FINAL REPORT ON
POTENTIAL HYDROELECTRIC POWER
MORA CANAL DROP

MASTER

TO
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
NO. EW-78-F-07-1760

BY
BOISE PROJECT BOARD OF CONTROL
BOISE, IDAHO

TUDOR ENGINEERING COMPANY
SAN FRANCISCO, CALIFORNIA

DECEMBER 1978

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December 12, 1978

Subject: Mora Canal Drop Feasibility Study

Gentlemen:

We are pleased to present this report on the hydro-electric power potential of the Mora Canal Drop.

The recommended project would consist of the installation of a 1900 kilowatt turbine and generator at the drop site. The Average Annual Energy generated would be 8,113,000 kilowatt hours.

The initial cost of the project would be approximately \$1,800,000. The annual cost, including amortization, would range between \$165,000 and \$180,000, depending on the financing methods adopted.

The cost of producing the power at the Mora Canal Drop would range between 20.3 mills/kwhr and 22.2 mills/kwh. The final figure will depend on the financing methods adopted.

The energy production curve closely matches the energy demand curve for the surrounding area. The Idaho Power Company has indicated a need for the power and has offered to purchase all power produced at the Mora Canal Drop for 26 mills/kwh, thus making the project feasible under any financing method adopted.

We therefore recommend that the Boise Project Board of Control proceed with the project and that discussions be initiated with potential power purchasers as soon as possible.

TUDOR ENGINEERING COMPANY

Tudor Engineering Company sincerely appreciates the opportunity to prepare this study. We believe that it is important to develop all economical small-scale hydro-electric sites where energy is presently being wasted. The Boise Project Board of Control should be commended for their action in initiating this study.

Very truly yours,

TUDOR ENGINEERING COMPANY

A handwritten signature in cursive script that reads "David C. Willer". The signature is written in dark ink and is positioned above the printed name and title.

David C. Willer
Principal Investigator

FINAL REPORT

MORA CANAL DROP

COOPERATIVE AGREEMENT

NO. EW-78-F-07-1760

TO

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE

BY

BOISE PROJECT BOARD OF CONTROL

NEW YORK IRRIGATION DISTRICT - BOISE, IDAHO

NAMPA AND MERIDIAN IRRIGATION DISTRICT - NAMPA, IDAHO

BOISE - KUNA IRRIGATION DISTRICT - KUNA, IDAHO

WILDER IRRIGATION DISTRICT - CALDWELL, IDAHO

BIG BEND IRRIGATION DISTRICT - NYSSA, OREGON

PREPARED BY

TUDOR ENGINEERING COMPANY

SAN FRANCISCO, CALIFORNIA

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I. INTRODUCTION

A. PURPOSE

The purpose of this report is to present the results of a study to investigate the feasibility of developing hydroelectric power at an existing canal drop structure on the Boise Project in Southwestern Idaho. It is intended that the information contained herein will form the basis of a decision whether or not to proceed with construction of the power facilities.

B. AUTHORITY

The study was authorized by an agreement between the Boise Project Board of Control ^{1/} and Tudor Engineering Company dated July 31, 1978. The majority of the funding for the report was provided by the United States of America acting through the Department of Energy under Cooperative Agreement No. EW-78-F-07-1760 with the Boise Project Board of Control.

C. SCOPE OF STUDY

This study covers the following primary objectives:

1. The recommended configuration and capacity of the hydroelectric facility.

^{1/} The Boise Project Board of Control is an entity formed under contracts between the United States of America, Department of Interior and five irrigation districts who are separate agencies of the state of Idaho and Oregon. The Districts are the New York Irrigation District, the Nampa and Meridian Irrigation District, the Boise-Kuna Irrigation District, the Wilder Irrigation District and the Big Bend Irrigation District.

2. The expected performance characteristics of the facility, including its peak power production, annual energy production and the anticipated project life.
3. The estimated capital cost and annual operation and maintenance costs of the facility.
4. The marketing potential for power produced at the site, and an estimated value of the power produced.
5. A financial and economic analysis of the project facilities including funding alternatives and benefit-cost ratios.
6. An initial assessment of the environmental and social impacts of the project, including the expected effect of the plant on operation of the canal system.
7. A description of necessary licensing requirements of local, State and Federal agencies.
8. A development schedule for putting power on line.

D. REPORT FORMAT

This report is presented in 11 chapters which contain discussions and present the data used and the results of the study. The discussion for each chapter is immediately followed by the related Tables and Figures. Plates are contained at the end of the report prior to the appendices.

E. ACKNOWLEDGEMENTS

Tudor Engineering Company is very appreciative of the assistance and cooperation extended by Mr. Ottis Peterson, Chairman, Power Supply Committee and by Mr. Royse Van Curen, Manager, Boise Project, and his staff during the preparation of this report. Without their timely assistance in conducting field surveys and collecting data, this report could not have been prepared.

II. EXISTING FACILITIES

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A. GENERAL

The Mora Drop structure is located in southwestern Idaho approximately 20 miles southwest of Boise on the Mora Canal. The general location is shown in Plate I. The purpose of the existing facility is to drop the flows of the Mora Canal a vertical distance of 36 feet, from the northern slope of Kuna Butte to the valley below. The canal flows range between 200 and 800 cubic feet per second (cfs) and provide irrigation water for approximately 70 square miles of farm land. The canal and existing drop structure are shown in Plate II.

The Mora Canal is part of a large canal system known as the Arrowrock Divison of the Boise Project, a development of the U.S. Bureau of Reclamation (U.S.B.R.). The Arrowrock Division provides for irrigation of approximately 200,000 acres of farm lands located to the west of Boise between the Boise and Snake Rivers. Of this total, the Boise Project Board of Control operates and maintains the canal system for 167,500 acres. The jurisdictional area boundary of the Boise Project Board of Control is identified in Plate I as "Boise Project Boundary". Most of the Board of Control land is located in Ada and Canyon counties, Idaho, but 1700 acres are located in extreme eastern Oregon.

The five irrigation districts comprising the Boise Project Board of Control have nearly repaid the entire cost of the Boise Project to the United States of America through the collection of water tolls on the land.

Farm lands within the Arrowrock Division produce most of the Nation's requirements for sweet corn seed. Other important farm products include sugar beets, corn, potatoes, onions, apples, hay, and range and dairy cattle.

B. SYSTEM DESCRIPTION

The overall system is composed of three upstream reservoirs on the Boise River, a downstream diversion dam, a canal network and one off-channel reservoir located within the Boise Project boundaries. The system layout is shown on Plate I.

Uppermost in the system is Anderson Ranch Dam and Reservoir on the South Fork of the Boise River approximately 60 miles upstream from Boise, Idaho. The earth fill dam is approximately 1,350 feet long at the crest with a maximum height of about 456 feet and a total active capacity of 464,200 acre feet.

Arrowrock Dam is located on the Boise River about four miles below the junction of the North and South Forks, and about twenty-two miles upstream from Boise, Idaho. This dam is a gravity arch structure having a height of 350 feet and a crest length of 1150 feet. The reservoir has a total capacity of 286,600 acre feet.

Lucky Peak Dam is located on the Boise River downstream from Arrowrock Dam approximately ten miles above Boise, Idaho. It is a project of the U. S. Army Corps of Engineers, primarily for control of destructive floods occurring along the main stem of the Boise River. Lucky Peak Dam is a rolled earthfill dam with a maximum height of 340 feet and an active storage of 280,000 acre feet.

The total storage rights to the districts comprising the Boise Project Board of Control in the three upstream reservoirs are 631,000 acre feet.

Two miles downstream of Lucky Peak Dam the 68 foot high rubble concrete Boise River Diversion Dam diverts the project flows into the Boise project canal system.

The New York Canal flows southwesterly from this point, eventually ending at Lake Lowell.

The Mora Canal branches from the New York Canal 26 miles downstream of the diversion point and the Mora Canal Drop is located twelve miles below the branch. The Mora Canal continues from this point towards Lake Lowell and the intermediate and surrounding farm land. The distance from the Mora Canal Drop to Lake Lowell is approximately 15 miles.

Below the Mora Canal Drop the canal continues to the west for 15 miles to the south side of Lake Lowell. The canal capacity decreases gradually from about 850 cfs just below the Mora Drop to around 250 cfs near Lake Lowell. Wasteways located at the southeast and southwest end of the lake (indicated in figure III as the "upper" and "lower" wasteway, respectively) can each divert up to 100 cfs from the Mora Canal. These flow into Lake Lowell, thus providing a supplementary means of conveying water to the lake.

Lake Lowell itself is an offstream storage reservoir with a capacity of 177,000 acre feet. It is formed by three earth fill dams ranging in height from 16 to 74 feet. The reservoir receives all of its water supply through the canal system.

Irrigation of farm land west of Lake Lowell is made possible by two canals which originate at the northwest end of the lake.

In total the Arrowrock Division includes a total of 677 miles of canals and laterals and 197 miles of drains. The larger canals of the system are shown on Plate I.

C. SYSTEM OPERATION

The three upstream reservoirs are filled during the spring period through operations based on runoff forecasts. Releases from storage for the downstream irrigation season are made primarily from May through September.

During the off season periods of March and April in the spring and October and November in the fall up to 1000 cubic feet per second is diverted via the New York Canal to fill Lake Lowell for the following irrigation season. Some of these Lake Lowell flows can also be diverted through the Mora Canal to augment the irrigation flows and gain additional power generation at the site. This capability will be discussed in more detail in Chapter V "Project Energy Production".

D. SITE DESCRIPTION

The existing facilities comprising the Mora Canal Drop are shown graphically on Plate II and in photographs on Figure II-1.

They consist of the Upper Mora Canal with an approximate capacity of 1100 cfs, a headworks structure with four gates and a weir that controls the flow of up to 300 cfs into the Waldvogel Canal, the Mora Canal Drop structure, a downstream stilling basin and the Lower Mora Canal with a capacity of 850 cfs.

The drop structure is composed of an inlet structure with three operating gates and three abandoned gate slots and a covered 13 foot by 6 foot rectangular drop structure 140 feet in length.

