-649769
22	0	74709	179569	18077	7521	10556	-639213
23	0	81433	195730	17751	7385	10366	-628847
24	0	88762	213346	17431	7252	10179	-618668
25	0	96751	232547	17117	7122	9996	-608672
26	0	105459	253476	16809	6993	9816	-598857
27	0	114950	276289	16506	6867	9639	-589218
28	0	125295	301155	16209	6744	9465	-579753
29	0	136572	328259	15917	6622	9295	-570458
30	0	148863	357803	15630	6503	9127	-561331
31	0	162261	390005	15348	6386	8963	-552369
32	0	176865	425105	15072	6271	8801	-543568
33	0	192782	463365	14800	6158	8643	-534925
34	0	210233	505068	14533	6047	8487	-526438
35	0	229045	550524	14272	5938	8334	-518104
36	0	249659	600071	14014	5831	8184	-509921
37	0	272128	654077	13762	5726	8036	-501884
38	0	296620	712944	13514	5622	7891	-493993
39	0	323315	777109	13270	5521	7749	-486243
40	0	352414	847049	13031	5422	7610	-478634
41	0	384131	923284	12797	5324	7473	-471161
42	0	418703	1006379	12566	5228	7338	-463823
43	0	456386	1096953	12340	5134	7206	-456618
44	0	497461	1195679	12117	5041	7076	-449542
45	0	542232	1303290	11899	4951	6948	-442593
46	0	591033	1420586	11685	4861	6823	-435770
47	0	644226	1548439	11474	4774	6700	-429070
48	0	702206	1687799	11267	4688	6580	-422490
49	0	765405	1839701	11064	4603	6461	-416029
50	0	834291	2005274	10865	4520	6345	-409685
51	0	909378	2185748	10669	4439	6230	-403455
52	0	991222	2382466	10477	4359	6118	-397337

Payback Period = Greater than 50 years

Economic Analysis for a Project Life of 35 Years
Present Net Value = $ - 501884
Benefit Cost Ratio = .57
Internal Rate of Return = 6.2 percent

Economic Analysis for a Project Life of 50 Years
Present Net Value = $ - 397337
Benefit Cost Ratio = .68
Internal Rate of Return = 8.2 percent

TABLE 8. Cost and Benefit Streams for Development Alternative C, at the Thief River Falls Dam. Base Year for Present Worth - 1982. Two-year construction period. 11 percent interest rate. 9 percent escalation rates. All figures are in dollars.

Annual Incremental Operation, Maintenance and Replacement Cost$ (1982 Base Year) = $13,520.

Year	Debt Service	OM & R Costs	Gross Income	Present Worth Benefits	Present Worth Costs	Present Worth Cash Flow	Net Present Value
1	66787	0	0	0	60169	-60169	-60169
2	133575	0	0	0	108412	-108412	-168581
3	133575	17509	47776	34934	110471	-75537	-244119
4	133575	19085	52076	34304	100561	-66257	-310376
5	133575	20802	56763	33686	91615	-57929	-368305
6	133575	22674	61872	33079	83537	-50458	-418763
7	133575	24715	67440	32483	76242	-43759	-462522
8	133575	26939	73510	31898	69651	-37754	-500276
9	133575	29364	80125	31323	63697	-32374	-532649
10	133575	32007	87337	30759	58315	-27557	-560206
11	133575	34887	95197	30204	53450	-23246	-583452
12	133575	38027	103765	29660	49051	-19391	-602842
13	133575	41450	113104	29126	45071	-15945	-618788
14	133575	45180	123283	28601	41470	-12869	-631657
15	133575	49246	134378	28086	38210	-10125	-641782
16	133575	53679	146473	27580	35248	-7679	-649460
17	133575	58510	159655	27083	32584	-5501	-654962
18	133575	63775	174024	26595	30159	-3565	-658526
19	133575	69515	189686	26116	27961	-1845	-660372
20	133575	75772	206758	25645	25966	-321	-660693
21	66787	82591	225366	25183	16692	8491	-652202
22	0	90024	245649	24729	9063	15667	-636535
23	0	98126	267758	24284	8899	15384	-621151
24	0	106958	291856	23846	8739	15107	-606044
25	0	116584	318123	23416	8582	14835	-591209
26	0	127077	346754	22994	8427	14568	-576641
27	0	138514	377962	22580	8275	14305	-562336
28	0	150980	411978	22173	8126	14047	-548289
29	0	164568	449056	21774	7980	13794	-534495
30	0	179379	489471	21381	7836	13546	-520949
31	0	195523	533524	20996	7695	13302	-507647
32	0	213120	581541	20618	7556	13062	-494585
33	0	232301	633879	20246	7420	12827	-481759
34	0	253208	690929	19882	7286	12596	-469163
35	0	275997	753112	19523	7155	12369	-456795
36	0	300837	820892	19172	7026	12146	-444649
37	0	327912	894772	18826	6899	11927	-432722
38	0	357424	975302	18487	6775	11712	-421010
39	0	389592	1063079	18154	6853	11501	-409509
40	0	424655	1158756	17827	6533	11294	-398216
41	0	462874	1263044	17506	6415	11090	-387125
42	0	504533	1376718	17190	6300	10890	-376235
43	0	549941	1500623	16880	6186	10694	-365541
44	0	599436	1635679	16576	6075	10501	-355039
45	0	653385	1782890	16278	5965	10312	-344727
46	0	712190	1943350	15984	5858	10126	-334601
47	0	776287	2118252	15696	5752	9944	-324657
48	0	846152	2308895	15413	5649	9765	-314892
49	0	922306	2516695	15136	5547	9589	-305303
50	0	1005314	2743198	14863	5447	9416	-295887
51	0	1095792	2990085	14595	5349	9246	-286640
52	0	1194413	3259193	14332	5252	9080	-277560

Payback Period = Greater than 50 years

Economic Analysis for a Project Life of 35 Years
Present Net Value = $ - 432722
Benefit Cost Ratio = .68
Internal Rate of Return = 7.5 percent

Economic Analysis for a Project Life of 50 Years
Present Net Value = $ - 277560
Benefit Cost Ratio = .81
Internal Rate of Return = 9.3 percent

TABLE 9. Cost and Benefit Streams for Development Alternative D, at the Thief River Falls Dam. Base Year for Present Worth - 1982. Two-year construction period. 11 percent interest rate. 9 percent escalation rates. All figures are in dollars.

Annual Incremental Operation, Maintenance and Replacement Cost$ (1982 Base Year) = $17,140.

