JORDAN CREEK

RECONNAISSANCE STUDY

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT

JUNE 1987

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

JORDAN CREEK, IDAHO-OREGON
RECONNAISSANCE STUDY

PREPARED FOR
CORPS OF ENGINEERS
WALLA WALLA DISTRICT
WALLA WALLA, WASHINGTON

PREPARED BY
MORRISON-KNUDSEN ENGINEERS, INC.
BOISE, IDAHO

DACWG8-86-D-003
W.O. #1932
JUNE, 1987

EXECUTIVE SUMMARY

This report presents the results of a reconnaissance study on Jordan Creek, located in Southwestern Idaho and Southeastern Oregon, which was done under contract to the U.S. Army Corps of Engineers, Walla Walla District. The study developed reconnaissance level designs for the construction of a dam on Jordan Creek. Preliminary designs were also prepared for the enlargement of the Antelope Feeder Canal and Antelope Reservoir.

Costs for constructing a dam on Jordan Creek ranged from $13,~~031~~733,000 to $17,~~273~~520,000. Enlargement of the Antelope Feeder Canal was estimated to range from $1,539,640 to $18,412,350 and the cost to enlarge Antelope Dam ranged from $1,401,000 to $4,155,000.

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SECTION 1.0
INTRODUCTION

1.1 Purpose of Study

This report has been prepared to supplement the Corps of Engineers (Corps) efforts on their flood studies for Jordan Creek, tributary to the Owyhee River, located in Southeastern Oregon and Southwestern Idaho. It presents the results of a reconnaissance study to construct a dam on Jordan Creek, upstream of the town Jordan Valley, Oregon, enlargement of the Antelope Feeder Canal and the enlargement of Antelope Dam.

1.2 Scope

The scope of work, as defined in the agreement between the Corps of Engineers (Corps) and Morrison-Knudsen Engineers, Inc. (MKE), comprises the development of preliminary designs, drawings, and cost estimates for several alternatives to reduce flooding along Jordan Creek. The services covered include the following:

- Preliminary design for a multiple-purpose dam on Jordan Creek with 65,000 AF storage, including hydropower.
- Enlargement of Antelope Feeder Canal from 550 cfs to 1000 cfs.
- Evaluate alternate alignments for Antelope Feeder Canal.
- Enlargement of Antelope Dam and reservoir from 70,000 AF to 110,000 AF, including hydropower.

The work was done at the reconnaissance level utilizing existing information only. Designs were developed only in enough detail so that concepts could be presented and preliminary cost estimates made.

1.3 Authority

The work was conducted under an Indefinite Delivery Contract, DACWG8-86-D-003, between the Corps of Engineers, Walla Walla District, and Morrison-Knudsen Engineers, Inc., Boise Regional Offices. The work was conducted from March, 1987 to May, 1987.

SECTION 2.0

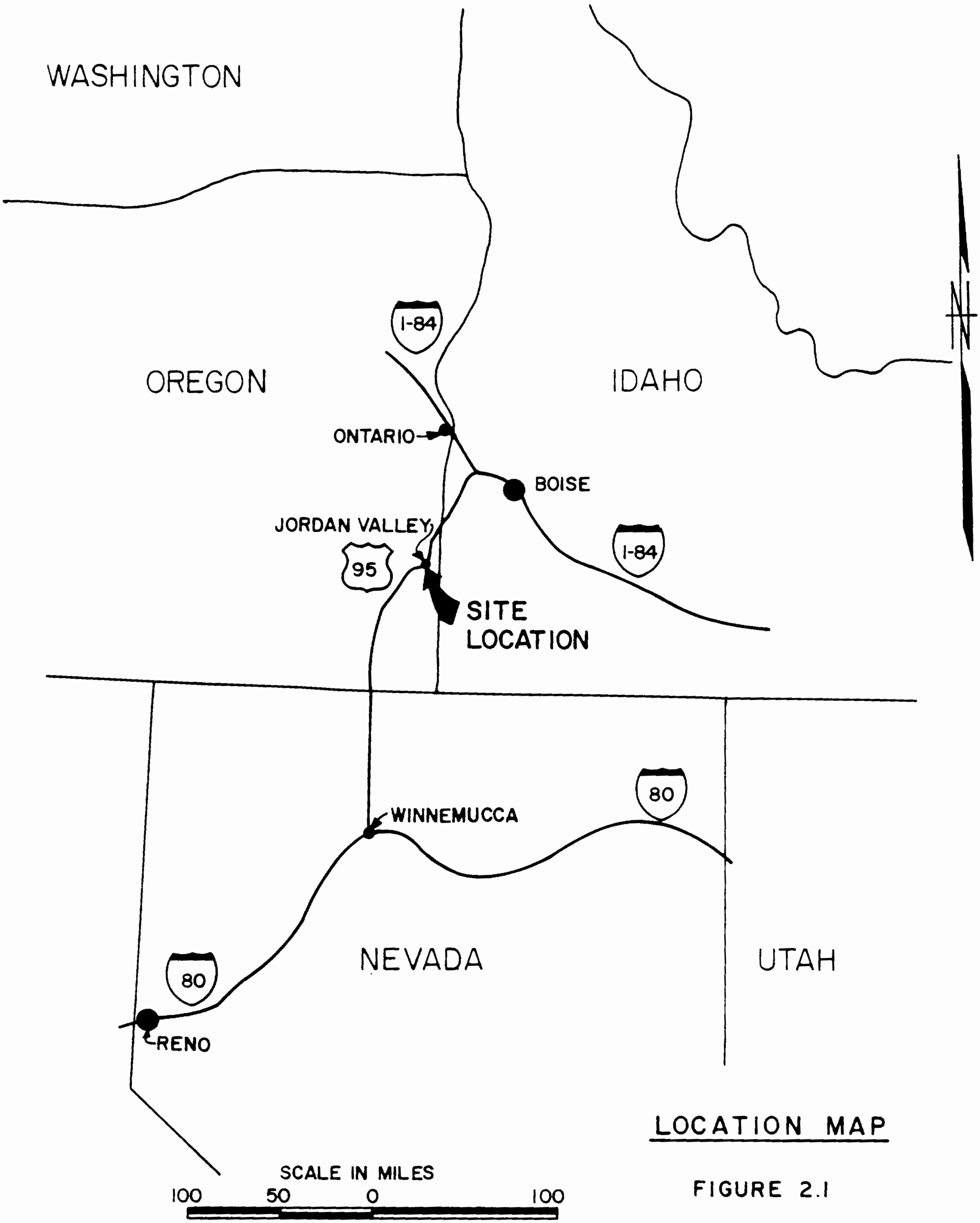
OVERVIEW

2.1 General

The Corps is performing a study on Jordan Creek tributary to the Owyhee River, in Southeastern Oregon to evaluate alternatives for reducing flood damages. They have identified two alternatives, the construction of a new dam about 12 miles upstream of the town of Jordan Valley, and the enlargement of the Antelope Feeder Canal, and increasing the storage of Antelope Dam. Figure 2.1 shows the study area location.

The proposed dam site on Jordan Creek was originally studied by the U.S. Bureau of Reclamation (USBR) during the late 1960's and early 1970's. It was originally proposed that an arch dam be constructed with a storage capacity of 65,000 AF. The current reconnaissance study proposes that an RCC dam of the same size and at the same location be built. Figure 2.2 shows the Jordan Dam project location. The new dam would include hydropower production as one of the uses. Details of the preliminary design are presented in Section 3.0.