E. BOISE PROJECT HISTORY

The first farming activity in the Boise Valley began in the 1880 period, with the construction of numerous small private irrigation schemes. Among these was a small canal which was the predecessor of the New York Canal. The Boise Project had its beginning with the passage of the Reclamation Act of 1902, which enabled land owners to organize and petition for Federal assistance in developing irrigation systems. Initial Federal investigations began in 1902, and by 1906 construction of the Arrowrock Division of the Boise Project began. The Boise River Diversion Dam was completed in 1908, the New York Canal by 1909 and the Deer Flat Dams for Lake Lowell in 1911. Arrowrock Dam was completed in 1916, and at that time was the highest dam in the world. The structure was raised five feet to its current height in 1937 and the cost of this dam has now been entirely repaid by the water users. Anderson Ranch Dam was completed by the U.S.B.R. in 1946, and Lucky Peak Dam by the U.S. Army Corps of Engineers in 1955. The five irrigation districts in the Boise Valley, which form the Boise Project Board of Control were initially involved with this project, and have retained their interest to this day.

These are the Big Bend, the Boise-Kuna, the Nampa-Meridian, the New York and the Wilder Irrigation Districts.

Following construction of the irrigation system, the U.S.B.R. maintained control over the Arrowrock Dam and Reservoir and the Diversion Dam (as "reserved works"). Operations of Lake Lowell, the New York Canal and all other canals and laterals constructed by the Federal Government were turned over to the five irrigation districts, and agreements were made providing for repayment of construction costs to the Government for these "transferred works". In 1926, an organization was formed to operate and maintain the canal system for the five districts. This organization, which continues to operate the system today, is known as the Boise Project Board of Control. Board members are selected from each of the five districts from within their own organizations, and these directors constitute the Board of Control. The Board elects a Project Manager, who has charge of the operation and maintenance of the project and is responsible to the Board.

F. WATER RIGHTS

The Boise Project Board of Control has obtained appropriative rights for consumptive use to direct diversion of 265 CFS of Boise River water through a series of decrees ranging in priority date from 1864 to 1900. An additional 10,640 cfs of primarily flood flow rights was obtained through a number of later decrees by the U.S.B.R. for the project ranging in priority from 1900 to 1924. Through contracts with the USBR, storage rights in Arrowrock and Anderson Ranch Reservoirs total 631,000 acre feet, which coupled with natural flow rights, provide sufficient volume for just over one full year of normal canal deliveries.

The Boise Project Board of Control is currently preparing an application to the State of Idaho for non-consumptive use of water for development of power at the Mora Canal Drop.

6

MORA CANAL DROP CHUTE
AND STILLING BASIN

MORA CANAL DROP
STILLING BASIN

WALDVOGEL CANAL HEADWORKS
AND MORA CANAL DROP INLET

III. CONCEPTUAL DEVELOPMENT

III. CONCEPTUAL DEVELOPMENT

A. GENERAL

This chapter discusses the general development concept for the site and describes commercially available generating equipment that could be used for the plant. The installed capacity of the turbines and generators is determined and the most optimal configuration and type of equipment is selected.

B. OVERALL FACILITIES AND ALTERNATIVE OPTIONS

Hydroelectric power plants transform the energy of falling water into electrical energy. In general, a hydroelectric power plant consists of a dam or canal for producing the head (and often storage of water); an intake and penstock or flume for conveying the water to the hydraulic turbine; the turbine itself which is coupled to a generator; and the accessory electrical equipment required to provide the power to a transmission system.

Specifically, at the Mora Drop, the facilities will consist of a new headgate structure for the Waldvogel Canal to be located downstream of its present location; new gates for the existing chute, which will remain in place as an emergency bypass of the turbines; the power plant intake works with a conduit connecting to the turbine; the power plant itself; and outlet works that tie into the Mora Canal just downstream of the existing stilling basin.

Within this general conceptual development, the type of turbine and generator, the size and number of units and the configuration of the power plant and penstock still remain to be determined. Those items are covered below.

C. DESCRIPTION OF AVAILABLE TURBINES

Conventional turbine equipment which is commercially available is classified either as impulse or reaction turbines.

An impulse turbine is one having one or more free jets discharging into an aerated space and impinging on the buckets of the runner. The jet size increases as the head on the turbine decreases and for low head application the cost of the impulse turbines are not competitive with the reaction type. Impulse turbines generally become competitive with reaction turbines at heads above 1000 ft. The head range of this study is such that impulse turbines have been eliminated as a practical selection.

A reaction turbine is one which passes water under pressure over the fixed angular vanes of the runner, imparting rotation and torque to the generator shaft. The configuration of a reaction turbine consists of a water case, a mechanism for controlling the quantity of water and distributing it equally over the runner intake, and a draft tube.

There are two principal types of reaction turbines; Francis turbines and propeller turbine. The propeller turbines may have either fixed or adjustable blades and several different configurations of propeller turbines are commercially available.

A Francis turbine is one having a runner with a large number of fixed blades attached to a crown (top) and a band (bottom). The dimensional configuration of the runner is designed to suit the head conditions of the application. Designs are commercially available to suit head conditions ranging from 15 to 1500 ft. In general the Francis turbine is not competitive with the Propeller type below a head of about 60 ft. The head range of this study is such that Francis turbines have been eliminated as an economic selection.

A Propellor turbine is one having a runner resembling a propeller with a small number of blades, usually 4, 5 or 6, to which water is supplied in an axial direction. The blades are attached to the hub of the runner. The blade angle is adjusted to suit the head conditions of the application. Runners are available in either Fixed Blade or Adjustable Blade designs. The suitable head range of Propeller turbines is from 15 to 110 ft. This type of turbine is therefore economically suitable for this study.

Propeller turbines are available for vertical, slant or horizontal mounting. The vertical mounted configuration is known simply as a conventional propeller turbine. The horizontal and slant mounted units have been given trade names which describe the mechanical design such as Tube, Bulb and Straflo. These various types have certain differences both in performance, cost and civil construction costs.

The configuration of a vertical shaft propeller turbine in an open flume configuration and a scroll case configuration are shown on Plate II.

The conventional vertical Propeller turbine is historically the most widely used of the types considered by this study. These units are available with either fixed or adjustable blades. The adjustable blades permit higher efficiencies when operating above or below design head and when operating below full gate capacity. The propeller Turbine may have an open flume or a penstock and steel spiral case construction. In open flume construction, the wicket gate mechanisms are located within the water passageways and are water lubricated. This is sometimes the most economical configuration but the maintenance requirements are high. When a penstock is utilized rather than the open flume, a concrete or spiral scroll case under pressure is used to direct the water flow to the turbine blades. Both the open flume and scroll case configurations are shown on Plate II.

The "Tube" turbine consists of a propeller-type runner mounted in a circular water passage. Downstream of the runner, the turbine shaft passes through the wall of the draft tube at a shallow elbow, and is connected to the generator. The turbine drives the generator through a gearbox, by means of a long downstream shaft. The generator is thus located outside the water passages so that sealing arrangements are simple. The costs of civil/structural work for tube turbines tends to be greater than vertical shaft installation because of the requirement of separate main areas for turbines and generator. A tube turbine configuration is shown on Plate II.

For a "Bulb" turbine configuration the water passage and turbine runner are similar to those of the "Tube" turbine. However, the "Bulb" turbine differs from the "Tube" turbine in that the generator is integrally housed in a "Bulb" within the turbine passageway. The generator is thus situated in the

immersed upstream cone and is driven by a shaft from the turbine runner directly. The operating characteristics of the "Bulb" turbine are similar to the Vertical Propeller Turbine and efficiencies are approximately equal to the vertical unit. Powerhouse size requirements of the Bulb turbine offers a smaller plan area but a larger depth than the Tube turbine. Maintenance accessibility of the Bulb turbine is less convenient than that of both the Vertical and Tube Turbines. Down time for major repair would probably be greater. A Bulb Turbine configuration is also shown on Plate II.

The Stra-flow type of turbine is the development of Sulzer Bros. Ltd. of Switzerland. The turbine characteristics are similar to the Bulb turbine discussed above. The mechanical arrangement differs in that the rotor of the generator is attached to the rim of the runner. The rim of the runner has a seal which uses filtered water at a higher pressure than the turbine effective head. The generator operates in air outside of the passageway. The design has been successfully operated in Europe and would appear to offer cost benefit for certain size units. To date, none have been installed in the United States.

In addition to the impulse and reaction turbine, a proprietary design called the Ossberger Turbine is available for head ranges from 15 to 550 ft. The runner design is classified as a cross flow which derives energy from both impulse and reaction turbine principles. Water is forced through a rectangular cross-section and guide vane system and then through the horizontal runner blades. This flow pattern has a unique advantage of working out refuse such as grass and leaves and melting snow and ice which may be forced between the blades of the runner as the water enters. Any quantity

of water from 16 percent to 100 percent of the design flow is usable with optimum efficiency. The cost at lower heads is generally higher than Propeller Turbines. An Ossberger configuration is shown on Plate II.

D. DESCRIPTION OF AVAILABLE GENERATORS

Generators can either be of the synchronous or induction type. Induction generators are often considered more practical for the smaller turbine-generator installations because they cost less and require less maintenance. They require no excitation and need only a squirrel-cage rotor which uses no wire windings or brushes. Furthermore, they do not run at exact synchronous speed, and complex equipment is not needed to bring them on line. They cannot be used to establish frequency, however, and must be connected to a system with synchronous generators, as they take their excitation from system current. The generators produce kilowatt-hours with a high degree of efficiency.

Synchronous generators are usually three-phase star or Y-connected machines with one end of each winding connected together in common, the other ends being used as line terminals. The alternating-current synchronous generator, or alternator, delivers its induced alternating current directly to the external circuit and is used where transmission is to be sent over long lines. The alternating current can be transformed to the desired transmission voltage.

For the purpose of this study, the generators considered are the more costly synchronous type because it is thought that the Idaho Power Company, the potential power purchaser, may not desire an induction-type generator. The use of an induction generator, if it meets the approval of all parties, should be reconsidered in final design studies.

E. SELECTION OF TURBINE

In selecting the turbine for a potential site, the size and number of units must be determined along with the use or non-use of adjustable blades for the turbine runner.