Year	Debt Service	OM & R Costs	Gross Income	Present Worth Benefits	Present Worth Costs	Present Worth Cash Flow	Net Present Value
1	84826	0	0	0	76420	-76420	-76420
2	169653	0	0	0	137694	-137694	-214114
3	169653	22197	65306	47751	140279	-92528	-306642
4	169653	24195	71183	46891	127693	-80803	-387444
5	169653	26372	77590	46046	116331	-70285	-457730
6	169653	28745	84573	45216	106072	-60856	-518585
7	169653	31333	92184	44401	96806	-52405	-570990
8	169653	34153	100481	43601	88436	-44835	-615825
9	169653	37226	109524	43816	80874	-38058	-653884
10	169653	40577	119381	42044	74039	-31995	-685879
11	169653	44229	130126	41287	67861	-26574	-712453
12	169653	48209	141837	40543	62274	-21731	-734184
13	169653	52548	154602	39812	57220	-17407	-751592
14	169653	57277	168517	39095	52647	-13552	-765143
15	169653	62432	183683	38391	48507	-10116	-775259
16	169653	68051	200215	37699	44758	-7059	-782318
17	169653	74176	218234	37020	41361	-4342	-786660
18	169653	80851	237875	36353	38283	-1930	-788590
19	169653	88128	259284	35698	35491	207	-788383
20	169653	96060	282619	35054	32957	2097	-786286
21	84826	104705	308055	34423	21179	13244	-773042
22	0	114128	335780	33803	11489	22313	-750729
23	0	124400	366000	33193	11282	21911	-728817
24	0	135596	398940	32595	11079	21517	-707301
25	0	147800	434845	32008	10879	21129	-686172
26	0	161102	473981	31431	10683	20748	-665424
27	0	175601	516639	30865	10491	20374	-645049
28	0	191405	563137	30309	10302	20007	-625042
29	0	208631	613819	29763	10116	19647	-605396
30	0	227408	669062	29227	9934	19293	-586103
31	0	247875	729278	28700	9755	18945	-567158
32	0	270183	794913	28183	9579	18604	-548554
33	0	294500	866455	27675	9406	18269	-530285
34	0	321005	944436	27176	9237	17939	-512346
35	0	349895	1029436	26687	9071	17616	-494730
36	0	381386	1122085	26206	8907	17299	-477431
37	0	415711	1223072	25734	8747	16987	-460444
38	0	453125	1333072	25270	8589	16681	-443763
39	0	493906	1453132	24815	8434	16380	-427383
40	0	538357	1583914	24368	8282	16085	-411297
41	0	586810	1726467	23929	8133	15795	-395502
42	0	639622	1881849	23497	7987	15511	-379991
43	0	697189	2051215	23074	7843	15231	-364760
44	0	759935	2235824	22658	7701	14957	-349803
45	0	828330	2437048	22250	7563	14687	-335115
46	0	902879	2656383	21849	7426	14423	-320693
47	0	984138	2895457	21455	7292	14163	-306530
48	0	1072711	3156048	21069	7161	13908	-292622
49	0	1169255	3440093	20689	7032	13657	-278965
50	0	1274488	3749701	20316	6905	13411	-265554
51	0	1389191	4087174	19950	6781	13169	-252384
52	0	1514219	4455020	19591	6659	12932	-239452

Payback Period = Greater than 50 years

Economic Analysis for a Project Life of 35 Years
Present Net Value = $ - 460444
Benefit Cost Ratio = .73
Internal Rate of Return = 8.1 percent

Economic Analysis for a Project Life of 50 Years
Present Net Value = $ - 239452
Benefit Cost Ratio = .87
Internal Rate of Return = 9.7 percent

TABLE 10. Cost and Benefit Streams for Development Alternative E, at the Thief River Falls Dam. Base Year for Present Worth - 1982. Two-year construction period. 11 percent interest rate. 9 percent escalation rates. All figures are in dollars.

Annual Incremental Operation, Maintenance and Replacement Cost$ (1982 Base Year) = $14,380.

Year	Debt Service	OM & R Costs	Gross Income	Present Worth Benefits	Present Worth Costs	Present Worth Cash Flow	Net Present Value
1	56553	0	0	0	50949	-50949	-50949
2	113106	0	0	0	91799	-91799	-142748
3	113106	18623	47691	34871	96319	-61448	-204196
4	113106	20299	51983	34243	87878	-53635	-257831
5	113106	22125	56661	33626	80253	-46627	-304458
6	113106	24117	61761	33020	73365	-40345	-344803
7	113106	26287	67319	32425	67140	-34715	-379518
8	113106	28653	73378	31841	61513	-29674	-409190
9	113106	31232	79982	31267	56425	-25158	-434349
10	113106	34043	87181	30704	51823	-21120	-455468
11	113106	37107	95027	30150	47660	-17510	-472978
12	113106	40446	103579	29607	43891	-14384	-487262
13	113106	44086	112901	29074	40479	-11406	-498668
14	113106	48054	123062	28550	37388	-8838	-507506
15	113106	52379	134138	28035	34587	-6552	-514058
16	113106	57093	146210	27530	32047	-4517	-518575
17	113106	62231	159369	27034	29743	-2709	-521283
18	113106	67832	173713	26547	27651	-1104	-522388
19	113106	73937	189347	26069	25752	317	-522070
20	113106	80591	206388	25599	24025	1574	-520496
21	56553	87845	224963	25138	16135	9003	-511494
22	0	95751	245210	24685	9639	15046	-496448
23	0	104368	267278	24240	9465	14775	-481673
24	0	113761	291334	23803	9295	14509	-467165
25	0	124000	317554	23375	9127	14247	-452917
26	0	135160	346133	22953	8963	13990	-438927
27	0	147324	377285	22540	8801	13738	-425189
28	0	160583	411241	22134	8643	13491	-411698
29	0	175036	448253	21735	8487	14348	-398450
30	0	190789	488596	21343	8334	13009	-385441
31	0	207960	532569	20959	8184	12775	-372667
32	0	226667	580500	20581	8037	12544	-360122
33	0	247078	632745	20210	7892	12318	-347804
34	0	269315	689692	19846	7750	12096	-335707
35	0	293553	751765	19488	7610	11879	-323829
36	0	319973	819424	19137	7473	11664	-312164
37	0	348770	893172	18793	7338	11454	-300710
38	0	380159	973557	18454	7206	11248	-289462
39	0	414374	1061177	18121	7076	11045	-278417
40	0	451667	1156683	17795	6949	10846	-267570
41	0	492318	1260785	17474	6823	10651	-256920
42	0	536626	1374255	17159	6700	10459	-246461
43	0	584922	1497938	16850	6580	10270	-236190
44	0	637565	1632753	16547	6461	10085	-226105
45	0	694946	1779701	16248	6345	9904	-216201
46	0	757492	1939874	15956	6230	9725	-206476
47	0	825666	2114462	15668	6118	9550	-196926
48	0	899976	2304764	15386	6008	9378	-187548
49	0	980974	2512193	15109	5900	9209	-178339
50	0	1069261	2738290	14836	5793	9043	-169296
51	0	1165495	2984736	14569	5689	8880	-160416
52	0	1270389	3253362	14307	5587	8720	-151696

Payback Period = Greater than 50 years

Economic Analysis for a Project Life of 35 Years
Present Net Value = $ - 300710
Benefit Cost Ratio = .75
Internal Rate of Return = 8.1 percent

Economic Analysis for a Project Life of 50 Years
Present Net Value = $ - 151696
Benefit Cost Ratio = .88
Internal Rate of Return = 9.8 percent