The second alternative for reducing flooding of Jordan Creek is the enlargement of the existing Antelope Feeder Canal and raising Antelope dam. The canal's capacity would be increased from 550 cfs to 1,000 cfs and Antelope Reservoir would be enlarged from 70,000 AF to 110,000 AF. Details of the preliminary design are presented in Section 4.0 and 5.0 respectively. Figure 2.2 shows the project areas for the Antelope Feeder Canal and Antelope Reservoir.



LOCATION MAP

FIGURE 2.1

MORRISON-KNUDSEN ENGINEERS, INC.

2.2 Cost Summary

Cost for the various alternatives are summarized below.

Jordan Creek Dam

RCC Dam	$13,~~031~~ 733,000
RCC Dam w/1.4 mw	17,~~273~~ 520,000

Antelope Feeder Canal

10% Reconstruction	$ 1,539,640
25% Reconstruction	1,875,270
Alignment "A"	3,973,850
Alignment "B"	18,412,350

Antelope Dam Enlargement

Enlarge Dam	$ 1,401,000
Enlarge Dam w/ .6 mw	3,761,000
Enlarge Dam w/ .9 mw	4,155,000

SECTION 3.0
JORDAN CREEK DAM

3.1 General

The Jordan Creek dam site is located on Jordan Creek about 12 miles upstream from the town of Jordan Valley in Owyhee County, Idaho, about ten miles upstream from the Idaho-Oregon state line. The dam axis could be located at several points along a stretch of the creek where a narrow canyon has been cut into the volcanic bedrock. The dam would impound a reservoir that would back water up into a relatively broader valley just upstream of the narrow canyon.

The dam site was studied from 1970 to 1973 by the U. S. Bureau of Reclamation (USBR) as part of the Jordan Valley Division of the Upper Owyhee Project. The dam was to provide storage for agricultural use and flood protection for downstream farms and the town of Jordan Valley. At that time the dam was conceived as a double curvature thin arch concrete dam with a normal water surface at an elevation of 4688 that would impound a reservoir of 65,000 acre-feet, 1,000 acre-feet of which was allocated to sediment storage. The estimated cost for dam construction in 1971 dollars was $8.24 million.

The current study consisted of performing a reconnaissance level redesign of the dam as a gravity structure constructed of roller compacted concrete (RCC) and preparing cost estimates of that design. For this study the same dam center line and reservoir characteristics were assumed as for the previous USBR study except that the spillway capacity was increased to pass the revised design flood.

The study is based on information from previous reports and studies, and on a site reconnaissance made on March 19, 1987. No geotechnical investigation was undertaken nor was a hydrologic analysis performed as these tasks were beyond the scope of the study.

3.2 Hydrology

The water supply for the project would be Jordan Creek which is a tributary to the Owyhee River. The watershed above the dam site is comprised of 415 square miles, and varies in elevation from 4,500 to over 8,000 feet mean sea level (msl). The sixty-year water study by the Corps shows the estimated runoff at the dam site to be as follows:

- 1927 - 1986 average annual runoff - 136,576 acre-feet
- maximum annual runoff - 339,697 acre-feet
- minimum annual runoff - 25,532 acre-feet

Figure 3.1 shows the average monthly flows at the dam site for the period of study (1927-1986). No reservoir operation studies were done as part of this investigation. The average end-of-month reservoir contents were taken from the USBR 1973 study for the Jordan Creek Dam.

3.2.1 Design Flood

For a high hazard dam such as Jordan Creek, the design flood would be the probable maximum flood (PMF). The design flood at the time of the USBR study was 14,000 cubic feet per second. No inflow hydrograph is available for the PMF and it was beyond the scope of this study to perform a full hydrologic analysis in order to develop one. For the purpose of this study a PMF flow of 30,000 cubic feet per second was adopted for design. This figure was based on a USBR curve of the probable maximum inflow peak versus drainage area for the Snake River in the Pacific Northwest Region. As no inflow hydrograph was available, the PMF could not be routed through the reservoir. The spillway was sized to pass the design flood of 30,000 cubic feet per second with one foot of freeboard.

3.2.2 Storage Capacity

The dam was sized to provide 65,000 acre-feet of total storage. Of that total 1,000 acre-feet was set aside for sediment accumulation. Active reservoir storage, therefore, would be 64,000 acre-feet. These figures are identical to those used in the USBR study.

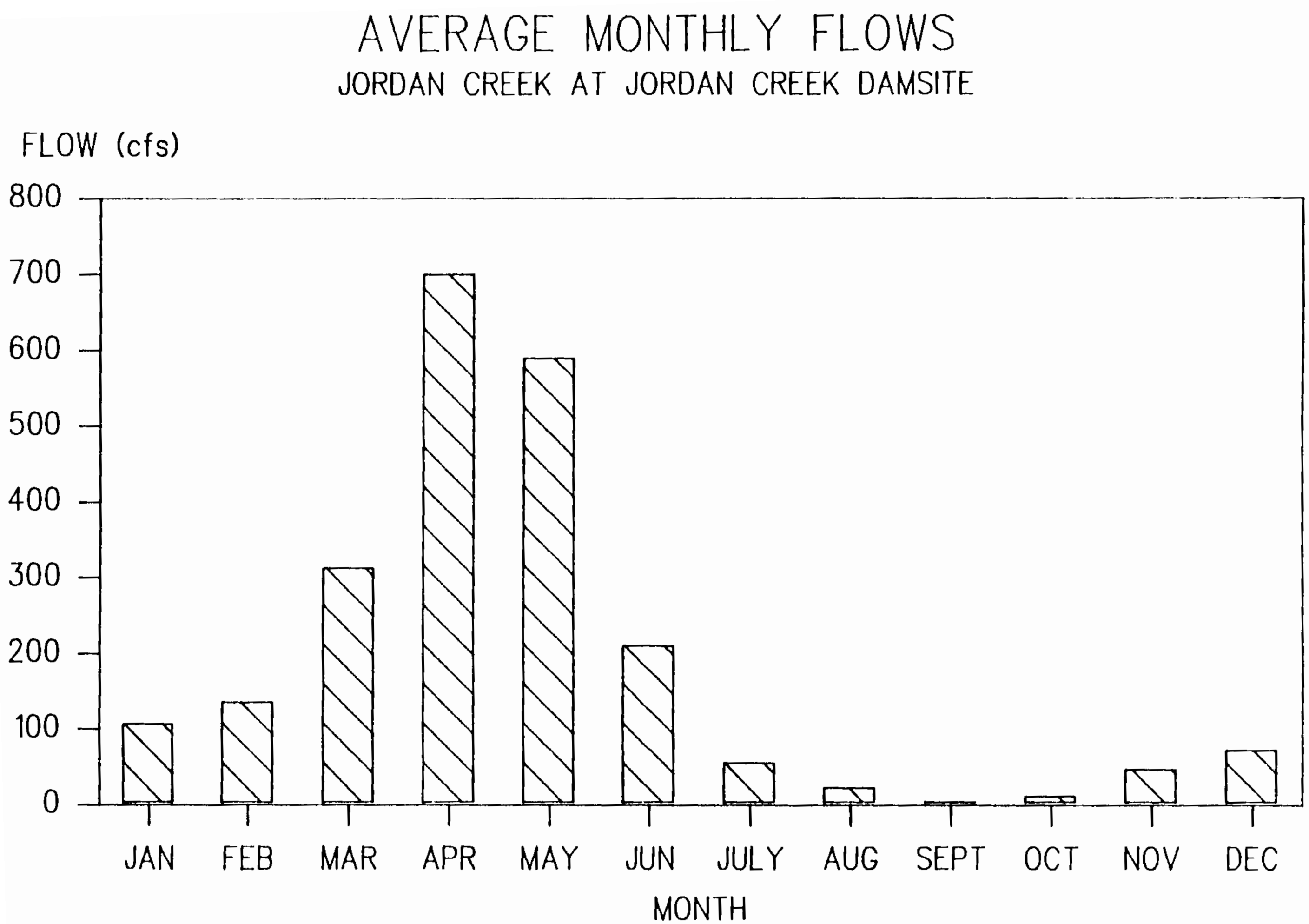

AVERAGE MONTHLY FLOWS
JORDAN CREEK AT JORDAN CREEK DAMSITE
FLOW (cfs)
800
700
600
500
400
300
200
100
0
JAN
FEB
MAR
APR
MAY
JUN
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIGURE 3.1

No reservoir operation studies were made as part of this work, although it is assumed that flood protection would be one of the primary purposes of the project. It was assumed that the reservoir would be operated to maximize flood control and irrigation water storage benefits.