The selection of turbine size is primarily a matter of economics. The larger the turbine size, the larger the flow that can be accommodated and the more energy that can be generated but the higher the cost. A series of marginal cost comparisons between alternative turbine sizes are therefore made in selecting the turbine size. This is based on the design hydrograph (see Figure V-2) and the hydraulic head.

A similar process is used in selecting the number of units. Every turbine is most efficient within a certain range of flows, with decreasing efficiency occurring beyond this range. Consequently, more power can usually be generated if two or more small turbines rather than one larger turbine are selected. For example, two turbines, each rated for 50 percent of the design flow, may produce more power throughout the season than one turbine rated at 100 percent of the design flow but will generally have a higher installed initial cost.

An additional turbine alternative to be investigated is the use of a fixed blade propeller runner versus an adjustable propeller blade runner. Adjustable runners are able to vary the angle of the propeller elements to the flow, while the fixed blades cannot. Fixed blade runners are much more economical than an adjustable blade runner but operate over a much narrower range of efficiency than adjustable blade units. The principle is similar to comparing the power output and operating efficiency of a machine such as an automobile with

and without a gear shift. Again, the comparison is a matter of economics and is accomplished by a series of marginal cost comparisons.

In assessing the number and size of units, and the use of adjustable or fixed runners for the Mora Canal Drop, the results indicated that the optimal installation for the site would be one unit of 1900 kw with adjustable blades. This criterion was then adopted in comparing the various types of turbines as will be covered below.

F. SELECTION OF RECOMMENDED PLANT CONFIGURATION

In selecting the type of turbine and corresponding plant configuration, the general methodology used was to first solicit estimates for a single 1900 kw turbine and generator from the various manufacturers. After the estimates were received, a preliminary design of the required civil and structural works for each was then performed. The total cost was then determined by adding the mechanical and electrical cost to the corresponding civil and structural costs and the totals were then compared.

Letters of inquiry were initially sent to the following manufacturers:

- 1- James Leffel Co. - Vertical Shaft Propeller Turbine
(U.S.A)
- 2- Allis Chalmers Co. - Tube Turbine
(U.S.A.)
- 3- Sanden Co. - Tube Turbine
(Norway)

- 4- Charmilles Corp. - Bulb Turbine
(Switzerland)
- 5- Stapenhorst Corp. - Ossberger Turbine
(Canada/Germany)
- 6- Escher Wyss - Straflo Turbine
(Austria)

Reply letters with estimates were then received from the James Leffel Co, Allis Chalmers, Sanden, and Charmilles. A telephone estimate was later received for two 1000 kw Ossberger units (rather than a single 1900 kw unit) from the Stapenhorst Corp. No reply was received from Escher Wyss for a Straflow turbine.

Civil and structural designs were then prepared for each estimate received. The James Leffel Co. submitted estimates for vertical shaft propeller turbines in both the open flume and concrete scroll case configuration. Tube turbine estimates were received from both Allis Chalmers and Sanden.

In an additional alternative comparison in the selection process, a steel penstock was compared with a cast-in-place concrete conduit. Since the hydraulic head is very low in this instance a cast-in-place concrete conduit proved to be the most economical configuration and was therefore used for all configurations where a penstock was necessary.

The results of the cost comparison for the various turbine configurations are shown in Table III-1 where the civil and mechanical/electrical costs are summarized and compared. The corresponding configurations are shown on

Plate III. The costs shown do not include other costs which would be common to all installations such as transmission line, engineering or administration costs. These are covered in Chapter VII where the total estimated project costs are presented.

The results of the cost comparison showed that the vertical shaft propeller with concrete penstock and scroll case had the lowest overall cost. However, the open flume vertical shaft propeller turbine and the tube turbine configuration were both very close (1.2 percent and 1.3 percent higher respectively).

It should be noted at this point that one unknown factor is the amount of rock excavation associated with open flume configuration. Outcroppings of basalt exist in the general vicinity and if basalt is encountered in the larger excavation associated with this configuration, the estimated cost would be considerably increased.

It was therefore judged that the vertical shaft propeller turbine configuration and the tube turbine were effectually equal and it would not be known until actual firm bids were received which configuration was actually lower in cost.

The original intent of this section had been to determine the most economical configuration and then to proceed with a more detailed layout and cost estimate for the selected configuration.

Since the cost results were effectually equal, and since the efficiencies and power outputs are the same, it was decided that both detailed configurations of the two would be presented. The details are covered in the following chapter.

TABLE III - 1

COST COMPARISON OF ALTERNATIVE
POWER PLANT CONFIGURATIONS

COSTS			
CONFIGURATION	CIVIL	MECH/ELEC	TOTAL
-Vertical Shaft Propeller w/Open Flume Design	\$460,000	830,000	1,290,000
-Vertical Shaft Propeller w/Conc. Penstock & Scroll Case	474,000	799,000	1,273,000
-Tube Turbine	434,000	855,000	1,289,000
-Bulb Turbine	519,000	1,374,000	1,893,000
-Ossberger Turbine	524,000	853,000	1,576,800

IV. RECOMMENDED DEVELOPMENT

IV. RECOMMENDED DEVELOPMENT

A. GENERAL

This chapter presents a detailed discussion of the proposed powerplant configuration for the tube turbine and the vertical shaft propeller turbine alternatives and the various new features to be constructed. The anticipated operating modes (or conditions) are described and pertinent design assumptions are presented.

B. DESCRIPTION

The recommended project development is presented on Plate III. As shown and as briefly described in the previous chapter, the development would consist of the installation of a 1900 kilowatt generator and the necessary modifications and new construction of control and conveyance facilities to accomplish this installation. This would consist of a new headworks structure for the Waldvogel Canal, new gates on the existing Mora Canal Drop, an inlet structure for the penstock, a concrete penstock and a powerhouse with the turbine generating and station electrical equipment. More detailed descriptions of these features are presented below.

1. Waldvogel Canal Headworks Structure

The existing headworks structure will be removed ~~and~~ and replaced with a new structure located approximately 75 feet downstream of the existing structure. The new structure will serve both as a canal headworks structure to control flows into the Waldvogel Canal and as a check

structure to divert the Mora Canal flows into the power facilities of the existing Mora Canal Drop.

2. Existing Mora Canal Drop

The existing Mora Canal Drop will remain to serve as an emergency bypass of the proposed power generating facilities. However, to accomplish this purpose some modifications will be necessary. The drop structure itself is presently in fair condition but six new slide gates with both manual and automatic opening features will be installed.

3. Penstock Inlet Structure

The Penstock Inlet Structure will be installed approximately 40 feet downstream of the existing Waldvogel Canal Headwork Structure. A trash rack and stop log grooves will be provided. Gates will not be necessary since the flow through the power plant will be controlled by the adjustable propeller blades, and /or wicket gates or butterfly valve located at the turbine. Should it become necessary to repair the penstock during the period of the canal irrigation season, the penstock and power production facilities can be isolated from the canal flows by installing stoplogs in the grooves provided. Such use is, however, expected to be infrequent.

4. Concrete Penstock

The penstock will consist of a square cast-in-place concrete box 8 feet by 8 feet. As previously mentioned, a concrete penstock was compared with a steel penstock

and was found to be considerably less expensive. A circular penstock would have less volume and would be slightly more hydraulically efficient but would require more costly forming.

5. Powerhouse and Generating Facilities

As shown on Plate III, two alternate powerhouse configurations are presented, a tube turbine alternate and a vertical shaft propeller turbine alternative. The alternative generating equipment has been described in the previous chapter and will not be further covered.

Either alternate will be installed in an enclosed powerhouse. The plant will be unattended and will run automatically with only periodic maintenance required. Remote monitoring of power output and facility status will occur at the power purchasers' operating center. Alarms will be rerouted to an operator's center or residence for action in an emergency situation.

6. Station Electrical Equipment

Station electrical equipment will include controls, switch gear, circuit breakers, a transformer, battery equipment and lights. The batteries and battery charger and the main control board will be installed inside the plant. All other equipment will be installed in a substation area located adjacent to the plant.

7. Transmission Line

A transmission line will be constructed to convey the electrical energy to Idaho Power Company's Bowmont

substation which is located approximately 5 miles southwest of the Mora Canal Drop. (see Plate I). The configuration will be a single pole, three wire line on 200 foot centers. The transmission will be at 69 kv.

C. FLOW CONTROL AND OPERATING MODES

Provisions for several operating conditions were considered during the conceptual design phase. These were the normal, emergency, and repair conditions. Details of these conditions are presented below:

1. Normal Operating Conditions

During the normal operating mode of the facilities all Mora Canal flows, down to a minimum of 250 cfs, will pass through the power plant. If conditions such as an extremely low water year or when long-term irrigation flows would drop below 250 cfs, the plant would be shut down and the flow would be diverted through the existing Mora Canal Drop.

2. Emergency Operating Conditions

During the normal operating condition described above when the plant is operating at full capacity, an instantaneous plant outage could occur. This would be an "emergency" condition where the generator output would be rejected by the system grid and the wicket gates (for the propeller turbine) would automatically close. At the same time the gates at the Mora Canal Inlet structure would automatically open and the flow would thus bypass the power plant. While this condition is possible and must therefore be anticipated, it will be of very short duration and would occur very infrequently.

3. Repair Condition

During the normal operating season, repairs could be necessary for some power plant facilities. In this case the plant would be normally shut down and the Mora Canal Drop would be normally opened and the plant would be bypassed as in the emergency condition described above. This condition also is expected to occur only very infrequently. All normal maintenance would be performed in the off-irrigation season (mid November to mid March) when all facilities were shut down. It is anticipated that preventive maintenance procedure will make unanticipated breakdowns unlikely.

V. PROJECT ENERGY
PRODUCTION

V. PROJECT ENERGY PRODUCTION

A. GENERAL

Determination of the energy production of a hydro-electric plant first involves determining the annual flow pattern at the site and secondly, performing computations to determine how much power a given turbine can generate from that flow. In this chapter, the basic hydrology of the Mora Canal is described, and an average flow pattern for the Mora Drop is presented. The energy and power computations are then described and the power study results tabulated.

B. DEFINITIONS

Several terms commonly used in power studies need to be explained, since they are necessary for the discussion which follows. These terms, which are defined below, include energy, power load curve, base load, peak demand, firm and secondary power, hydraulic head and turbine efficiency.