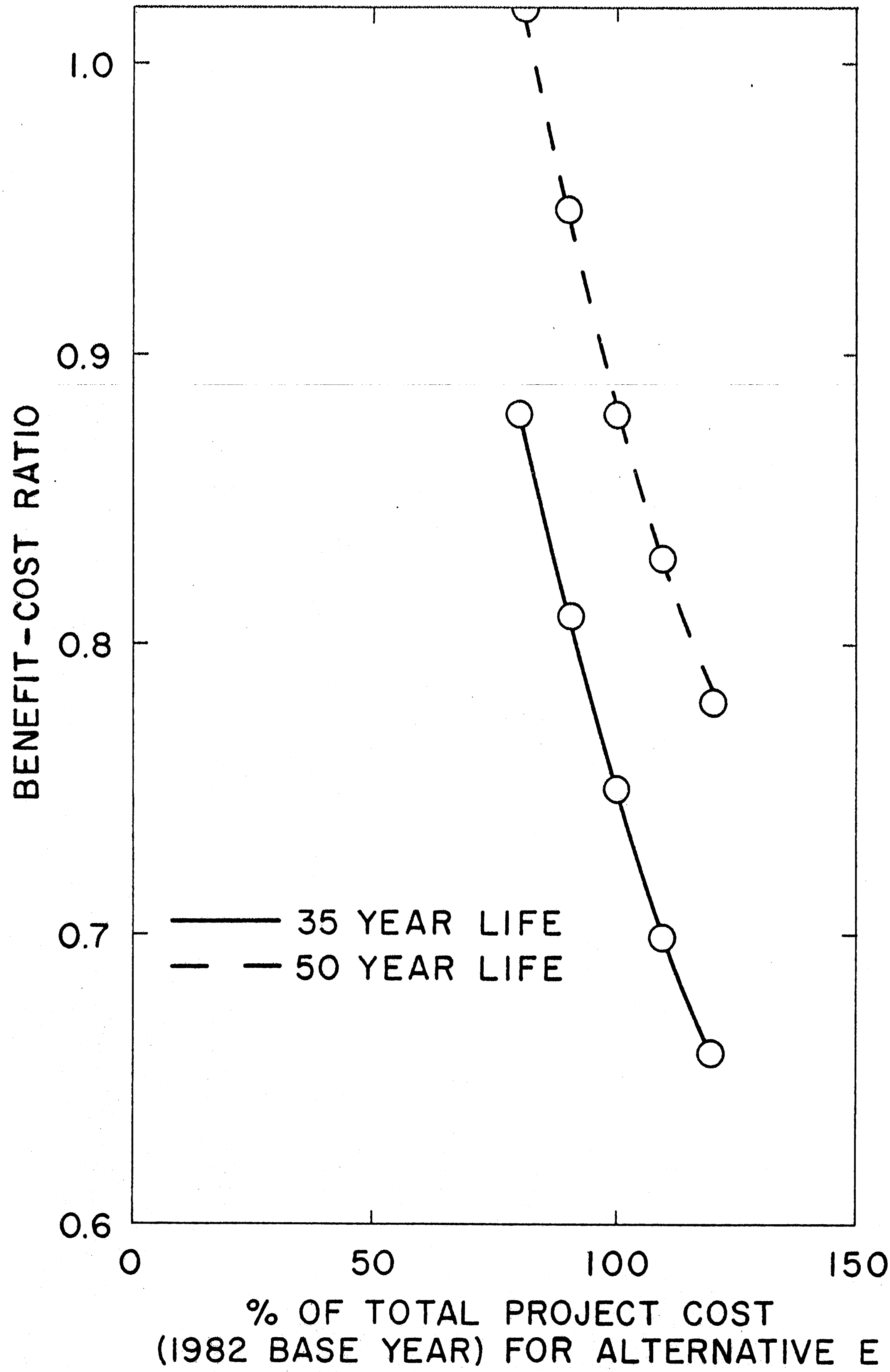

Fig. 25. Benefit/cost ratio as a function of variation in total project cost for Alternative E at the Thief River Falls Dam.

indicates that cost-effective construction techniques are unlikely to make the proposed project feasible under the economic assumptions given herein.

2. Discount and Escalation Rates

Hydropower feasibility is highly sensitive to the difference between the discount and escalation rates used in the economic analysis. Table 11 gives the economic indicators which result from 9 and 13 percent discount rates. The escalation rate remained at 9 percent, so the difference between discount and escalation rates is zero and 4 percent in Table 11. Table 11 indicates that a 9 percent discount rate changes economic feasibility from poor to marginal. A 39-year payback period is still the best which is achieved.

3. Operation, Maintenance, and Replacement Costs

Probably the most difficult cost to accurately predict is the annual operation, maintenance, and replacement (OM&R) cost. It is the only cost in the economic analysis which is not set at the beginning of the project. The OM&R costs are incurred throughout the life of the facility. Consequently, any prediction of these costs will be more speculative when compared to the other costs. OM&R costs were computed using the method described in Ref. [8].

Since the City of Thief River Falls currently employs powerplant operators at the powerplant, the overall OM&R costs were reduced in the sensitivity analysis. However, although operation and maintenance costs may be assumed by the current facility personnel, replacement costs cannot. Therefore, it does not seem likely that the incremental OM&R costs may be eliminated entirely. Figure 26 illustrates the benefit-cost ratio for Alternative E as a function of incremental OM&R costs. For a zero OM&R cost the resulting economic indicators are favorable. An annual OM&R cost of $1730 (1982 base year), or 12 percent of the estimate given herein, however, results in a 35-year benefit-cost ratio of 1.0, and a more marginal feasibility.

4. Value of Energy

Normally, hydropower feasibility is dependent to a large degree upon the price at which the generated electricity is sold. However, the details of the contractual agreement between the City of Thief River Falls and NMPA place a larger weight upon capacity credit earnings as a source of benefit for the addition of incremental capacity at the site. The value of energy is quite low for the city. Therefore, calculations were performed in order to determine to what degree project feasibility would be enhanced, given an increase in the value of energy.

Figure 27 indicates the benefit-cost ratio as as function of value of energy for Alternative E at the Thief River Falls Dam for both 35- and 50-year project economic lives. A value of energy of 2.5 cents/kWH (compared to the current 1.018 cents/kWH) would be required in order to yield significantly improved economic indicators for the proposed development.

TABLE 11. Comparison of 9 percent and 13 percent Discount Rates for Alternatives B, C, D, and E at the Thief River Falls Dam (1982 Base Year)

Alternative	Discount Rate %	Present Net Value ($)	Benefit-Cost Ratio	Internal Rate of Return (%)	Payback Period (Yrs)
35 Year Life					
B	9	-348095	0.73	6.2	*
C		-201766	0.86	7.5	44
D		-130145	0.93	8.1	39
E		-77905	0.94	8.1	39
B	13	-597857	0.45	6.2	*
C		-577775	0.54	7.5	*
D		-668346	0.58	8.1	*
E		-440980	0.60	8.1	*
50 Year Life					
B	9	-111875	0.92	8.2	*
C		148814	1.09	9.3	44
D		369175	1.17	9.7	39
E		258785	1.16	9.8	39
B	13	-550625	0.51	8.2	*
C		-507678	0.61	9.3	*
D		-568509	0.65	9.7	*
E		-373660	0.68	9.8	*

* - Indicates payback period greater than 50 years.