3.3 Geology and Construction Materials

3.3.1 Geology

The Jordan Creek dam site is located in a narrow "V" shaped canyon approximately 400 feet deep and 100 to 200 feet wide at the bottom, eroded into a thick, flat lying rhyolitic lava flow. Rhyolite is exposed on both abutments at the site and extends to the rim of the canyon above the top of the potential dam crest. Weathering and alteration of the rhyolite is slight. The rhyolite is fairly hard and dense, but it is cut by many nearly vertical joints or fractures. In some places, the rhyolite also has closely spaced horizontal joints. Despite this jointing, the rhyolite would make a good foundation for the dam.

At the dam site, the lower flanks of the canyon walls are covered with as much as 20 feet of slopewash, and there are alluvial materials up to 24 feet deep in the bottom of the canyon. (USBR 1973).

3.3.2 RCC Construction Materials

Aggregate for RCC could be obtained from quarrying sound outcrops of rhyolite within the reservoir but would most likely be obtained from the alluvial sands and gravels in the valley bottom just upstream of the dam site. The material consists of clean, well rounded sound cobbles, gravel and sand representing the rock types occurring within the drainage basin. The gravel would have to be crushed and screened prior to use as RCC aggregate.

No RCC trial mixes were performed as part of this study. For the purpose of estimating, an RCC mix with a cement content of 150 pounds per cubic yard was conservatively assumed. The RCC was considered to have an in-place density of 150 pounds per cubic foot.

3.4 Dam Design

3.4.1 Foundation

The RCC gravity dam would be founded on sound rhyolitic bedrock as described previously. The strength characteristics of the foundation rock are expected to be far in excess of the strength of the RCC, and therefore no foundation stability problems are anticipated. The exact depth to acceptable foundation rock has not been adequately established by the subsurface investigations to date. However, based on field observations, and the USBR's design, it was assumed that sound rock would occur at a depth of 25 feet across the river flood plain and at the base of the canyon walls, and at a depth of ten feet on the bedrock abutments. The reconnaissance level design includes a single-row grout curtain into the foundation rock to a depth equal to one-half the hydraulic head.

3.4.2 RCC Dam

The RCC dam design for this reconnaissance level evaluation is shown on Exhibit 1. It was designed as a gravity section with a vertical upstream face and a sloping downstream face of 0.75H to 1V. Experience has shown this to be a conservative design in which internal shear stresses are minimized and tensile stresses at the heel are eliminated altogether. It is expected that the strength of the RCC attained by the proposed mix would meet the design strength requirements for compression and tension. Above the spillway ogee elevation of 4688 both the upstream and downstream faces of the dam would be vertical. The crest width is 20 feet at elevation 4708.

The reconnaissance level design provides for installing PVC lined precast concrete panels on the upstream face of the dam. The panels would be backed by one foot of conventional air-entrained concrete. The upstream facing system would not only protect the RCC from potential freeze-thaw deterioration but would also provide the first and second lines of defense against seepage.

The downstream face of the dam and spillway chute would be formed in one-foot steps of conventional concrete. The downstream facing concrete would resist weathering, reduce wastage of RCC, provide a resistant surface in the event of overtopping, and provide a stable slope during construction.

Bedding concrete is provided at the contact of RCC with the foundation rock and for a distance of six feet downstream from the upstream facing at each lift. The purpose of the bedding concrete is to insure adequate shear strength at the contact surfaces between lifts and provide a third line of defense against seepage through lift contacts in the RCC.

No contraction joints or special provisions for crack control were considered in this design. Requirements for such provisions would be dictated by the results of a detailed thermal analysis that exceeds the scope of this study.

Prudent concrete gravity dam design dictates that the dam be drained and that foundation uplift pressures be minimized. Therefore, Jordan Creek Dam has been provided with a six-foot by eight-foot drainage gallery running longitudinally through the dam at approximately elevation 4,570. The drainage gallery was extended into the rock at each abutment as a drainage tunnel. The tunnels and gallery slope to the gallery access located above the outlet conduit/penstock. Drain holes at ten-foot centers extend upward from the gallery to the normal pool elevation to provide the RCC section with internal drainage. Foundation drain holes were also laid out every ten feet and penetrate to a depth equal to one-half the hydraulic head at the dam foundation contact.

3.4.3 Outlet Conduit/Penstock

The dam has been provided with a 72-inch diameter steel lined outlet conduit/penstock encased in reinforced concrete and founded on sound bedrock in the left abutment. The conduit/penstock was sized to pass 245 cubic feet per second at the design operating head available. The intake to the outlet conduit is located at the top of a vertical riser at elevation 4570, above the estimated elevation of sediment accumulation. The conduit/penstock would be equipped with a vertical slide gate at the intake and operated hydraulically from the control building/powerhouse. The intake would be protected with a trash rack. The conduit will also be used for diversion during construction.

3.4.4 Powerhouse

The Jordan Creek dam project would include hydropower generation as one of the purposes. The proposed hydropower facility would be a dual-turbine arrangement with a total capacity of 1.43 MW. Estimated capital cost for the project is $3.02 million. For this reconnaissance level study, it was assumed that two Francis units would be used; one sized at .9 mw and the other at .5 mw. An average head of 82 feet was used in the design of the power plant. Details on the selection of the hydropower facilities are presented in Section 3.5.

3.4.5 Spillway

A service spillway 120 feet wide and 20 feet deep has been provided to discharge into the center of the valley and would have a capacity of 3,000 cfs to pass the PMF. The spillway ogee, chute, and stilling basin slab would be of conventional reinforced concrete. Structural concrete containment walls were laid out from the crest to the end of the stilling basin on either side of the spillway. The stilling basin is 20 feet deep and extends 100 feet downstream of the toe of the dam.

The spillway chute would be lined with a two-foot thickness of conventional, reinforced concrete and be formed using one-foot steps. The stepped spillway would serve to dissipate a large percentage of the hydraulic energy and thus reduce the dimensions of the stilling basin.

3.4.6 Relocations

Approximately seven miles of existing county road would have to be relocated around the new reservoir. An access road to the control building/powerhouse and dam crest at the left abutment has been included in the design.

3.5 Hydropower

One of the purposes of the Jordan Creek Dam would be hydropower generation. The power plant would be located at the base of the RCC dam. The proposed hydropower installation will generate power from the releases made for irrigation. Since most releases are dedicated to irrigation, it was assumed that the operation would be similar to that outlined in the 1973 USBR report.