1. Energy

The classical definition of energy is the ability to do work. Both energy and work are measured in foot pounds; electrical generation and usage is measured in kilowatt-hours.

2. Power

The classical definition of power is rate of work or work done in a specified time. In electrical gen-

eration and usage the usual units of power are kilowatts or megawatts (1000 kilowatts).

3. Load Curve

The load curve for an electric utility is a plot of power demand versus time in hours, days, weeks or months of the year.

4. Base Load

Base load is that portion of the load curve where demand is continuous or nearly continuous 100 percent of the time.

5. Peak Demand

Peak demand is the maximum demand in kilowatts for a given period. For example, the annual peak demand is the maximum demand in kilowatts that occurs within a given year; the daily peak demand is the maximum demand in kilowatts that occurs within a given day.

6. Firm Power

In marketing the energy from a hydroelectric project, the seller cannot assume delivery of any more power than is continuously available in minimal or critical water years. This power on which delivery can be assumed, even under worst-case circumstance, is called firm power.

7. Secondary (Non-Firm) Power

Power other than firm power produced by a particular installation is called non-firm (or secondary) power.

8. Hydraulic Head

The total hydraulic head available to a turbine refers to the difference in elevation between the water surface in the reservoir or forebay and that of the downstream tailwater. In this report "hydraulic head" will be shortened to "head".

9. Turbine Efficiency

Turbine efficiency refers to the ratio between the actual power output of the turbine and the theoretical power output for a "perfect" turbine. Efficiency can refer to the turbine by itself, or to the plant as a whole, including the generator and any gear box, clutch or similar unit. In this report, efficiency refers to the power production of the plant as a whole.

C. HYDROLOGY

In power studies for hydroelectric projects, the accuracy and dependability of the study ultimately rests on the hydrologic data used and how well this data is likely to indicate the future conditions which can reasonably be expected. Ideally, a long term record (25 to 50 years) is available, and, while the future cannot be predicted for any given years, the future average can reasonably be expected to be close to the long-term past average.

In the case of the Mora Canal, detailed flow records are available only for the period of 1972 to 1977. However,

long term average data is available for the total area water supplies and this data indicates that the five-year period of 1972 through 1976 is very close to the long-term average. It is therefore felt that using this period of record would be indicative of the long-term average values which could reasonably be expected to occur in the future.

Figure V-1 indicates the project water deliveries in acre feet per season for the entire Boise Project service area for the Period of 1926 to 1977. Examination of this graph shows that annual diversions have varied greatly during the period 1926 to 1961, but since that time have steadied considerably. This steadying effect is partly due to completion of Anderson Ranch Dam in 1946, which produced a significant volume of additional storage for the project and partly due to more efficient operation of the reservoir system by the agencies involved, as spring runoff forecasting procedures have greatly improved. Also, application by the Boise Valley farmers has smoothed out over the years, reflecting more efficient irrigation practices.

This figure indicates that the period 1972 through 1976 was very close to the long-term average project water deliveries and can therefore be reasonably expected to indicate future average deliveries as well. Calculations indicate that the annual Mora Canal diversion during the period 1972 to 1976 period averaged three percent over the 51 year median flow from 1928 to 1978.

It should be noted that the severe drought year of 1977 was not used in the five year "average" period. During 1977 Mora Canal Diversions were only 71 percent of the Long-term (51 year) median flow. According to an examination of the data available for the Boise River Twin Springs gauge,

1977 was by far the lowest of any year on a record dating back to 1912. A frequency analysis of the data indicates that the return interval of this drought is approximately 200 years.

From the available daily flow records for the Mora Canal and Waldvogel Canal, average flows through the Mora Canal Drop were computed for each week for the year 1972 through 1976.

Based on discussions with the Boise Project Board of Control, it was determined that by a modest change in canal operating practice, more than historic flows can be conveyed in the Mora Canal. On the average, 250,000 AF of irrigation water per year is delivered to Lake Lowell through the New York Canal during the period of March through November. Because of the two Mora Canal wasteways that discharge into Lake Lowell, some of this New York Canal flow could be diverted into the Mora Canal at its headgates. This water would then flow through the Mora Drop turbine, continue in the canal to near Lake Lowell, and be diverted into Lake Lowell through the two wasteways. Since the canal itself has a capacity of only 250 cfs near the upper wasteway, this figure represents the greatest amount of water that may be conveyed to Lake Lowell through the Mora Canal. During the peak irrigation period of July through late August, the full 250 cfs capacity of the Mora Canal near Lake Lowell is needed to deliver water to irrigators along the canal and therefore no additional flow to Lake Lowell is possible during this period. Thus, Mora Canal flows could be increased by up to 250 cfs in spring and fall, ranging down to near zero during July through mid-August. The total annual flow over the Mora Drop could by

this change in system operation be increased by 15-20 percent each year, extending the length of the power generation season.

If the Mora Drop power plant is constructed, the Board of Control intends to change their operating practice to take advantage of this additional flow. Consequently, the flow schematics used for the power studies in this report assumes this change will be made. The modified flow pattern is shown in figure V-2 along with the historical average flows. The outer limits of this curve were therefore utilized for the flows to calculate the power production of the Mora Canal Drop.

D. STUDY METHODOLOGY

Power production by any hydraulic turbine is a function of the installed capacity, the turbine and generator operating characteristics, the flow passing through the turbine, and the net head through which the flow passes.

As previously discussed, the installed capacity of the installation was assumed to be a 1900 kw tube or vertical shaft propeller turbine.

The operating characteristics of the turbine and generator are expressed in terms of efficiencies. At flows below the design value for the unit, the efficiency of the turbine and generator is relatively low. Efficiency climbs as the flow increases, reaching its peak at a flow rate slightly below the design discharge. For flows higher than this peak efficiency point, the turbine-generator efficiency drops. Efficiency also varies somewhat with the hydraulic head available: it decreases rapidly for heads below 50 percent of the

design value, increases slowly as the head rises from 50 percent to the design head, and remains fairly constant above the design head.

The power output of each size and type of turbine for varying hydraulic head and flow conditions can be plotted on graphs known as performance curves. By comparing these curves, it can be seen that performance differences are fairly minor for different turbines of the same general design. All variable-pitch propeller turbines, for example, including both vertical shaft and tube turbines, have very similar performance characteristics. For this reason, feasibility-level power studies can be conducted using a typical performance curve for the type of turbine considered, rather than running separate power studies for each turbine to be evaluated.

The performance curve used to evaluate power production of the tube and vertical shaft turbines for the Mora Drop site is shown in Figure V-3. This curve was plotted from data compiled by the I.P. Morris Hydraulic Laboratory in Eddystone, Pennsylvania, based on the performance of a number of variable-pitch propeller turbines.

The flows assumed to pass through the turbine and generator are shown as the outer limits of the graph presented on Figure V-2. This figure was discussed earlier in the chapter. The turbine efficiencies are such that no generation was assumed for flows less than 250 cfs or greater than 750 cfs. When flows greater than 750 cfs occur, it was assumed that the excess would bypass the power plant through the existing Mora Canal Drop Structure.

The net hydraulic head is obtained by assuming a constant upper water level in the upper Mora Canal, a friction loss as a function of flow through the penstock and powerplant and a tail water elevation which is a function of the Lower Mora Canal discharge. The resulting graph of net head versus flow is presented on figure V-4.

The power and energy production for the Mora Canal Drop was then computed using the 1900 kw of installed capacity, the performance curve of Figure V-3, the flow of Figure V-2 and the net head of Figure V-4.

E. STUDY RESULTS

The average monthly power and energy production for the operating season are shown by two-week periods in Table V-1 and are plotted on Figure V-5 and V-6 respectively. Total annual energy production is expected to average 8,113,000 kwh based on an average operating season from March 16 through November 15 using the historical average flows and the additional flow to Lake Lowell. Average weekly power production will range from 638 kw in March and November to 1900 kw during the peak irrigation season in July and August. Using the historical flows only, the average annual energy production is 6,612,000 kwh based on an operating season of April 16 through October 15.

The results of a power study, conducted for the 1977 irrigation season indicates that during any rare drought of this magnitude, annual energy production will total about 4,100,000 kwh or 57 percent of the average production. However, it is not likely that another drought as severe as the 1977 season will occur within the economic lifetime of the Mora Drop power plant.

TABLE V - 1
AVERAGE MONTHLY POWER AND ENERGY

Period	<u>Historical Flows Only</u>		<u>Historical Flows w/Lake Lowell Flows</u>	
	Average Power (kw)	Average Energy (kwh)	Average Power (kw)	Average Energy (kwh)
3/16 - 3/31	0	0	684	263,000
4/1 - 4/15	0	0	905	309,000
4/15 - 4/30	902	324,000	1083	389,000
5/1 - 5/15	1610	578,000	1691	607,000
5/16 - 5/31	1687	648,000	1700	653,000
6/1 - 6/15	1559	562,000	1653	596,000
6/16 - 6/30	1777	636,000	1777	636,000
7/1 - 7/15	1900	684,000	1900	684,000
7/16 - 7/31	1900	730,000	1900	730,000
8/1 - 8/15	1900	684,000	1900	684,000
8/16 - 8/31	1824	701,000	1824	701,000
9/1 - 9/15	1501	544,000	1501	544,000
9/16 - 9/30	1111	400,000	1178	424,000
10/1 - 10/15	336	121,000	1064	383,000
10/16 - 10/31	0	0	684	263,000
11/1 - 11/15	0	0	684	247,000
TOTAL		6,612,000 kwh		8,113,000 kwh

SOURCE:
BOISE PROJECT BOARD OF CONTROL
ANNUAL REPORT FOR 1977

MORA CANAL DROP
HYDRO GRAPH

FIGURE

V-2

NOTES:

$N_s = 138$

H_R = SELECTED DESIGN HEAD

KW_R = RATED CAPACITY AT H_R

Q_R = DISCHARGE AT KW_R AND H_R

E_R = EFF. AT $KW_R = 1.0\%$ LESS THAN E_P

E_P = PEAK EFF. = EFF. AT $0.80 KW_R$

E_G = GENERATOR EFF.