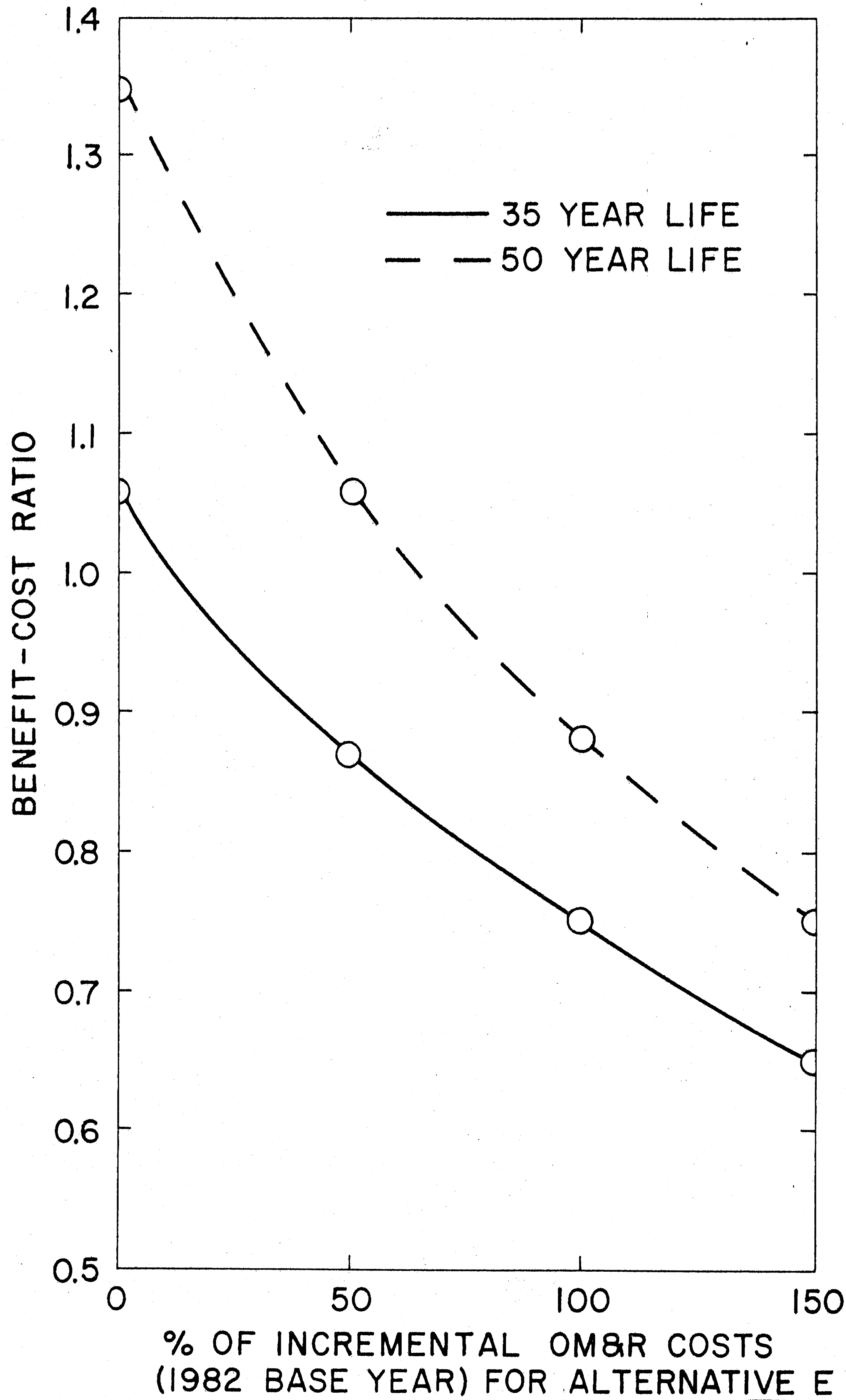

Fig. 26. Benefit/cost ratio as a function of variation in incremental operation maintenance and replacement costs for Alternative E at the Thief River Falls Dam.

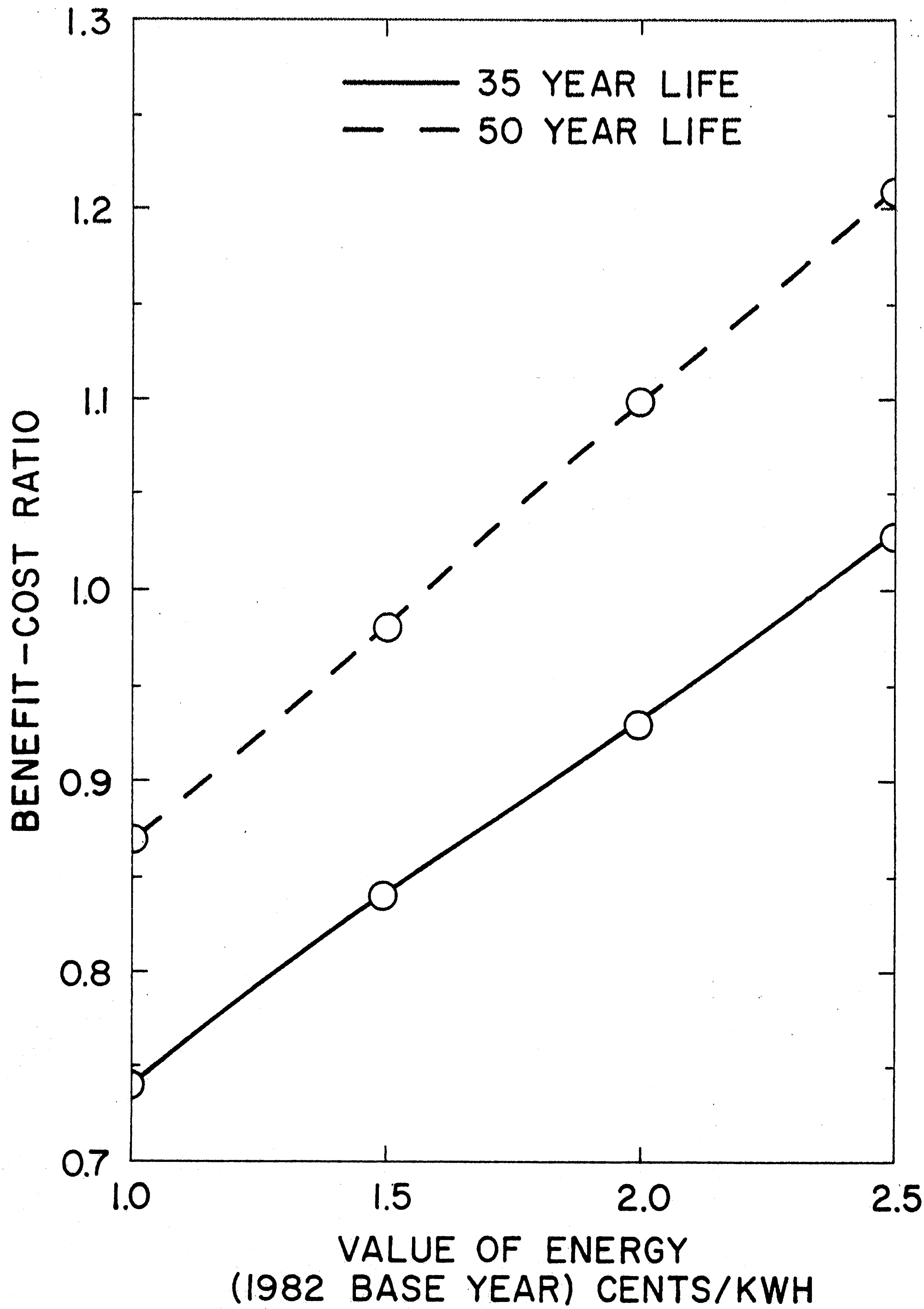

Fig. 27. Benefit/cost ratio as a function of value of energy for Alternative E at the Thief River Falls Dam.