3.5.1 Stream Flow and Reservoir Content

Stream flow data for the proposed Jordan Creek Dam and Reservoir was obtained from the 1973 USBR study for Jordan Creek. The average monthly outflow and average end-of-month storage over the forty-year period from 1927 to 1967 was taken from the 1973 USBR study. Outflows for the period ranged from a maximum of 556 cfs to a minimum of two cfs, with an overall average of 142 cfs. Figure 3.2 shows the average monthly outflows for the study period. Reservoir water surface elevation and tailwater rating curves were used to calculate available heads for each month. Since tailwater elevations differed by only two feet for minimum and maximum outflows, the tailwater elevation was assumed to be constant at an elevation of 4,553 feet. Maximum and minimum available heads were estimated to be 122 and 8 feet, respectively, with an overall average of 85 feet. Average monthly heads are shown in Figure 3.3. Stream flow and reservoir content data, along with other calculated values, are included in Appendix C.

3.5.2 Power and Energy Estimates

Power and energy estimates were developed based on an average water year. Power plant capacity was obtained using the formula:

$$P = \frac{Qh}{14}$$

Where:

P = power plant capacity in kW
Q = maximum power plant flow, in cfs
h = power plant design head, in feet

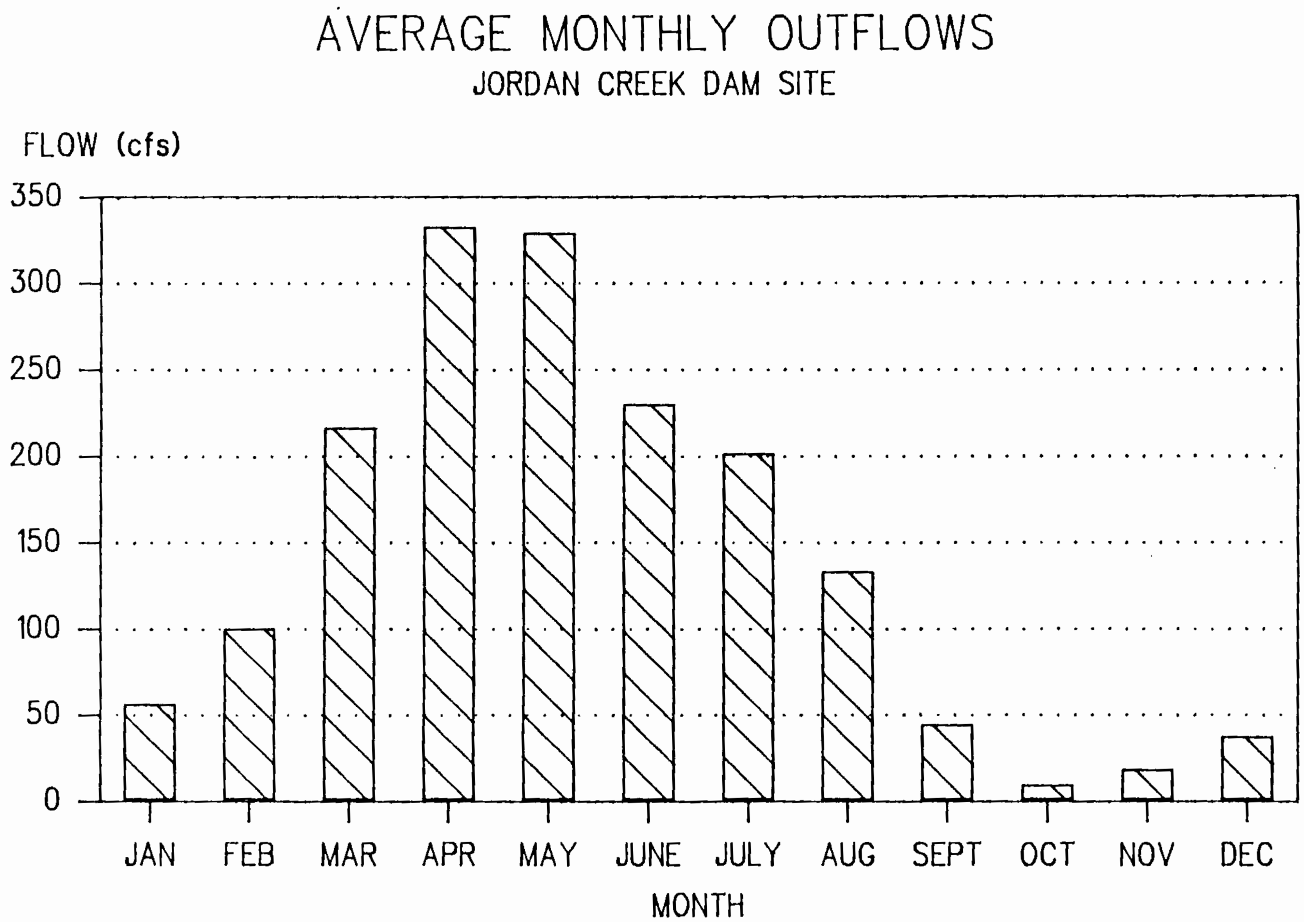

AVERAGE MONTHLY OUTFLOWS
JORDAN CREEK DAM SITE
FLOW (cfs)
350
300
250
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIGURE 3.2