NOTE:
INCLUDES PENSTOCK LOSSES

NOTE:
INSTALLED CAPACITY = 1900 kw

MORA CANAL DROP
AVERAGE MONTHLY POWER

FIGURE

V-5

MORA CANAL DROP
AVERAGE MONTHLY ENERGY

FIGURE

v-6

VI. VALUE OF
HYDROELECTRIC POWER

VI. VALUE OF HYDROELECTRIC POWER

A. GENERAL

Having established the amount and pattern of the hydroelectric power production at the Mora Canal Drop, it now remains to determine the value of that power. This chapter demonstrates the area-wide need for additional future power supplies and identifies the potential power customer. The unit value of the power is discussed and using this value and the information concerning average annual power production, the value of the average annual power production is determined.

B. MARKETING POTENTIAL OF POWER PRODUCED

The power purchaser for the project is expected to be the Idaho Power Company, an investor-owned utility. Appendix A contains a letter from Idaho Power indicating their firm interest in purchasing the power to be generated at the Mora Canal Drop.

The Idaho Power Company serves much of southwest and south central Idaho, a small portion of eastern Oregon and a very small area in northern Nevada. In 1975, the Company's system, a combined hydro-thermal base, consisted of 16 hydro plants, a combustion turbine plant, and a share in the ownership in a coal-fired plant located in Wyoming. The total installed capacity in 1975 was 2,044,000 kw.

Consumption trends within the service area of the Idaho Power Company have been marked by rapid growth in the recent past and similar growth is expected to continue in the future. Figure VI-1 shows the forecasted load growth

from 1974 for the high, most probable, and the low estimate growth expected. ^{1/}

The monthly demand pattern is presented on Figure V-2 which shows the estimated monthly loads for 1980 and 1990. The estimated average annual Mora Canal Drop power production is also plotted on Figure VI-2 to show the close match between the production pattern and the demand pattern.

Idaho Power Company is attempting meet their expected growth in demand by new construction and participation in several different projects. For several years it has been seeking authorization to construct a 500,000 kw coal-fired plant in Southern Idaho. A request to construct the Pioneer Unit near Boise was turned down by the Idaho State PUC due to environmental considerations in 1976. A new application is currently pending for a site near the southern Oregon-Idaho border.

In Wyoming, at the Jim Bridger Power Plant, approval of a proposed fourth generating unit has been granted and will increase their one-third share of the plant's production from 500,000 to 667,000 kw. In Nevada they will soon be getting 125,000 kw from the coal-fired Valmy Plant.

The Company is also seeking to expand their capacity by adding several new hydroelectric facilities. An expansion of peaking capacity by adding a fifth unit at Brownlee Dam is

^{1/} Arthur D. Little, Inc. "Idaho Power Company's Need For Additional Generating Capacity" Final Report to Idaho Public Utilities Commission, February 1976.

now under construction. This unit will add approximately 290,000 kw of peaking capacity throughout the year. Other hydro projects being considered currently include construction of a series of run-of-the river dams along the Snake River in south central Idaho, with total installed power capacity totalling around 250,000 kw. Much of this capacity, however, would not be available during the summer. They are also negotiating with the State of Idaho to purchase the power to be generated by adding a 3000 kw generator at Barber Dam in Southern Idaho.

A comparison of future energy supply and demand is somewhat difficult since it cannot be predicted with certainty either how much new generating capacity will be brought on line or exactly what the demand will be. However, some estimates using reasonable assumptions can be made.

Figure VI-1 shows the annual forecasted energy supplies with and without a new 500,000 kw plant in Southern Idaho but with the thermal plants and hydroelectric plants mentioned alone. The graph shows substantial deficits beginning in 1982 if such a plant is not on line by April 1981. Since a plant of this type and size requires a lead time of about 5 years from the time of approval to facility completion, and since no approval has yet been granted, it can be reasonably be concluded that some energy deficits may well occur in the 1980's in the Idaho Power Company's Service Area.

In summary, there is a documented need for additional power in Southern Idaho in the future, particularly during the summer peaking period when power from the Mora Drop will be available. While a 1900 kw power plant at the Mora Drop will not by itself make much of an impact in the forecasted power deficits, a number of small plants such as the Mora Canal Drop Plant could have a noticeable effect.

C. UNIT VALUE OF POWER

The "economic value" of hydroelectric power can be taken to be the least cost of alternative power. Since the power produced at Mora Canal is not firm power in the traditional definition (since it cannot be guaranteed to be available 100 percent of the time) it has a value only as non-firm or secondary hydroelectric energy. However, as shown on Figure VI-2, the production pattern closely matches the peak area demand pattern and a case can therefore be made that the energy from the Mora Canal Drop is a form of firm energy since equivalent firm energy would have to be supplied if the Mora Canal Drop energy was not utilized. A very conservative approach would be to consider that the economic value of this energy is equal at a minimum to the cost of fuel oil utilized to generate power at a conventional oil-fired generating station.

The selling price, or "financial value", of the power is also important. The financial value is the price at which the developer of the power source would sell the power to a power purchaser. The financial value must be greater than the development cost, or the project is economically unfeasible. Similarly, the selling price must be less than the economic value, or the purchaser would have no incentive to buy the power. Thus, if the power is to be sold to a power purchaser, the financial value must be less than the economic value.

Initial discussions have been held with the Idaho Power Company regarding purchase of the Mora Canal Drop power production. They have indicated their firm interest in the project in a letter to the Board offering to purchase all the power produced at a price of 26 mills per kwh. A copy of this letter is included as Appendix A.

Experience on similar projects throughout the western states indicates that 26 mills/kwh is a reasonable financial value for the project power. Tudor Engineering Company has recommended to the Boise Board that this is a fair price around which to structure a power purchase agreement.

The unit value of power for the Mora Canal Drop will therefore be taken as 26 mills per kwh for all economic and financial analyses.

D. PROJECT POWER VALUE

In Chapter VI, it was shown that the average annual energy production at the Mora Canal Drop was estimated to be 8,113,000 kwh. Combining this figure with the financial value of 26 mills per kwh yields an estimated average annual Project Power Value of \$210,938.

MORA CANAL DROP
PEAK DEMAND FOR
IDAHO POWER COMPANY

FIGURE

PROJECTED MONTHLY AVERAGE LOADS OF
IDAHO POWER COMPANY AND AVERAGE
MONTHLY POWER GENERATION AT MORA
CANAL DROP

FIGURE

**MORA CANAL DROP
ANNUAL ENERGY SURPLUS/DEFICIT,
AVERAGE MW**

FIGURE

VI-3

VII. PROJECT COSTS

VII. PROJECT COSTS

A. GENERAL

The project costs consist of the initial capital costs and continuing annual costs. This chapter presents those estimated costs and the underlying assumptions.

B. INITIAL CAPITAL COSTS

The initial capital costs consist of construction costs and the interest during construction.

The construction costs are summarized in Table VII-1A for the vertical shaft propeller turbine alternative and Table VII-1B for the alternative tube turbine. The detailed cost estimate from which the summaries were derived are presented in Appendix B-1 and B-2. These cost estimates are based on recent bid prices for similar construction work and direct quotes from various equipment manufacturers. In addition, since it is the intent of the Boise Board to construct as much of the project as possible with their own work force, the concrete price used in the estimate of \$70 per cubic yard was furnished by Mr. Royse Van Curen, the Boise Board Project Manager.

The costs for the vertical shaft propeller turbine and the tube turbine are both presented because the total costs were extremely close and the purpose is to illustrate both the closeness and the differences in the two cost estimates. However, on all further analyses, the cost estimates for the lowest cost alternative, the vertical shaft propeller alternative will be used.

The engineering costs are presented in Table VII-2. The necessary engineering activities consist of an environmental impact assessment, the final FERC application, surveys and soils investigations, miscellaneous permits, contract plans and specifications and construction management.

The administrative costs are also shown on Table VII-2. They consist of administrative efforts by the Boise Board staff, and fees for the financial consultant and the bond counsel.

The total initial costs are summarized in Table VII-3 which also indicates the interest during construction. As shown, the total initial cost is estimated to be \$1,783,750.

C. ANNUAL COSTS

The annual costs for the project will consist of a bond or loan repayment cost and the operation and maintenance costs.

The bond or loan repayment costs depend on the source of the funds, the length of repayment time and the interest rate. These are financial matters and will be discussed in the following chapter.

The estimated annual operation and maintenance costs are shown in Table VII-4. They include insurance, manpower costs, interim replacement costs (for miscellaneous repairs during the life of the facility) and general expenses. As shown, the Annual Operation and Maintenance Costs will total \$24,700 per year.

TABLE VII - 1A
CONSTRUCTION COST SUMMARY ^{1/}
PROPELLER TURBINE ALTERNATE

<u>Acct. No.</u> ^{2/}	<u>Cost Item</u>	<u>Amount</u>
330	Land & Land Rights	\$ 2,000
331	Structures & Improvements	166,750
332	Reservoir, Dams and Waterways	226,000
333	Waterwheels, Turbines and Generators	568,000
334	Accessory Electrical Equipment	105,000
335	Miscellaneous Power Plant Equipment	53,000
355	Transmission Line	<u>100,000</u>
	Subtotal	1,220,750
	Contingencies	<u>153,000</u>
	Total Construction Cost	\$ 1,373,750

^{1/} See appendix B-1 for detailed construction estimate

^{2/} FERC cost account no.

TABLE VII - B
CONSTRUCTION COST SUMMARY 1/
TUBE TURBINE ALTERNATE

<u>Acct. No.</u> <u>2/</u>	<u>Cost Item</u>	<u>Amount</u>
330	Land & Land Rights	\$ 2,000
331	Structures & Improvements	145,700
332	Reservoirs, Dams and Waterways	214,000
333	Waterwheels, Turbines and Generators	629,000
334	Accessory Electrical Equipment	95,000
335	Miscellaneous Power Plant Equipment	53,000
355	Transmission Line	<u>100,000</u>
	Subtotal	\$ 1,238,700
	Contingencies	<u>141,300</u>
	Total Construction Cost	\$ 1,380,000

1/ See appendix B-2 for detailed construction estimate
2/ FERC cost account no.