IX. ENVIRONMENTAL IMPACT OF PROPOSED DEVELOPMENT

A. Background

Since small-scale hydropower facilities are generally developed at existing dam sites, the environmental impact is usually limited; there is no land inundated due to new dam construction and the character of the stream is not greatly altered. The environmental impact of small-scale hydropower facilities should not be entirely discounted, however. There are likely to be a few cases where a fishery may be harmed, public health may be threatened due to dredge spoils, or a historic structure may be destroyed. The scope of this section is to identify, in general, the potential environmental impacts of small-scale hydropower plants at existing dam sites. The goal of this section is to determine the potential impacts in accordance with the Federal Energy Regulatory Commission's (FERC) requirements for the filing of a Short-Form Minor License or Exemption from Licensing for hydroelectric power development.

In order to evaluate the environmental impacts of a hydropower facility, the mode of operation must be specified. Operational modes may be divided into two general categories:

1. Run-of-River. Hydropower plants which have insufficient reservoir storage for seasonal peaking are classified as run-of-river. This category includes facilities which have enough reservoir storage for peaking on a daily basis. We prefer to differentiate between these two subcategories with the terms "strict run-of-river" and "daily storage."

2. Seasonal Peaking. If the facility will be used for store-release peaking on a seasonal basis, the river or stream will be subject to larger and more intermittent water level fluctuations. A seasonal peaking operation may therefore have a more detrimental effect on the environment.

The following aspects of the operation of a hydroelectric facility are important for environmental considerations:

1. Minimum flow
2. Water level fluctuation
3. Fish passage through hydraulic turbines
4. Dredging and disposal of dredged material
5. Water quality impacts
6. Threatened or endangered species

There will also be additional temporary impacts during construction. Timing of construction activities may be such that they minimize impact upon the spawning activities of fish and other facets of aquatic life.

Other construction activities which could have an adverse effect upon the environment include dredging and dust control. This is most easily controlled by installing a cofferdam to reduce excessively turbid releases to the stream. Land use impacts that should be addressed concern the fact that powerhouses and dams alter the general scenery along a river, displace streamside vegetation, and present obstacles to terrestrial wildlife species [11]. Indirect impacts of small-scale hydropower may lead to new opportunities and responsibilities for supporting recreational, commercial, agricultural, or residential activity [11].

There are also several other considerations for which the degree of severity or applicability must be determined on a site-specific basis. These include powerline construction, noise reduction, earthwork, historical and archaeological significance, endangered species (plants and animals), recreation (parks, canoe routes, etc.), and aesthetic quality. Also of prime importance in determining impacts would be the designation of a river or stream as a Wild and Scenic River on either a state or federal basis. There are usually no impacts incurred due to the dam itself since the impoundments have been in place for a long period of time. It is therefore likely that environmental modifications have already taken place [11]. Fish and wildlife habitats have already adapted to the environment created by the existing dam.

An effective means of screening the site-specific environmental impacts is by utilizing an environmental impact matrix as shown in Fig. 28 [12] for the Thief River Falls Dam. The facility will be operated on a run-of-river basis.

B. FERC Requirements

The Federal Energy Regulatory Commission (FERC), in its application procedure, requires an environmental report to be filed. "The environmental report should be consistent with the scope of the project and the environmental impacts of the proposed action; e.g., authorization to operate and maintain a project...using an existing dam or other facility would require less detailed information than authorization to construct a new project." [13]

The City of Thief River Falls has two options in complying with FERC requirements. The first is to file an "Application for Amendment of License," with a revised Exhibit L (plans and specs). No environmental report is specifically required but may be requested by the FERC. The second option is to file for an exemption from licensing. The exemption will specifically require an environmental report; however, annual license fees and periodic review and renewal are not required with an exemption. The disadvantage to an exemption is that it provides no legal protection from downstream or upstream developments which may harm power production. Regardless of which FERC licensing option is followed, some State of Minnesota permits will require an environmental analysis.

⊗ POSITIVE IMPACT

● SIGNIFICANT IMPACT

⊙ LIMITED IMPACT

☐ INSIGNIFICANT OR NO IMPACT

			PROPOSED ACTIVITIES — CONSTRUCTION: EARTHWORK CLEARING/GRADING/EXCAV.	DEMOLITION/DISPOSAL	INTERIM FLOOD CONTROL	COFFER DAM/DEWATERING	HEAVY EQUIPMENT USE	MATERIAL TRANSP./STORAGE	TEMPORARY STRUCTURES AND FACILITIES	WORKER AND EQUIP. ACCESS	WORKER INFLUX	PHYSICAL PLANT & OPERATION: PERMANENT STRUCTURES & FACILITIES	ELECTRIC DISTRIB. CIRCUITS	ELECTRIC GENERATION	FLOW CONTROL	IMPOUND, MANAGEMENT	WORKER & EQUIP. ACCESS	SECURITY & SAFETY
NATURAL FACTORS	TERRESTRIAL	SOILS																
		LAND FORM					⊙			⊙			⊙					
	HYDROLOGICAL	SURFACE WATER LEVELS	⊙			⊙												
		SURFACE WATER QUALITY	⊙	⊙		⊙									⊙	⊙		
		UNDERGROUND WATER QUALITY														⊙		
		WELL WATER SUPPLY																
	BIOLOGICAL	VEGETATION																
		FISH AND AQUATIC WILDLIFE	⊙		⊙	⊙									⊙	⊙		
		BIRDS																
		TERRESTRIAL WILDLIFE																
	ATMOSPHERIC	AIR QUALITY																
CULTURAL FACTORS	SOCIAL	SCENIC VIEWS & VISTAS	⊙	⊙			⊙		⊙	⊙		⊙	⊙					
		OPEN SPACE QUALITIES																
		HISTORICAL ARCHEOLOGICAL SITES																
		RARE AND UNIQUE SPECIES																
		HEALTH AND SAFETY					⊙											
		AMBIENT NOISE LEVEL	⊙	⊙			⊙											
		RESIDENTIAL ACTIVITY																
		EMPLOYMENT (SHORT TERM)	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗							
		EMPLOYMENT (LONG TERM)												⊗				
		HOUSING (SHORT TERM)																
		HOUSING (LONG TERM)																
		LOCAL GOVERNMENT FISCAL EFFECTS																
		BUSINESS ACTIVITY									⊗							
	LAND USE - LAND VALUE	AGRICULTURAL																
		RESIDENTIAL																
		COMMERCIAL																
		INDUSTRIAL																
		OPEN SPACE																
	INFRASTRUCTURE	TRANSPORTATION																
		UTILITIES												⊗				
		WASTE DISPOSAL	⊙	⊙														
		GOVERNMENT SERVICES																
	RECREATION	HUNTING																
		FISHING	⊙			⊙												
		BOATING				⊙												
		SWIMMING																
		PICNICKING																
		HIKING-BIKING																

Fig. 28. Environmental impact matrix for hydropower development at the Thief River Falls Dam.