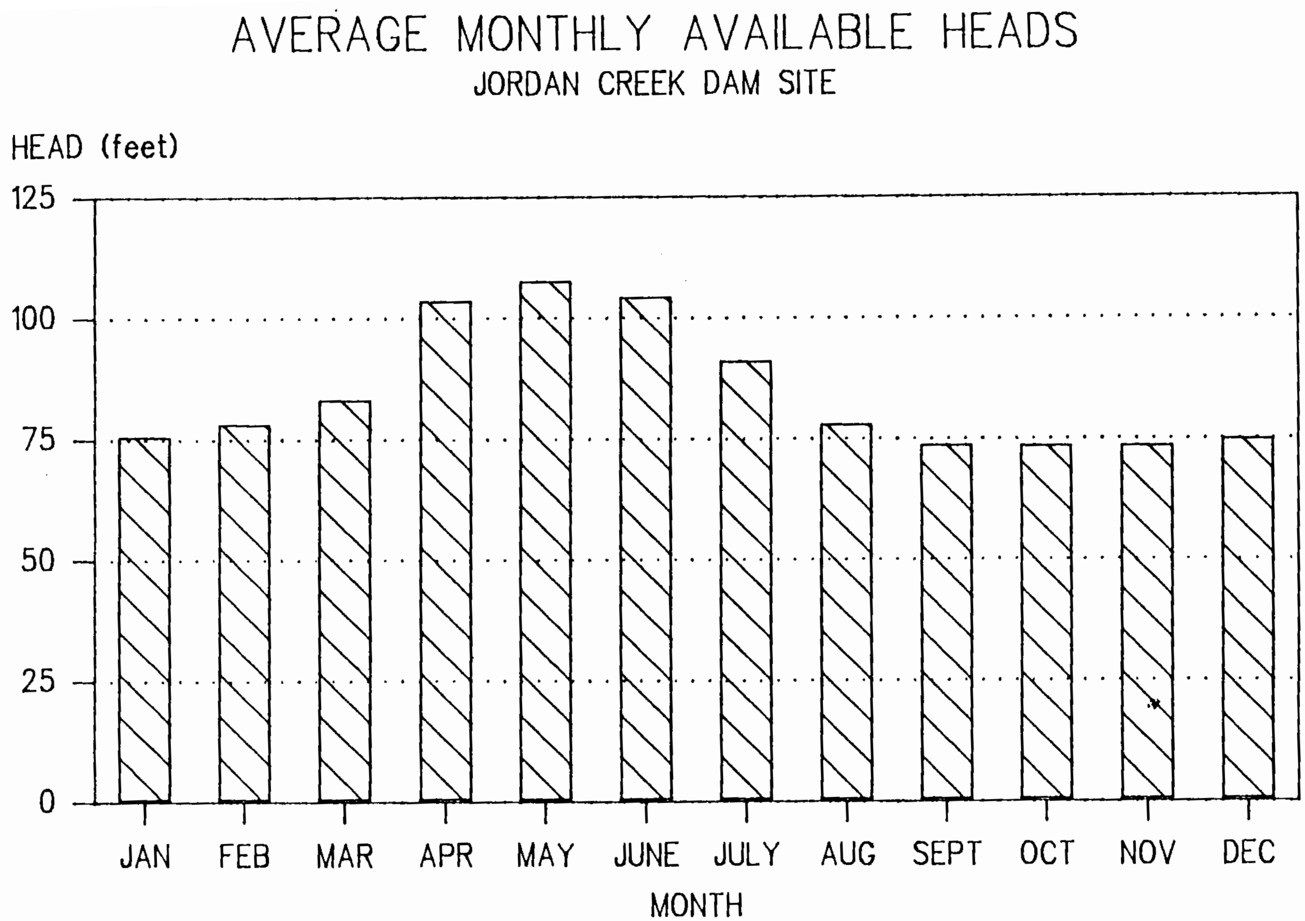

AVERAGE MONTHLY AVAILABLE HEADS
JORDAN CREEK DAM SITE
HEAD (feet)
125
100
75
50
25
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIGURE 3.3

A power plant design head of 82 feet was used, which is equal to 80 percent of the average maximum monthly head of 108 feet, less five percent for head loss. Average annual energy generation was obtained using the formula:

$$E = \frac{Q'h'}{14} \times 8,760 \times 0.95$$

Where:

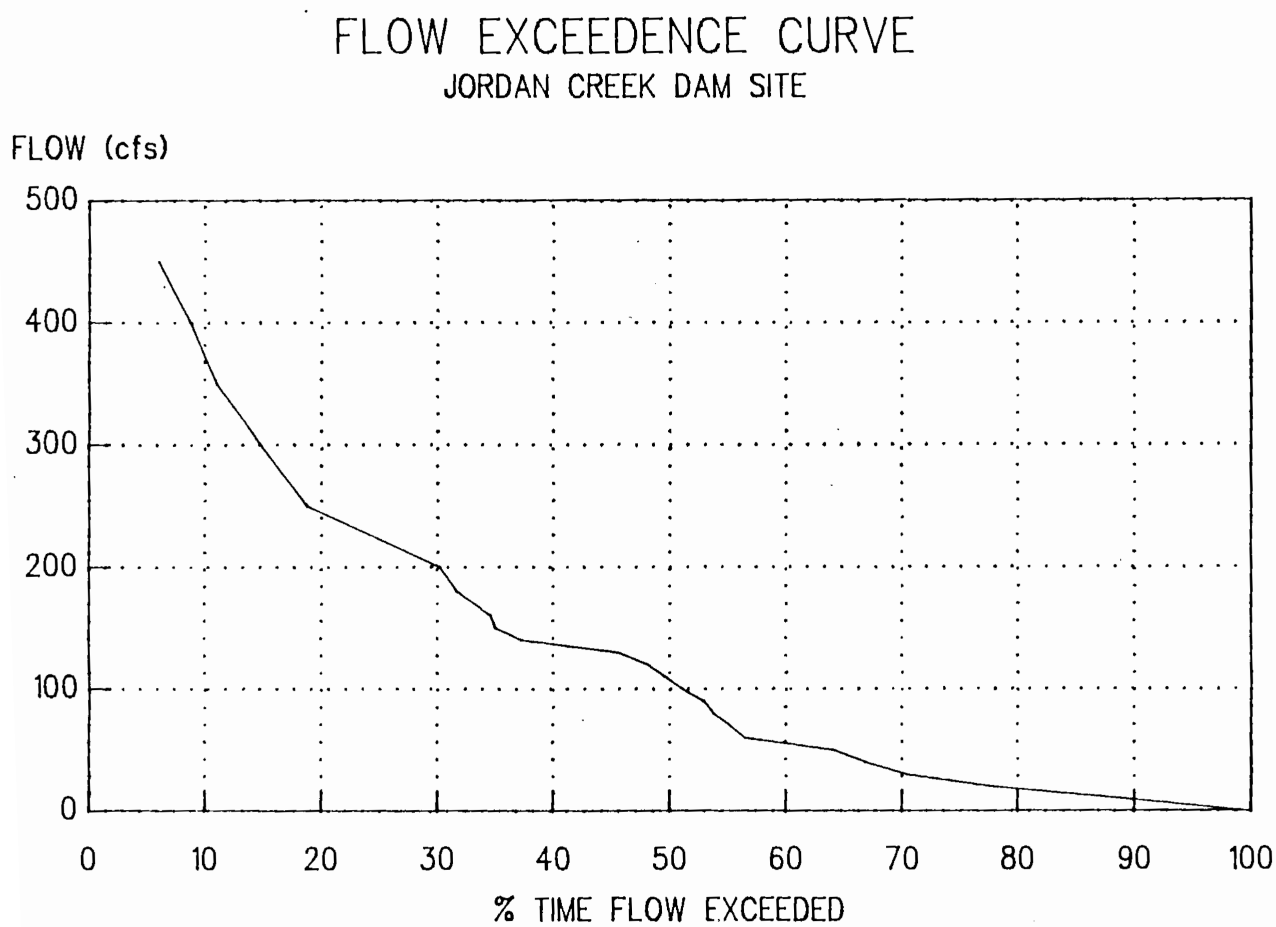
E = average annual energy, in kwh
Q' = average annual power plant flow, cfs
h' = power plant design head, feet

The average annual power plant flow, Q', was determined from the flow-exceedance curve (Figure 3.4) computing the area under the curve between the maximum and minimum power plant flows. The maximum and minimum power plant flows depend on the operating range of the turbine. It was assumed that the minimum power plant flows were 30 percent of the maximum power plant flows.

3.5.3 Selection of Optimum Power Plant Size

To determine the most economical power plant size, average annual energy production was determined for various alternatives using flow duration curves and the net available head. Based on the estimated cost and energy production, the various alternatives were evaluated to determine which had the lowest cost per kilowatt hour.

Two curves were developed, one for a single turbine and another for a double turbine power plant configuration. For a single turbine power plant, a flow corresponding to 30 or 40 percent exceedance, or 137-200 cfs, appears to be the most economical as shown in Figure 3.5. For a double turbine power plant, a flow corresponding to 20 percent exceedance, or 245 cfs, was determined to be the most economical (Figure 3.5). The difference in cost per kilowatt hour between the single and double turbine



FLOW EXCEEDENCE CURVE
JORDAN CREEK DAM SITE
FLOW (cfs)
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME FLOW EXCEEDED