TABLE VII - 2
ENGINEERING AND ADMINISTRATIVE COSTS

ENGINEERING COSTS*

Environmental Impact Assessment	\$ 20,000
Final FERC Application/Approval (Minor)	15,000
Surveys and Soil Investigation	10,000
Miscellaneous Permits	5,000
Contract Plans and Specifications	125,000
Construction Management ^{1/}	<u>101,000</u>
Total Engineering Costs	\$276,000

ADMINISTRATIVE COSTS (BOISE BOARD)

Administration	\$ 14,000
Financial Consultants	25,000
Bond Counsel	<u>30,000</u>
Total Administrative Costs	\$ 69,000

1/ One Resident Engineer and office support for shop drawings

TABLE VII - 3
INITIAL COST SUMMARY

Construction Cost	\$ 1,373,750
Engineering Cost	276,000
Administrative Cost	<u>69,000</u>
Subtotal	\$ 1,718,750
Interest During Construction	<u>65,000</u>
Total Initial Cost	\$ 1,783,750

TABLE VII - 4
ANNUAL OPERATION AND MAINTENANCE COSTS

Insurance	\$ 3,500
O&M Manpower	12,000
Interim Replacement	4,000
General Expenses	<u>5,200</u>
Total Annual O&M Cost	\$ 24,700

VIII. FINANCIAL ANALYSIS
AND ENERGY COSTS

VIII. FINANCIAL ANALYSIS AND ENERGY COSTS

A. GENERAL

The costs of producing energy are directly related to the method of financing employed. This will determine the interest rate and the repayment period and will therefore directly influence the annual expenses and the energy costs. This chapter presents the financial alternatives available to the Boise Board of Control for the project and presents the cost per kilowatt hour and the cost per installed kilowatt.

B. FINANCIAL ALTERNATIVES

There are two potential sources of funding open to the Boise Project Board of Control to finance the Mora Canal Drop Project. These are government loans through the Department of Energy (D.O.E) and the direct sale of general obligation or revenue bonds.

The D.O.E. loans are made possible by recently enacted legislation known as the "Public Utility Regulation Policies Act of 1978". This act authorizes the Secretary of Energy to make loans to any municipality, electric cooperative, industrial development agency, nonprofit organization, or other person of up to 75 percent of the project costs of small hydroelectric projects. The terms of the loan would be for up to 30 years and the interest rate would be the discount rate or interest rate used at the time the loan is made for water resource planning projects under section 80 of the Water Resources Development Act of 1974. This rate is currently 6 7/8 percent. The act further authorizes the appropriation of

\$100,000,000 per year for each of three years to fund these loans. The loans would be paid by power sale revenues derived from the project.

This act became effective in November 1978 and the Congress has not as yet actually appropriated any funds nor has the D.O.E. drawn up rules and regulations concerning application and granting of such loans. Conversations with D.O.E. officials indicate that the earliest such funds would be available would be late in 1979 or mid-1980. However, it would appear that when funds are available that the Mora Canal Drop Project would be eligible for such a loan.

The second source of funding would be by the sale of revenue bonds. This is the "conventional" source of funding which has most commonly been used on previous projects similar to the Mora Canal Drop. Federal tax laws currently provide that if the power from the project is purchased, as assumed, by an investor-owned utility (such as Idaho Power Company) bonds up to \$1,000,000 could be sold exempt from federal income tax. Under this condition it is currently estimated that such bonds could be sold at an interest rate of 7.0 percent. Bonds in an amount in excess of \$1,000,000 would be subject to federal income tax provision and would most likely carry an interest rate of 10 percent at this time. The term of both the tax exempt and taxable bonds would be for 40 years. To be sold as revenue bonds the power purchaser must pledge to retire the bonds. This would be provided for in the power purchase agreement which would be negotiated with the purchaser prior to the bond sale.

Using those two sources of funds, two primary financing options for the project can be identified. These

would be:

1. Obtain a loan from D.O.E. for the first 75 percent of the project cost at an interest rate of $6 \frac{7}{8}$ percent and a term of 30 years. Sell tax exempt revenue bonds for the remaining 25 percent of the project cost at an interest rate of 7 percent and a term of 40 years. This funding method will be called the "D.O.E Loan Option" in the ensuing discussions.
2. Sell tax exempt revenue bonds in the amount of \$1,000,000 at a non-taxable interest rate of 7 percent. Sell bonds sufficient to cover the remaining project cost at a taxable rate of 10 percent. The term of both bond issues would be for 40 years. This funding method will be called the "Conventional Funding Option" in the ensuing discussion.

C. ENERGY PRODUCTION COST (E.P.C.)

With the project costs, financing options, and power production established, the project Energy Production Cost (E.P.C.) and the cost per installed kilowatt can now be determined.

Table VIII-1A presents the E.P.C. for the Mora Canal Drop using the "D.O.E. Loan Option". As shown, the annual expense of \$164,607 is a combination of bond and loan payments and the annual operation and maintenance cost. Under this financial option, the Energy Production Cost would be 20.3 mills/kwh with an average annual energy production figure of 8,113,000 kwh (with Lake Lowell flow) and 24.9 mills/kwh with an average annual energy production of 6,612,000 kwh

(using historical flows only).

Table VIII-1B presents the E.P.C for the Mora Canal Drop using the "Conventional Funding Option". As shown, the annual expenses are a combination of two bond payments and the annual operation and maintenance cost. Under this option the E.P.C. would be 22.2 mills/kwh with an average annual energy production of 8,113,000 kwh and 27.3 mills/kwh with an average annual energy production of 6,612,000 kwh.

As can be seen, the lowest E.P.C. is 20.3 mills/ kwh using the D.O.E. Loan Option and assuming that the historical Mora Canal Drop flows are augmented as previously discussed in Chapter V with water for Lake Lowell.

With an installed capacity of 1900 kw, and an initial cost of \$1,783,750, the project has a cost per installed kw of \$937. This figure is independent of the financing option used.

TABLE VIII - 1A
ENERGY PRODUCTION COST
w/ D.O.E. LOAN OPTION

<u>INITIAL COST</u>	\$1,783,750
---------------------	-------------

ANNUAL EXPENSES

Repayment: .75 x \$1,783,750 @ 6 7/8%, 30 years	106,458
--	---------

.25 x \$1,783,750 @ 7%, 40 years	33,449
-------------------------------------	--------

Operation and Maintenance:	<u>24,700</u>
----------------------------	---------------

Total Annual Expenses	\$ 164,607
-----------------------	------------

ENERGY PRODUCTION COST (E.P.C.)

a) Average Annual Energy = 8,113,000 kwh

$$\text{E.P.C.} = \frac{164,607 \times 1000}{8,113,000} = \underline{\underline{20.3 \text{ mills/kwh}}}$$

b) Average Annual Energy = 6,612,000 kwh

$$\text{E.P.C.} = \frac{164,607 \times 1,000}{\cancel{8,612,000}^6} = \underline{\underline{24.9 \text{ mills/kwh}}}$$

TABLE VIII - 1B
ENERGY PRODUCTION COST
w/ CONVENTIONAL FUNDING OPTION

INITIAL COST \$1,787,750

ANNUAL EXPENSES

Repayment: \$1,000,000 @ 7%,
40 years 75,091

\$ 787,750 @ 10 %
40 years 80,555

Operation and Maintenance 24,700

Total Annual Expenses \$ 180,346

ENERGY PRODUCTION COST (E.P.C.)

a) Average Annual Energy = 8,113,000 kwh

$$\text{E.P.C} = \frac{180,346 \times 1000}{8,113,000} = \underline{\underline{22.2 \text{ mills/kwh}}}$$

b) Average Annual Energy = 6,612,000 kwh

$$\text{E.P.C.} = \frac{180,346 \times 1000}{6,612,000} = \underline{\underline{27.3 \text{ mills/kwh}}}$$

IX. ECONOMIC EVALUATION

IX. ECONOMIC EVALUATION

A. GENERAL

The economic evaluation of the project is basically a comparison of the benefits and costs over the life of the project. The method of comparison used in this report will be the benefit cost ratio. Private utilities generally use the rate of return on investment but public agencies generally utilize the B/C ratio.

B. PROJECT LIFE

The economic life will be taken as 50 years. This is the estimated length of time the project will be in service producing power and accruing benefits.

Hydroelectric generating equipment often has a service life well beyond 50 years when the equipment is properly maintained. Typical maintenance procedure consists of yearly repair of the runner, shaft seal and inspection of moving parts, refurbishing of bearings every 5 to 10 years and stator rewinding every 15 to 20 years.

It is assumed that an effective O&M program will be adopted that will incorporate periodic inspection and preventive maintenance procedures. A 50 year life can therefore reasonably be expected.

C. COST AND BENEFIT STREAMS

As previously covered, the project costs depend on the method of financing employed. Table IX-1 presents the

annual costs over the 50 year project life for the "D.O.E. Loan" and "Conventional Financing" methods of financing. These cost streams show the repayment costs ending after 30 or 40 years when complete repayment has been made, but with the annual O&M costs continuing over the entire 50 year project life.

The project benefits depend on the average annual energy generated. Table IX-1 also shows the annual project benefits with 6,612,000 kwh annually (historical flows only) and 8,113,000 kwh annually (historical flows augmented with Lake Lowell flows). It is assumed that the added Lake Lowell flows would also be available under normal conditions but for comparative purposes, both conditions are presented.

D. BENEFIT COST RATIOS

The Benefit Cost Ratio is derived by dividing the present worth of the project benefit stream by the present worth of the project cost stream.

The present worth of both the benefits and costs depend on the discount rate employed. This is generally taken as the cost of money to the borrowing agency, in this case the Boise Project Board of Control. Since interest rates are currently in a considerable state of flux, the present worth for the benefits and costs have been computed using discounts rates of 6 percent, 8 percent and 10 percent.

The resulting Benefit Cost Ratios for the D.O.E. Loan option are shown in Table IX-2A. With average annual energy of 8,113,000 kwh the B/C ratio ranges from 1.41 to 1.33 depending on the discount rate. With average annual energy of

6,612,000 kwh the B/C ratio ranges from 1.15 to 1.08.