The contents of an environmental report should include [13]:

(1) Brief description of project and mode of operation (run-of-river or peaking).

(2) Description of environmental setting in or near project area. (Special attention should be given to endangered plant and animal species, critical habitats, sites on Wild and Scenic Rivers, sites eligible for or included on National Register of Historic Places.)

(3) Impact of continued operation of project or from construction of an existing dam or facility.

(4) ~~Description of equivalent alternative power means if application~~ is not authorized.

(5) Description of steps taken by the application in consulting with federal, state and local agencies during preparation of the environmental report. Indicate which agencies received the final report and provide copies of letters containing the comments of the agencies.

C. Water Level Fluctuations and In-Stream Flows

Water level fluctuations will have their most adverse impact at a seasonal peaking plant. However, the mode of operation at Thief River Falls is such that the proposed increase in capacity will only be operated at peak during maximum winter demand. Furthermore, it will only be operated for approximately three hours every twelve hours. In anticipation of the peak demand, the operators will try to retain as much capacity in the reservoir as possible while still releasing required minimum flows. The synchronization of peak electrical demand with the peak hydropower output is necessary to offset the rates paid by the City of Thief River Falls as described in Section V.C. During non-peak demand periods, output at the site is governed by the outlet flow from the Lower Red Lake. Operation of the plant during this period will be entirely as a run-of-river facility. The maximum drawdown allowed at peak periods is one-foot, consistent with the current operational procedure. The minimum flow release required at the Thief River Falls Dam has been set at approximately 80 cfs [18]. Presently, this flow can be achieved by water passing through leaks in the dam gates and by water passing through the partially opened wicket gates of the No. 1 turbine [18].

D. Water Quality

Potential water quality consideration in tailwaters below dams include:

(1) alteration of temperature regimes,
(2) reduced turbidity,

(3) changes in dissolved oxygen,
(4) increase in the dissolved form of some metals, and
(5) altered nutrient and organic matter regimes. [15]

Important aspects to consider are thermal and chemical stratification in the reservoir and depth of water withdrawal. If water is discharged from the hypolimnion, colder tailwaters may occur in the summer and warmer tailwaters in the winter. Possible adverse results from such discharge patterns include reductions in aquatic life, benthic invertebrate diversity, and modifications in the spawning activity of fish. This is true of very deep reservoirs. Shallow reservoirs, however, are often insufficiently deep to allow significant thermal stratification to take place. Therefore, in run-of-river projects without significant storage capacity or depth, these types of problems will not be encountered. Most low-head turbine installations intake a column of water and do not draw water off at a certain level. With this mixing of the water column, the problems associated with low dissolved oxygen will not be encountered. A stratified reservoir would require a much more detailed investigation of its possible impacts.

No adverse impacts upon stream water quality are expected from hydropower development at the Thief River Falls Dam.

E. Fish Passage Through Hydraulic Turbines

The hydroelectric plant at Thief River Falls is currently in operation. Therefore, any change in plant operation or turbine units will have a limited impact upon fish mortality.

"It is important to put turbine related fish mortality at conventional hydroelectric facilities into perspective. Turbine related mortality is only one of many causes of mortality to downstream migrating juveniles as a result of hydropower development; other factors affecting survival are spillways, downstream passage facilities, predation, and delay in migration."[20] With the trash racks currently in place, only the smallest juveniles are capable of being passed through the turbines. All downstream migrants which are too large to pass through the trashracks will be passed over the spillway (as has been done historically).

Fish which do enter the turbine may be subject to mechanical injury with the turbine runner or internal injury due to pressure changes. However, it is known that the highest fish survival rates occur when the turbine is operated at maximum efficiency. This condition is a goal which will be strived for in the operation of the plant since it will produce the most efficient power production from a given streamflow. Problems encountered by fish due to cavitation will also be minimized when the turbine is operated at maximum efficiency. The turbines which are being considered for installation at Thief River Falls do not appear to pose any significant problems to fish passage.

Impingement against the trash racks is another potential source of fish mortality at the Thief River Falls Dam. Trashrack velocities are not high enough to cause severe impingement problems, but some limited fish impingement may occur.

F. Construction Impacts

The effect of construction activities would be temporary but could have potentially adverse impacts to the environment. The most significant problem which could occur during construction activities would be an adverse effect on water quality. All necessary precautions should be taken so that no excessively turbid water is released to the stream. Of prime importance is the fact that construction should be scheduled such that there will be a minimal effect on the fish spawning season. Construction period water level fluctuations should be done as to not interfere with the littoral zone ecosystem. All necessary state and federal permits should be obtained. A consultation with these agencies well in advance of scheduled construction is advised to insure that all regulations will be followed and to prevent delay of the project.

Fish species, spawning season, and diversity taken above and below the Thief River Falls Dam through electro-fishing are given in Tables 12 and 13 [22]. Many construction activities involve excavation and dredging. Cofferdams around the construction area will minimize the impact of these construction activities. Turbid water should not be released during fish spawning season. In addition, dredging activities should be such that no municipal water supplies are contaminated. This study recommends that construction activities be timed to minimize the release of turbid water during April and May, which is the most critical fish spawning period for the Red Lake River at Thief River Falls.

Testing and/or sampling of the sediment should be taken to determine its physical, chemical, and biological characteristics to make a proper determination of adverse effects caused by sediment resuspension. A suitable disposal site for the dredge material should also be chosen.

Close coordination with state agencies is a necessity to insure that all regulations and restrictions are met.

G. Historic Preservation

In the course of FERC's licensing procedure, the Advisory Council on Historic Preservation and the State Historic Preservation Officer must be consulted to insure that no historic or cultural sites will be adversely affected. "Many older hydropower sites, while not of national significance, have played an important role in the local history of an area and thus are important enough to stimulate local concerns. Additions and other needed alterations of the exterior of a structure should be designed in keeping with the historic and aesthetic value of an area, especially if other historic structures are in close proximity." [24] Sites on the National Register of Historic Places are given special protection by federal law. Therefore, it is important to review each site for potential archeological, cultural, and historic significance.