FIGURE 3.4

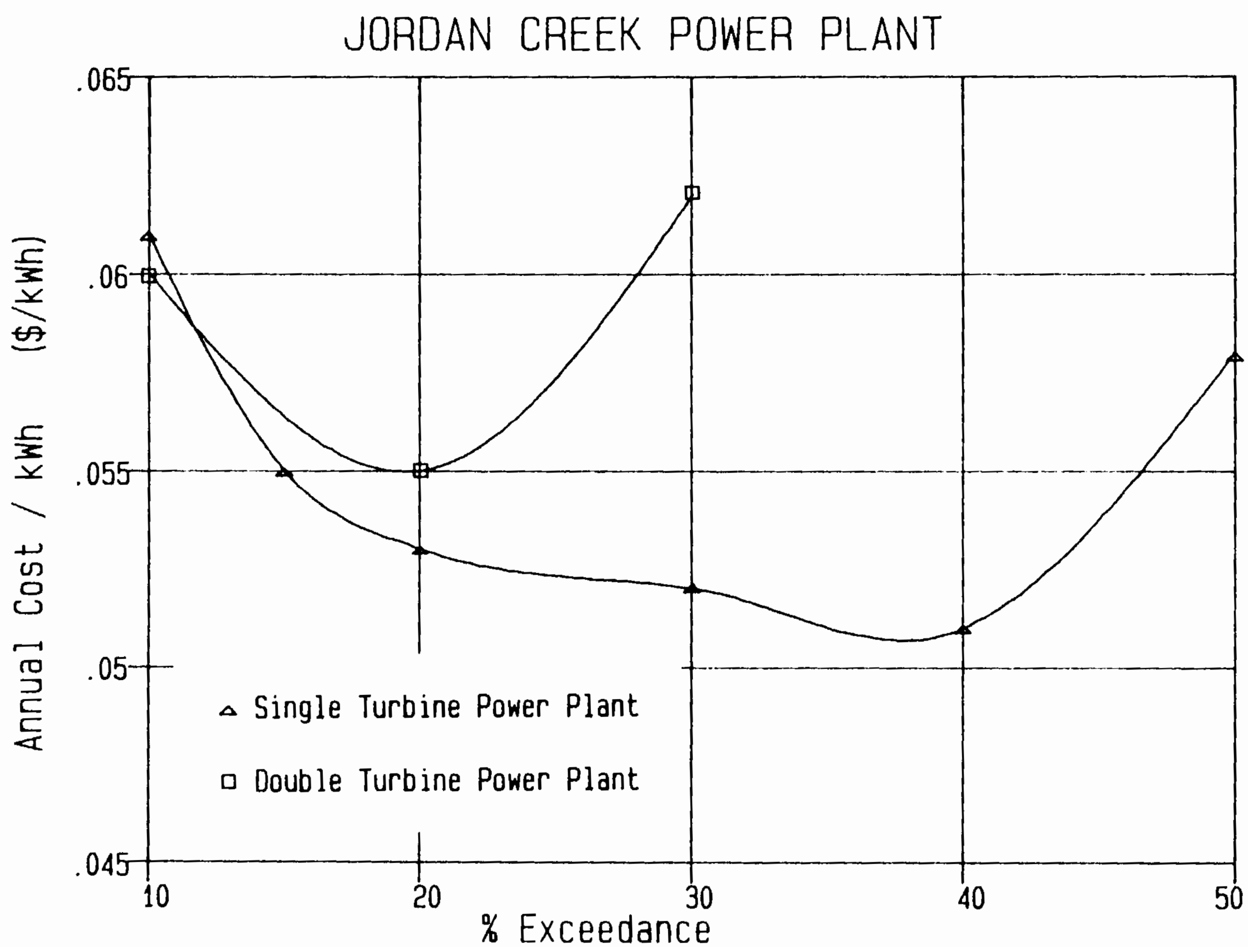

JORDAN CREEK POWER PLANT
Annual Cost / kWh ($/kWh)
.065
.06
.055
.05
.045
10
20
30
40
50
% Exceedance
Single Turbine Power Plant
Double Turbine Power Plant

FIGURE 3.5

power plant was small. Since the double turbine power plant adds more versatility and has a higher capacity and energy production, it was chosen over the single turbine power plant. For this reconnaissance study, the final selection was for two turbines, one having a maximum flow of 160 cfs and the other 85 cfs, for a total design flow of 245 cfs. Total plant capacity was estimated to be approximately 1.43 MW, with with an annual average energy generation of 5,752 Mwh and an estimated cost of $3.02 million.

3.5.4 Power Plant cost Estimates

Cost estimates were obtained using the Electric Power Research Institute's (EPRI) "Simplified Methodology for Economic Screening of Potential Small-Capacity Hydroelectric Sites", and also the "Hydropower Cost Estimating Manual, (May 1979), published by the Corps. Power plants ranging from capacities of 802 kW to 2,200 kW were evaluated using both single and double turbine power plants. The corresponding power plant costs, along with other information, is shown in Table 3.1. It should be noted that these costs do not include cost of transmission line. Capital costs were computed using published cost curves for April, 1979, and were then adjusted to 1987 costs using an escalation factor of 1.50. The escalation factor was calculated using USBR cost indexes. Power plant costs for two turbines were adjusted since multiple unit powerhouses cost less than building multiple single-unit houses. In this case, a multiple unit factor of 1.60 was used for the powerhouse, and all other costs were assumed to be the same as for a single unit power plant.

3.6 Cost Estimate

A reconnaissance level construction cost estimate was prepared for the Jordan Creek Dam project. The cost estimate was derived from the bid item list representing quantities for major work items necessary to construct the project. Unit costs were assigned to each bid item based on recent construction bids and MKE's experience with similar work and cost curves for the hydropower facilities. The estimates were prepared in 1987 dollars and no adjustments were made for escalation or inflation. A 25 percent contingency factor was added to the cost estimate. The bid item is presented in Appendix B. The estimated cost to construct Jordan Creek Dam ranges from $13,~~031~~733,000 with no power facilities to $17,~~273~~520,000 including a 1.43 mw power plant.

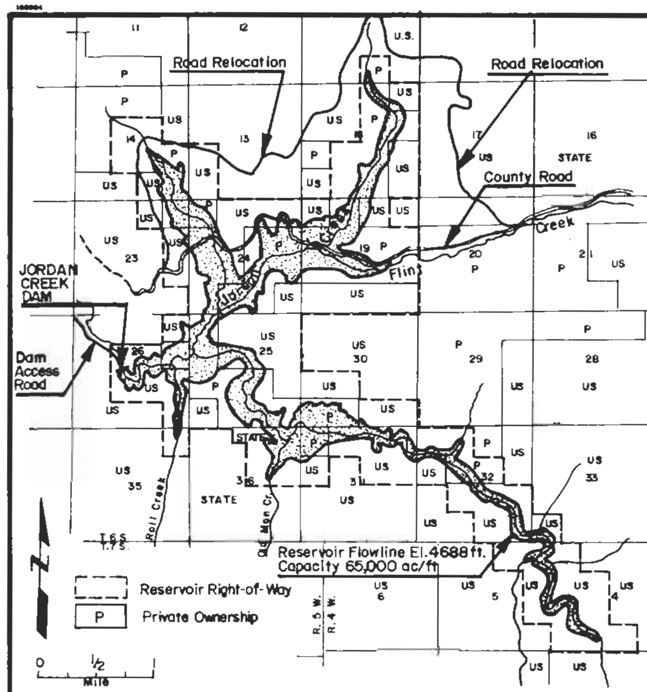
JORDAN CREEK DAMSITE
HYDROELECTRIC COST SUMMARY

	Flow Range (cfs) Maximum	Minimum	Power Plant Head (feet)	Power Plant Capacity (kW)	Average Annual Energy Generation (MWh)	Capital Cost (million $)	Annual Cost ($)	Annual Cost/kWh ($/kWh)
SINGLE TURBINE								
10% EXCEEDENCE	375	112	82	2,200	5,950	3.45	362,361	$0.061
15% EXCEEDENCE	300	90	82	1,760	5,459	2.85	299,342	$0.055
20% EXCEEDENCE	245	73	82	1,430	5,020	2.55	267,832	$0.053
30% EXCEEDENCE	200	60	82	1,170	4,572	2.25	236,323	$0.052
40% EXCEEDENCE	137	41	82	802	3,851	1.88	197,461	$0.051
50% EXCEEDENCE	110	33	82	644	3,266	1.80	189,058	$0.058
DOUBLE TURBINE								
10% EXCEEDENCE (245 cfs & 130 cfs)	375	43	82	2,200	6,580	3.77	395,972	$0.060
20% EXCEEDENCE (160 cfs & 85 cfs)	245	30	82	1,430	5,752	3.02	317,198	$0.055
30% EXCEEDENCE (130 cfs & 70 cfs) TOTAL 200 CFS	200	25	82	1,170	4,923	2.92	306,694	$0.062