The B/C ratios for the Conventional funding option are shown in Table IX-2B. With average annual energy of 8,113,000 kwh the B/C ratio ranges from 1.21 to 1.18 and with an average annual energy of 6,612,000 kwh, the B/C ratio ranges from 0.99 to 0.96.

Tables IX-2A and IX-2B show that the B/C ratios are not very dependent on the discount rate used, but are quite sensitive to the average annual energy value used and the method of financing chosen.

It should be noted that inflation has not been taken into account in the analysis and the results are therefore very conservative. The only component of the annual costs that can escalate is the \$24,700 O&M component since the bond or loan repayment costs of \$139,907 or \$155,646 will be fixed. However, the annual benefits of \$171,912 and \$210,938 will almost certainly increase since part of the power sales agreement will provide for the selling price of the project power to be tied to a fuel cost index, and increased fuel costs will certainly occur.

To illustrate the effect of a very mild inflation rate of 3 percent, a B/C computation was made using the Conventional Funding option with average annual energy of 6,612,000 kwh and a discount rate of 8 percent. As shown in Table IX-2B, the B/C ratio for this case is 0.97. If it is assumed that the bond repayment costs of \$155,646 remain fixed, the O&M cost of \$24,700 increases at 3 percent per year and the benefits of \$171,912 increases at 3 percent per year, the B/C ratio changes from 0.97 to 1.68. A similar analysis of the other non-inflation B/C ratio would show similar results.

E. CONCLUSIONS AND RECOMMENDATIONS

From the above data and analysis it can be concluded that the Mora Canal Drop is an economically feasible project. It is recommended therefore that the Boise Project Board of Control proceed with negotiation for a power sales agreement with the Idaho Power Company. Assuming that a satisfactory agreement can be reached, it is further recommended that financing under the D.O.E. Loan option be pursued when monies for such funding become available.

TABLE IX - 1
COST AND BENEFIT STREAMS

<u>YEAR</u>	<u>COST STREAM</u>		<u>BENEFIT STREAM</u>	
mkwh	w/DOE Loan	w/Conv. Fin	@6.6 mkwh	@8.1
1	\$164,607	\$180,346	\$171,912	\$210,938
↓	↓	↓	↓	↓
30	164,607			
31	58,149			
↓	↓	↓		
40	58,149	180,346		
41	24,700	24,700		
↓	↓	↓	↓	↓
50	24,700	24,700	171,912	210,938

TABLE IX - 2A
BENEFIT COST RATIOS
w/ D.O.E. LOAN OPTION

		Discount Rate		
		6%	8%	10%
<u>Energy = 8,113,000 kwh/yr.</u>				
Present Worth Benefits	\$3,324,784	2,580,510	2,091,408	
Present Worth Costs	2,357,964	1,899,520	1,575,560	
Benefit Cost Ratio	1.41	1.36	1.33	
<u>Energy = 6,612,000 kwh/yr.</u>				
Present Worth Benefits	\$2,709,660	2,103,085	1,704,473	
Present Worth Costs	2,357,964	1,899,520	1,575,560	
Benefit Cost Ratio	1.15	1.11	1.08	

TABLE IX - 2B
BENEFIT COST RATIOS
w/CONVENTIONAL FUNDING OPTION

	Discount Rate		
	6%	8%	10%
<u>Energy = 8,113,000 kwh/yr.</u>			
Present Worth Benefits	\$3,324,784	2,580,510	2,091,408
Present Worth Costs	2,745,190	2,158,178	1,766,975
Benefit Cost Ratio	1.21	1.20	1.18

<u>Energy = 6,612,000 kwh/yr.</u>			
Present Worth Benefits	\$2,709,660	2,103,085	1,704,473
Present Worth Costs	2,745,190	2,158,178	1,766,975
Benefit Cost Ratio	0.99	0.97	0.96

X. DEVELOPMENT PLAN

X. DEVELOPMENT PLAN

A. GENERAL

This chapter presents a development plan to initiate project construction, implement all activities and bring power on line.

B. DETAILED PLAN

The general plan to implement the Mora Canal Power Project is shown graphically in Figure X-1.

The first activity involves negotiations with a power purchaser. The end result of the negotiations will be a "Memorandum of Understanding" in which the Boise Project Board of Control will pledge to sell and the power purchaser will pledge to buy all power produced at the Mora Canal site. This document will stipulate all details, including a clause in which the selling price of the electric energy will be tied to a suitable escalation index. Following the final design of the project when all costs are known, the document will be revised as required to form the final power purchase contract.

The other activities follow the start of power negotiations. Assuming some bond sales will be necessary, legal services and professional advice regarding financial assistance is obtained during the power sales agreement and continue until all bonds are sold or until the necessary loans are obtained from D.O.E.

The FERC application and design and construction activities will immediately start after the conclusion of the power negotiations. The recently passed energy bill directed the FERC to prepare some revised and simplified guidelines for small hydroelectric projects. However, no revised instructions concerning this matter are as yet available. On the schedule, one year has been allowed for the FERC license application approval process. However, this time may later be considerably shortened. Shown on the schedule but actually a part of the FERC application is the preparation of Exhibit W, an Environmental Impact Statement. It is shown separately since it is a major activity and is often also required by other agencies as well.

It has been assumed that the civil features will be primarily constructed by the construction and maintenance staff of the Boise Project Board but that the mechanical/electrical equipment would be installed by a contractor.

The process to obtain all other necessary permits and agreements will also be initiated following the completion of the power negotiations. In the case of the Mora Canal Power Project, an agreement between the U.S. Bureau of Reclamation for the use of Boise Project lands and facilities must be completed. Also, a water use permit for power generation must be obtained from the Idaho Department of Water Resources. Both activities have already been initiated by the Boise Board of Control.

As shown, the proposed Development Plan would bring power on line at the beginning of the 1982 irrigation season.

1980

1981

1982

MORA CANAL DROP
PROJECT DEVELOPMENT
PLAN

FIGURE

X-1

XI. ENVIRONMENTAL, SAFETY
AND SOCIO-INSTITUTIONAL
ASPECTS

XI. ENVIRONMENTAL, SAFETY AND SOCIO-INSTITUTIONAL ASPECTS

A. GENERAL

This chapter presents an initial assessment of the environmental safety and socio-institutional aspects of the project. As described below, these impacts are expected to be minor.

B. ENVIRONMENTAL IMPACT

The Mora Drop is located at the northwest edge of a highlands area that extends to near the Snake River 12 miles to the south. The summit of Kuna Butte, 500 feet in elevation above the valley is located 1.5 miles southeast of the drop. The valley areas to the north and west of the drop are quite flat, sloping gently toward the northwest.

The highlands area has remained largely in its natural state, with only limited disturbance by human activity. The area is covered with the sage-grassland association that once extended over most of the valleys of southern Idaho. Principal floral species include Big Sagebrush, several species of perennial bunch grasses, with incursions by the annual cheat grass. A number of upland game birds occupy the area, including Bobwhite, Ring-necked pheasant, Chukar partidge, and Hungarian partridge. Several families of small rodents are common in the sage grasslands, including rabbits, gophers, ground squirrels and field mice. A few predators inhabit the area, including the coyote, red fox, an occasional Golden eagle, and several species of hawks and owls. The highlands area is little used by Boise Valley residents, other

than for some recreation vehicle travel and small game and upland bird hunting.

The valley land use near the drop site is typical of rural farm areas, with between five and ten homes per square mile, and with an almost unbroken crop cover between houses. The nearest community is the city of Kuna, a rural farm town of 1500 people, which is located three miles northeast of the Mora Drop.

Kuna is now beginning to serve as a "bedroom community" for commuters to the Boise area, 16 miles further to the northeast; so subdivisions are now beginning to appear within and near the town, and the population is beginning to climb.

Aquatic life in the Mora Canal is limited, since it remains dry between four and six months each year. A few rainbow and brown trout are introduced each year from the Boise River, but there are no pools in which they might remain during the dry season.

Construction and operation of a hydroelectric plant at the Mora drop is not expected to have any significant impact on the highland or farmland environment. Since little or no modification of existing canal flow patterns are anticipated, operation of this plant will not have any effect on the Deer Flat Wildlife Refuge.

No water pollutants will be released by the facility. The only effect of the installation on the Mora Canal water quality is likely to be some silt and turbidity from construction-related activities. If most work is done during

the winter season when the canal is dry, silting is likely to be quite minor.

The only impact of the plant on air quality of the region is likely to be dust from construction activities, some construction vehicle emissions and minor amounts of ozone released by the generators during operation of the plant. On the other hand, to the extent that use of this generating facility will reduce power production at coal-fired thermoelectric plants elsewhere, a slight improvement in air quality at the latter sites may be expected.

Noise attributable to construction of the plant may cause some reduction in bird and mammal activity in the immediate vicinity of the Drop. However, noise levels will be low when the plant is in operation, so this is expected to be a temporary condition. Construction vehicle usage is likely to increase traffic density on nearby rural roads, which may disturb residents located near the Drop. However, only five to ten homes will be affected, and this traffic will decrease to present levels once the plant is in operation.

The power plant will require a concrete building measuring approximately 30 feet wide by 30 to 50 feet long by 25 to 50 feet high. Approximately 10 feet of the height would be underground, so the top of the structure would not extend far above the top of the canal. The structure will have some visual impact when viewed from the valley. It will be nearly invisible from the north slopes of Kuna Butte. Due to the low population density of the valley areas near the site, this visual impact is not expected to be significant. A second visual impact will develop with construction of a transmission line by Idaho Power Company. This line will need to extend

approximately 4.5 miles, primarily along existing roadways in the valley. It is possible that an existing pole line could be utilized for part of the transmission line, to reduce the significance of this impact.

C. SAFETY ASPECTS

No major safety hazards are expected as a result of power plant operations. The plant will be fully enclosed, so there will be no electric shock hazard to casual site visitors. No moving parts of the plant will be exposed. Some increase in flows through the two wasteways at Lake Lowell is likely in spring and fall. At the Mora Drop, the existing drop chute will normally be dry when the power plant is on line. The hazard of this structure to site visitors will consequently decrease with construction of the facility.