TABLE 12. Species and Diversity of Fish Taken Upstream of Dam at Thief River Falls on the Red Lake River (Source: Minnesota Department of Natural Resources, 1976, J. W. Emblom, Aquatic Biologist)

Species	Total No.	Spawning Season [23]
Walleye	5	Spring shortly after thaw
Northern Pike	2	April - Early May
Rock Bass	12	May - Early June
White Sucker	103	Mid-May
Sh. Redhorse	25	
Drum	13	
Yellow Perch	3	May
Barbot	1	Jan.- Feb. before thaw
Br. Bullhead	1	
Common Siner	9	
Bl. Sided Darter	34	
Hornyhead Chub	17	

TABLE 13. Species and Diversity of Fish Taken Downstream of Dam at Thief River Falls on the Red Lake River (Source: Minnesota Department of Natural Resources, 1976, J. W. Emblom, Aquatic Biologist)

Species	Total No.	Spawning Season [23]
Golden Redhorse	41	Late May - Early July
Drum	60	
Sh. Redhorse	86	
White Sucker	56	Mid-May
Carp	16	Mid-May
Silver Redhorse	12	Late May-Early June
Quillback	11	
Barbot	14	Jan - Feb before thaw
Walleye	13	Spring shortly after thaw
Yellow Perch	12	May
Rock Bass	5	May - Early June
Bl. Bullhead	2	
Channel Catfish	2	April - May
Northern Pike	1	April - Early May
Chestnut Lamprey	4	May
Common Shiner	11	
Bl. Sided Darter	76	
Johnny Darter	3	May - June
Longnose Dace	25	May - June
Hornyhead Chub	4	

Communication with the Minnesota Historical Society indicates that none of the hydropower development alternatives considered herein will adversely impact any historic structure. The society requests further review, however, before any construction is undertaken.

H. Endangered Species

There are no endangered animal species identified by the U. S. Fish and Wildlife that will be affected by the Thief River Falls project. The Minnesota Natural Heritage Program (Minnesota Department of Natural Resources) has surveyed the project area. The Minnesota Natural Heritage Program concluded that there is no recorded occurrence of priority plant communities at this site. Correspondence is given in the Appendix.

I. Recreation - Thief River Falls

According to Ref. 23, the Red Lake River is a splendid wild river with good fishing opportunities between Thief River Falls and Red Lake Falls. Rough fish populations are usually larger than those of sport species and the most abundant species are redhoses, suckers and drum (as can be seen from Tables 12 and 13). Reference [25] states that some of the most popular fishing areas are located near the junction of the Red Lake River with the Thief River (e.g. - in the immediate vicinity of the dam). In addition, the most scenic portion of the river is described as being the 25 mile reach between Thief River Falls and Red Lake Falls.

The Red Lake River is also used for canoeing purposes and is "...one of the few canoeing rivers in Northwest Minnesota." [25] A dam has been in place at this section of the river since 1890; therefore portaging at this location has been necessary for a long time. In addition, increasing the capacity (output) at the dam will not obstruct the walkway (used by the citizens to cross the river) across the top of the dam.

All of the development alternatives proposed herein will have a minor (if any) impact upon recreational resources at the Red Lake River Dam.

J. Agency Contacts/Correspondence

Close coordination with public agencies is essential early in the developmental phases of the project to assure that regulatory requirements and acceptable policies become known. "Both beneficial and adverse effects of small hydropower development will be a function of project design and operation as well as the nature of the existing environment that will be altered. Successful mitigation of adverse effects associated with such development will depend upon (1) accurate prediction of the magnitude of adverse impacts and (2) early awareness of potentially significant environmental issues. Ecologists and environmental scientists must be consulted during the preliminary design phase of project development. By defining the relevant environmental issues at this stage, meaningful discussions can be held with all responsible and interested agencies and groups." [14]

It should be noted that mitigation of impacts of existing dam sites should be viewed in the context of an already perturbed environment [26]. Feasibility studies completed to date have validated this assumption: "The experience of our firm in conducting feasibility studies at three hydroelectric sites indicates that identifiable adverse environmental impacts associated with restoration of the three facilities are relatively minor." [12]

The various stage contact agencies, as well as letters of correspondence, are included on the following pages [27].

STATE AGENCIES TO BE CONTACTED FOR SMALL HYDROPOWER DEVELOPMENT

1. MINNESOTA DEPARTMENT OF NATURAL RESOURCES - Division of Waters

   a. Inquiries to the Director, Attn: Development Section

   b. EAW (Environmental Assessment Worksheet). Even if not mandatory, we strongly suggest that one be prepared by mutual cooperation within DNR. Purposes:

      - to give early and preliminary thought to any and all problems and benefits which may occur, and

      - to bring the project before the public early in development and avoid delays later in project.

   c. One permit may be issued to cover the concerns of:

      - work in public waters,
      - water appropriation,
      - dam safety - modification of dam,
      - water regulation & usage,
      - fish and wildlife habitat (including rare species),
      - recreation, and
      - water quality.

      The decision to issue a single permit is made on a site specific basis.

   d. Generally DNR requires permits for raising or lowering of spillway level, fluctuating water level, and discharges which are different than historical records, dam modification, dredging and disposal of dredged material (spoil), shore protection, riprap, shoreline excavation, partial or complete drainage, water level control structure, stream or channel enlargement, or relocation.

2. MINNESOTA POLLUTION CONTROL AGENCY

a. Inquiries to the Director, Attn: Permit Section - Water Quality

b. The 1977 Clean Water Act gives authority to the MPCA to certify hydropower projects. This MPCA Certification is a prerequisite for permitting by FERC, DOE, Coast Guard or any other Federal Agency issuing permits of this type.

c. The MPCA has authority to become the primary agency issuing NPDES (National Pollutant Discharge Elimination Systems) permits, replacing FERC, Corps, etc., but has not exercised this authority. They may possibly do so in the future.

d. Primarily concerned with water quality during construction and operation. These concerns include but are not limited to: maintaining minimum and constant flows, reaeration, thermal stratification dredging and downstream water supply.

e. The MPCA must also review all secondary consideration, such as downstream flooding, effects of fish and wildlife, etc., before issuing certification according to Minnesota Statutes, Part 116B.09, Subd. 2.

3. STATE PLANNING AGENCY (including Environmental Quality Board-EQB)

a. Power Plant Siting

- Certificate of site compatibility N/A to sites less than 50 MW

- Construction permit for transmission lines if:

  - greater than 200 kV
  - greater than 50 miles

b. Environmental Planning

Current Rules

<u>Actions Requiring Environmental Assessment Worksheet with Local Government as Responsible Agency:</u>

- An action that will eliminate or significantly alter a wetland of Type 3, 4, or 5 (as defined in U.S. Department of Interior, Fish and Wildlife Service, Circular 39, "Wetlands of the U.S.," 1956) of five or more acres in the seven-county metropolitan area, or of 50 or more acres outside the seven-county metropolitan area, either singly or in a complex of two or more wetlands.

Actions Requiring Environmental Assessment Worksheet with State Agency as Responsible Agency:

- Any new or additional impoundment of water creating a water surface in excess of 200 acres. (DNR)

- Construction of electric generating plants at a single site designed for, or capable of, operation at a capacity of 200 or more megawatts (electrical). (PCA)

- Construction of electric transmission lines and associated facilities designed for, or capable of, operation at a nominal voltage of 200 kilovolts AC or more, or operation at a nominal voltage of ± 200 kilovolts DC or more and of 50 miles or more in length. (EQB)

Proposed Rules:

- Impoundment of 160 acres or more

- Generating capacity 10-200 megawatts - require an EAW

- Generating capacity 200 or more megawatts - required an EIS.

c. EQB could also serve as staff agency and oversee the analysis of EAW and EIS if required.