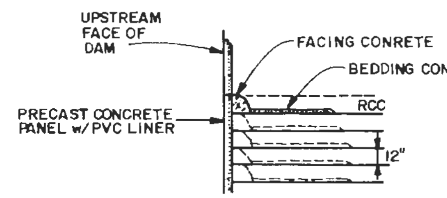
NOTE: Costs Are For Power Facilities Only - Does Not Include Dam.
Operation and Maintainance Assumed at 1.5% of Capital Cost
Assumes a 50 Year Project Life

TABLE 3.1

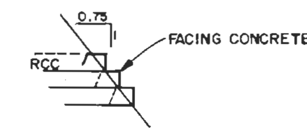
A determination of total project cost was beyond the scope of this study. If the project were to be carried forward a new feasibility study would have to be performed in which the cost of archeological surveys, mining claim examination, property acquisition, fishery enhancement, wildlife mitigation, and recreational facilities would need to be considered. In addition, cost allocations would have to be made for a complete geotechnical evaluation of the foundation and construction materials, an RCC trial mix program, final design, and construction management.



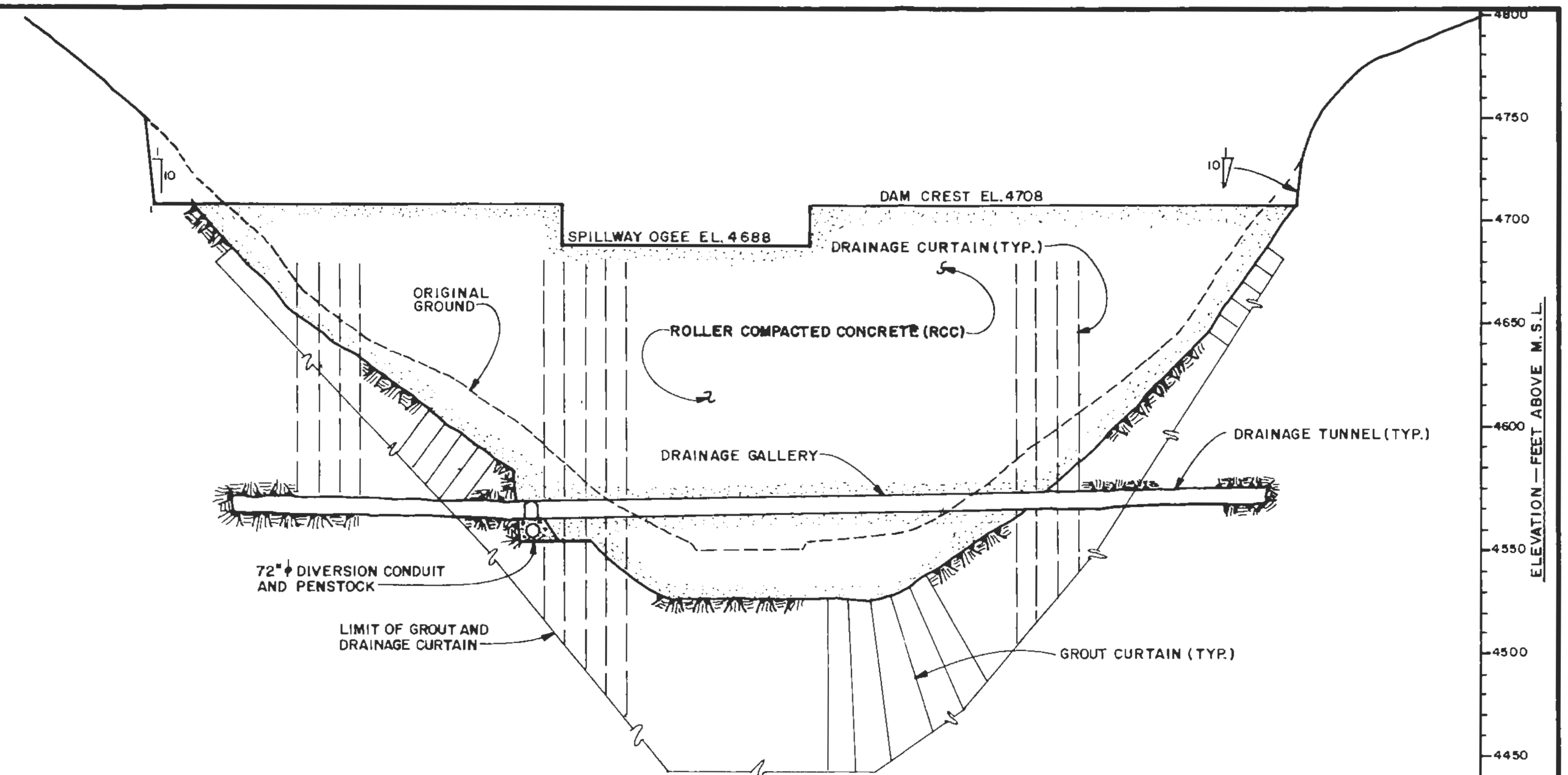
RESERVOIR & PROPERTY OWNERSHIP MAP



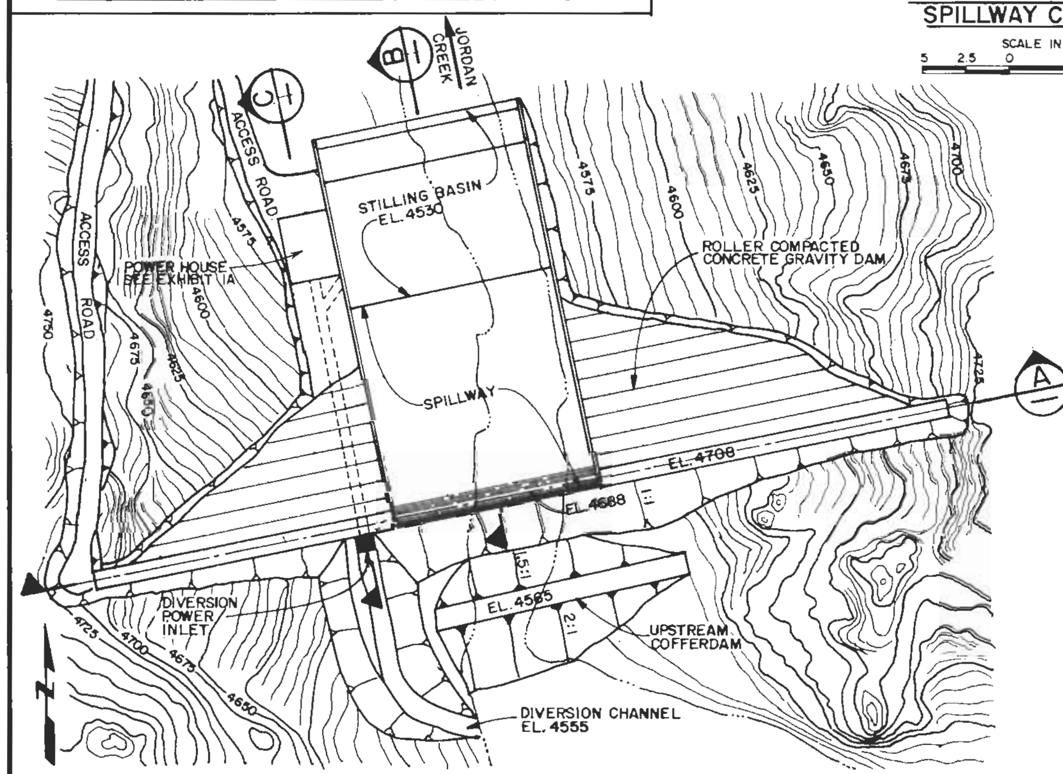
DETAIL 1
UPSTREAM FACE
SCALE IN FEET
5 2.5 0 5 10