D. SOCIO-INSTITUTIONAL IMPACT

Construction and operation of a power plant at the Mora Drop should have a slightly beneficial impact on the regional and national economy. The power cost will be cheaper than most other options for future power that Idaho Power Company is considering. The Mora power plant thus will help hold down the cost of power for all consumers. Since most construction work on the plant will be done by Boise Project Board of Control personnel, its impact on the local job market will be minor. In the long run, however, a successful power plant at the Mora Drop is likely to spark greater interest in construction of hydroelectric plants at similar sites throughout the region. Future construction projects of this type will directly benefit the local construction economy, and indirectly benefit the regional economy by helping to hold down power rates.

- MORA CANAL DROP
- PROPOSED TRANSMISSION LINE
- BOWMONT SUBSTATION
- BOISE PROJECT BOUNDARY

BOISE PROJECT BOARD OF CONTROL
MORA CANAL DROP
LOCATION MAP

PLATES

PLAN
SCALE 1"=20'

ELEVATION
2740
2730
2720
2710
2700
2690
2680

ELEVATION
2740
2730
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2700
2690
2680

ELEVATION
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2680

ELEVATION
2740
2730
2720
2710
2700
2690
2680

TYPICAL SECTION A
SCALE 1"=20'

UPPER MORA CANAL

UPPER MORA CANAL

UPPER MORA CANAL

ELEVATION
2740
2730
2720
2710
2700
2690
2680

ELEVATION
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ELEVATION
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2700
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2680

BOISE PROJECT BOARD OF CONTROL
MORA CANAL DROP

ALTERNATIVE INSTALLATIONS

APPENDIX A

—

Snake River

HYDRO POWER

IDAHO POWER COMPANY

BOX 70 BOISE, IDAHO 83707

November 22, 1978

JAMES E. BRUCE
PRESIDENT &
CHIEF EXECUTIVE OFFICER

Mr Ottis Peterson
Chairman of Power Committee
Boise Project Board of Control
2908 Alamo Road
Boise, Idaho 83704

Dear Mr Peterson:

You have asked the Idaho Power Company to indicate its interest in purchasing the energy which might be generated by a small power plant constructed on the canal system under control of the Boise Project Board of Control Board at a location described as the Mora Drop. It is our understanding that the power plant would be constructed, owned and operated by the Board.

The Company does have a continuing and increasing need for electric energy when the energy has some degree of reliability or in the alternate, has a value as fuel replacement. The illustration of the expected generation from the Mora site shows that some of the energy would be adaptable to an irrigation load and the remainder would need to be used for fuel replacement.

The basis upon which the Company would be interested in purchasing the energy from the Mora site is generally described as follows:

1. The Company would agree to purchase all energy generated by the plant.
2. Idaho Power Company will construct, own, operate and maintain a 34.5 kV transmission line and the new circuit bay in its existing Bowmont Substation to interconnect the Mora generating plant to the Company's existing transmission system. The preliminary estimate for the cost of this interconnection is approximately \$90,000. The Company's annual costs relating to this investment will be deducted from the energy payment. The Board would own the step-up transformer and generator circuit breaker located at the power plant.
3. The Company would expect the installations in the power plant to provide for startup and shutdown control from the Boise Bench Substation and be provided with the normal protection equipment.

4. The Company would be willing to operate and maintain the power plant but would expect the Board to require a daily walk-through by a Board employee and have an annual shutdown for cleaning, inspection and preventive maintenance either by its own employees or by the Company. Any work performed by the Company would be on a time and materials basis. The final design of the controls would be reviewed by the Company to see that they are compatible with the Company's system.

5. Payment for the energy would be based on the metered amount received at 34.5 kV at the Bowmont Substation.

6. The energy payment will be 26 mills per kilowatt-hour.

This sets forth in preliminary form our idea of the possible arrangements under which the Mora energy could be purchased by the Company. Please call Mr Hogg to arrange for discussion of this program.

Sincerely,

James E Bruce
President & CEO

RAH:JEB:mlm

APPENDIX B

DETAILED COST ESTIMATE

OCTOBER 1978 PRICES

PROPELLER TURBINE ALTERNATIVE

<u>Acct</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
330	LAND & LAND RIGHTS	LS			2,000	\$ 2,000
331	STRUCTURES AND IMPROVEMENTS					
331.01	Mobilization & Demobilization	LS			20,000	
331.02	Common Excavation	CY	2,500	2.50	6,250	
331.03	Rock Excavation	CY	2,500	10.00	25,000	
331.04	Foundation Preparation	SF	3,000	2.00	6,000	
331.05	Grouting and Sealing	LS			5,000	
331.06	Power Plant Concrete	CY	750	70.00	52,500	
331.07	Reinforcing Steel	LB	93,250	0.40	37,500	
331.08	Compacted Backfill	CY	1,500	3.00	4,500	
331.09	Access Road & Site Work	LS			10,000	
	TOTAL ACCOUNT 331					\$166,750
332	RESERVOIR DAM AND WATERWAYS					
332.01	Concrete, Forebay Improvements	CY	150	70.00	10,500	
332.02	Concrete, Inlet Works	CY	200	70.00	14,000	

DETAILED COST ESTIMATE

OCTOBER 1978 PRICES

PROPELLER TURBINE ALTERNATIVE

<u>Acct</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
332.03	Concrete, Penstock	CY	250	70.00	10,500	
332.04	Concrete, Tailrace	CY	200	70.00	14,000	
332.05	Concrete, Misc.	CY	150	70.00	10,500	
332.06	Reinforcing Steel	LB	118,750	0.40	47,500	
332.07	Misc. Metalwork	LB	50,000	1.20	60,000	
332.08	Gates, Guides & Appurt.	LS	25,000	1.50	37,500	
332.09	Compacted Backfill	CY	1,500	3.00	4,500	
332.10	Miscellaneous Items	LS			10,000	

TOTAL ACCOUNT 332

\$226,000

333 WATERWHEELS, TURBINES & GENERATORS

333.01	Turbine	LS			164,000	
333.02	Generator	LS			340,000	
333.03	Governor	LS			35,000	
333.04	Freight & Installation	LS			29,000	

TOTAL ACCOUNT 333

\$568,000

DETAILED COST ALTERNATIVE

OCTOBER 1978 PRICES

PROPELLER TURBINE ALTERNATIVE

<u>Acct</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
334	ACCESSORY ELECTRICAL EQUIPMENT					
334.01	Transformer	LS			14,000	
334.02	Circuit Breaker & Switchgear	LS			26,000	
334.03	Control Equipment	LS			25,000	
334.04	Bus, Cable, Conduit & Grounding	LS			10,000	
334.05	Misc. Equipment	LS			9,000	
334.06	Freight & Installation	LS			21,000	
	TOTAL ACCOUNT 334					\$105,000
335	MISCELLANEOUS POWER PLANT EQUIPMENT					
	Communication System	LS			30,000	
	Misc. Equipment	LS			15,000	
	Freight & Installation	LS			8,000	
	TOTAL ACCOUNT 335					53,000
355	TRANSMISSION LINE	LS				100,000
	GRAND TOTAL ALL ACCOUNTS					\$ 1,220,750

APPENDIX B-1

DETAILED COST ESTIMATE

OCTOBER 1978 PRICES

TUBE TURBINE ALTERNATIVE

<u>Acct.</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
330	LAND & LAND RIGHTS	LS			2,000	\$ 2,000
331	STRUCTURES AND IMPROVEMENTS					
331.01	Mobilization & Demobilization	LS			20,000	
331.02	Common Excavation	CY	2,200	2.50	5,500	
331.03	Rock Excavation	CY	2,200	10.00	22,000	
331.04	Foundation Preparation	SF	2,650	2.00	5,300	
331.05	Grouting & Sealing	LS			5,000	
331.06	Power Plant Concrete	CY	600	70.00	42,000	
331.07	Reinforcing Steel	LB	75,000	0.40	30,000	
331.08	Compacted Backfill	CY	1,300	3.00	3,900	
331.09	Access Road & Site Work	LS			12,000	
	TOTAL ACCOUNT 331					\$ 145,700
332	RESERVOIR DAM AND WATERWAYS					
332.01	Concrete, Forebay Improvement	CY	150	70.00	10,500	
332.02	Concrete, Inlet Works	CY	150	70.00	10,500	

DETAILED COST ESTIMATE

OCTOBER 1978 PRICES

TUBE TURBINE ALTERNATIVE

<u>Acct</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
332.03	Concrete, Penstock	CY	250	70.00	17,500	
332.04	Concrete, Tailrace	CY	150	70.00	10,500	
332.05	Concrete, Misc.	CY	150	70.00	10,500	
332.06	Reinforcing Steel	LB	106,250	0.40	42,500	
332.07	Misc. Metalwork	LB	50,000	1.20	60,000	
332.08	Gates, Guides & Appurt.	LB	25,000	1.50	37,000	
332.09	Compacted Backfill	CY	1,500	3.00	4,500	
332.10	Miscellaneous Items	LS			10,000	
TOTAL ACCOUNT 332						\$ 214,000
333	WATERWHEELS, TURBINES & GENERATORS					
333.01	Turbine & Generator	LS			579,000	
333.02	Freight & Installation	LS			29,000	
TOTAL ACCOUNT 333						\$ 629,000

DETAILED COST ESTIMATE

OCTOBER 1978 PRICES

TUBE TURBINE ALTERNATIVE

<u>Acct</u>	<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Price</u>	<u>Amount</u>	<u>Acct. Total</u>
334	STATION EQUIPMENT					
334.01	Transformer	LS			14,000	
334.02	Circuit Breaker & Switchgear	LS			26,000	
334.03	Control Equipment	LS			15,000	
334.04	Bus, Cable, Conduit & Grounding	LS			10,000	
334.05	Miscellaneous Equipment	LS			9,000	
334.06	Freight & Installation	LS			21,000	
	TOTAL ACCOUNT 334					\$ 95,000
335	MISCELLANEOUS POWER PLANT EQUIPMENT					
	Communication System	LS			33,000	
	Miscellaneous Equipment	LS			12,000	
	Freight & Installation	LS			8,000	
	TOTAL ACCOUNT 335					\$ 53,000
335	TRANSMISSION LINE	LS				\$ 100,000
	GRAND TOTAL ALL ACCOUNTS					\$ 1,238,700