X. REFERENCES

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APPENDIX

CORRESPONDENCE

ATLAS POLAR
COMPANY LIMITED

May 7, 1982

St. Anthony Falls Hydraulic Laboratory,
3rd Avenue South East, at the Mississippi River,
Minneapolis, Minnesota 35414

Attention: Mr. Robert Knowlton

Dear Mr. Knowlton:

Further to our telephone conversation yesterday morning, please find enclosed, literature describing the Hercules Hydrorake System.

As background, the Hercules was first developed in Sweden in the early 1960's and there are presently over 200 units in operation in Europe. Atlas Polar manufacturers in Toronto for the North American market, where machines have been in service since 1977. Listed below are three installations located in Wisconsin that you or individuals from the Power Company may wish to visit sometime in the future:

(1) Customer: Consolidated Papers, Wisconsin Rapids, Wisc.
Station: Stevens Point, Wisconsin 4800 KW, 6 units
Intake Width: 190 ft. Intake Depth: 20 ft.
In service date: October, 1980
Contact: Louis Pilsner (715) 422-3481

(2) Customer: Kaukauna Electric & Water, Kaukauna, Wisc.
Station: Old Badger Plant, Kaukauna
Intake Width: 107 ft. Intake Depth: 21 ft.
In service date: July, 1981
Contact: Frank Granberg (414) 766-5721

(3) Customer: Consolidated Papers, Wisconsin Rapids, Wisc.
Station: Wisconsin Rapids Generating Stn. 10,000 KW, 2 Units
Intake Width: 64 ft. Intake Depth: 27 ft.
In service date: September, 1981
Contact: Louis Pilsner (715) 422-3481

At this time, we can provide rough ballpark pricing for the rack widths and depths we discussed over the telephone. These prices are on an installed basis and do not include duty or taxes. In addition, this pricing covers the raking unit only. In other words, any automatic or mechanical means to remove debris from the deck should be discussed separately. Options include a transporter system discussed in the brochure, a continuous belt conveyor, or simply raking debris to the deck level and have and have maintenance personnel clear the deck at their convenience. Depth does not affect the prices below.

Cont'd...

Intake Width	1982 Price Installed (US Dollars)
(a) 8-1/2'; 10'; or 12-1/2'	$ 46,000.00
(b) 21'	$ 48,000.00
(c) 36'	$ 52,000.00

As we discussed, the above pricing assumes there are no overhead obstructions to interfere with installation or operation of the Hercules. In some cases, the machine can be programmed to move around certain obstacles. The other factor to consider is the proximity of the station to the racks. With an extreme rack angle, a close power house can present an obstruction as the booms tilts to enter the water. All these considerations would be discussed before firm pricing is provided.

Thank you for your interest in the Hercules, and should you have any questions, please do not hesitate to call or write. We look forward to hearing from you as your feasibility study proceeds further.

Yours very truly,

ATLAS POLAR COMPANY LIMITED

Bert Ander

B. E. Ander, P. Eng.
Product Manager
HERCULES HYDRORAKE SYSTEM

BEA/rc

Encl.

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
BOX 25, CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

DNR INFORMATION
(612) 296-6157

FILE NO.________

March 30, 1981

Robert Knowlton
St. Anthony Falls Hydraulic Laboratory
3rd Avenue SE @ Mississippi River
Minneapolis, MN 55414

Dear Bob;

I am enclosing some electrofishing field data on the river reaches on the Red Lake and Minnesota Rivers that you requested. On the Red Lake River, Station 4a is 4 miles upstream of Thief River Falls, Station 4b is 2 miles upstream of Thief River Falls, and Station 5b is 0.5 miles downstream of the Thief River Falls dam.

The data on the Fishook River was xeroxed from a watershed report and contains little fisheries information on the Fishook River itself.

If you have any further questions, please call or we can arrange another meeting when you return the data I loaned you.

Sincerely,

John W. Enblom, Aquatic Biologist
Division of Fish and Wildlife
Ecological Services Section

JWE:blt
Enclosures

MINNESOTA HISTORICAL SOCIETY
FOUNDED IN 1849
690 Cedar Street, St. Paul, Minnesota 55101 • (612) 296-6126

27 January 1982

Mr. John Gulliver
St. Anthony Falls Hydraulic Laboratory
3rd Avenue SE at Mississippi River
Minneapolis, Minnesota 55414

Dear Mr. Gulliver:

RE: Review of the historical significance of Anoka Dam (Anoka County), Fishhook River Dam (Hubbard County), Minnesota Falls Dam (Yellow Medicine County), and the Thief River Falls Dam (Pennington County).

MHS Referral File Number: M 992

Thank you for the opportunity to review and comment on the above project. It has been reviewed pursuant to responsibilities given the State Historic Preservation Officer by the National Historic Preservation Act of 1966 and the Procedures of the National Advisory Council on Historic Preservation (36CFR800).

This review reveals that we do not have sufficient information to make specific determinations of significance on the above dams. However, we can make the following observations based on the information we have received thus far.

1. To date, we have received no data on the Anoka Dam (Anoka County). We request the opportunity to assess the historic significance of the dam should any work be proposed or considered.

2. Review of the Fishhook River Dam in Park Rapids (Hubbard County) revealed conflicting information on the date of the dam's construction and its specific uses prior to hydro-electric conversion. Current information does not address what, if any, historical links the present dam has to the earlier 19th century dam constructed on the site. Further, additional photos will be needed to assess the current dam structure and any extant generator equipment.

From the information received thus far it appears that the Fishhook River Dam and Power retains reasonable integrity. If the project is to be continued, further research to assess its historical significance should be considered.

3. Further review of the Thief River Falls Dam (Pennington County) also depends on the receipt of additional information. Photographs in the SHPO file indicate that the power house retains reasonable integrity. However, it is necessary to determine if generating equipment remains and to assess the historical significance of the site area. Should any work be proposed or considered we request the opportunity for further review once additional information is received.

4. Review of the information on the Minnesota Falls Dam (Yellow Medicine County) indicates that the power house, operator's cottage, headgates, and original turbines have been demolished or removed. Although historically associated with one of Yellow Medicine County's early river town settlements, which is no longer extant, the integrity of the site has been compromised by the removal of the associated structures and equipment.

As stated before, should any of the above projects be considered for implementation, we request the opportunity to further review their historical significance. Prior to making a final determination, our office would like to review historic and current photos of the dams, as well as information detailing the dams' original construction, original use(s) by the area or community, and subsequent structural changes.

If you have any questions please do not hesitate to contact Dennis Gimmestad at 726-1171. Thank you for your attention to cultural resources in your planning process.

Sincerely,

Dennis A Gimmestad

for Russell W. Fridley
State Historic Preservation Officer

RWF/fr