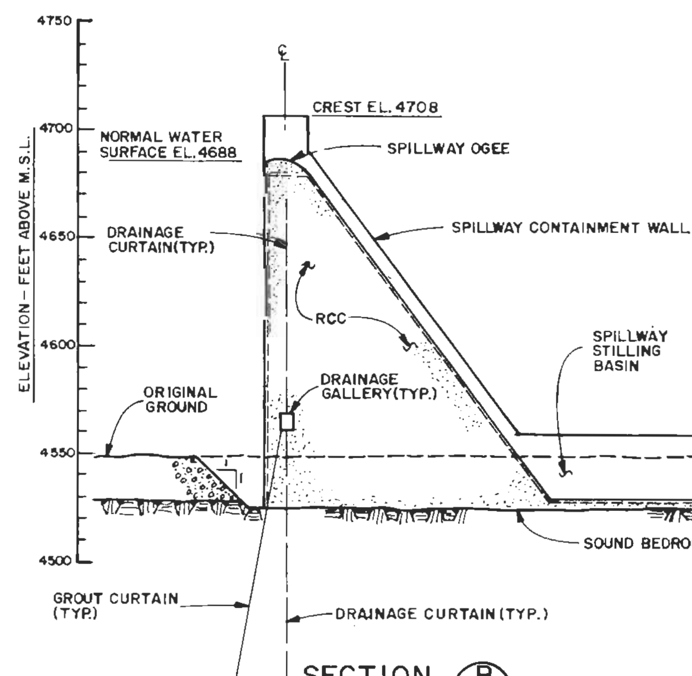
DETAIL 2
DOWNSTREAM FACE & SPILLWAY CHUTE
SCALE IN FEET
5 2.5 0 5 10



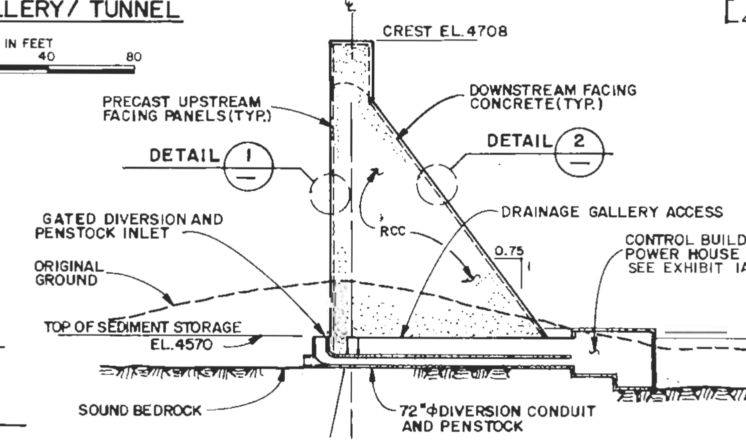
SECTION A
DRAINAGE GALLERY/ TUNNEL
SCALE IN FEET
40 20 0 40 80



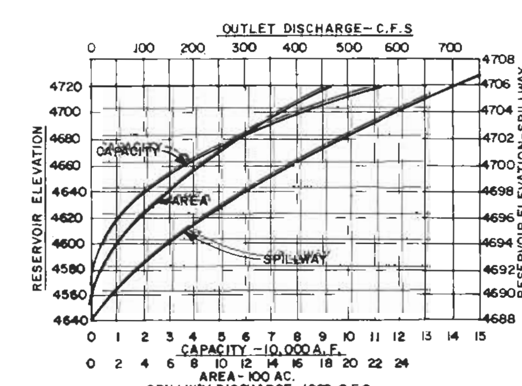
PLAN
SCALE IN FEET
50 25 0 50 100



SECTION B
MAXIMUM DAM SECTION / SPILLWAY
SCALE IN FEET
40 20 0 40 80



SECTION C
DIVERSION CONDUIT/ PENSTOCK & POWER HOUSE
SCALE IN FEET
40 20 0 40 80



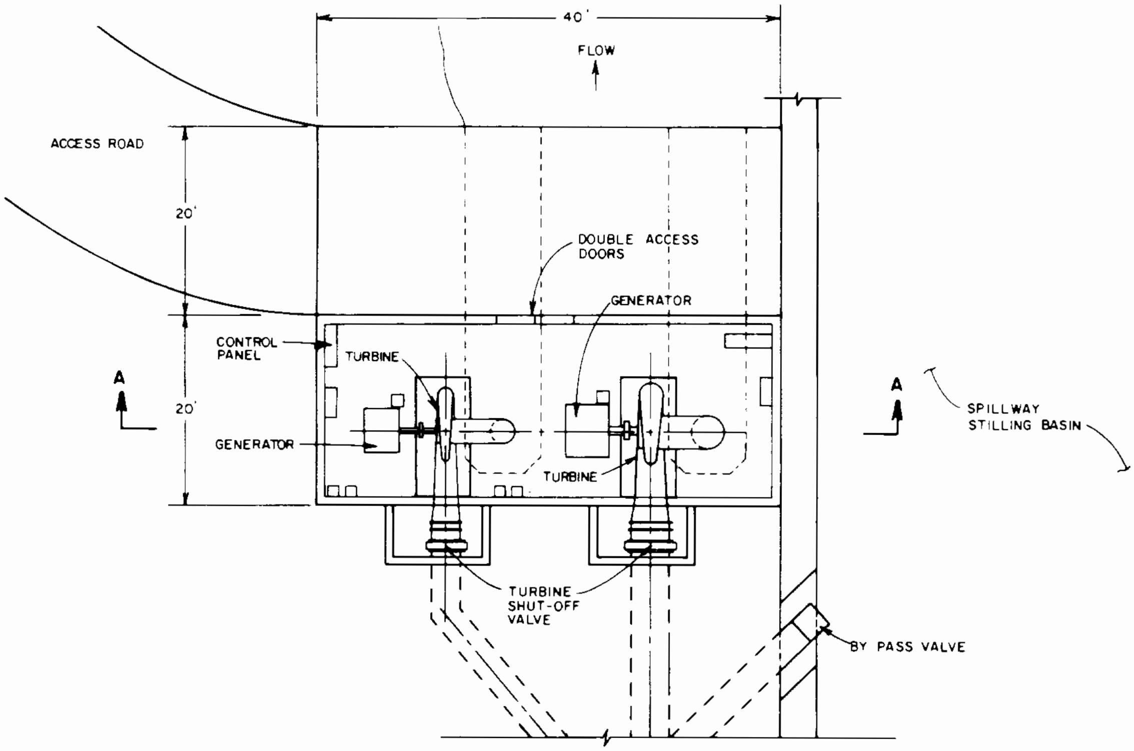
AREA, CAPACITY AND DISCHARGE CURVES

CORPS OF ENGINEERS
JORDAN CREEK RECON. STUDY

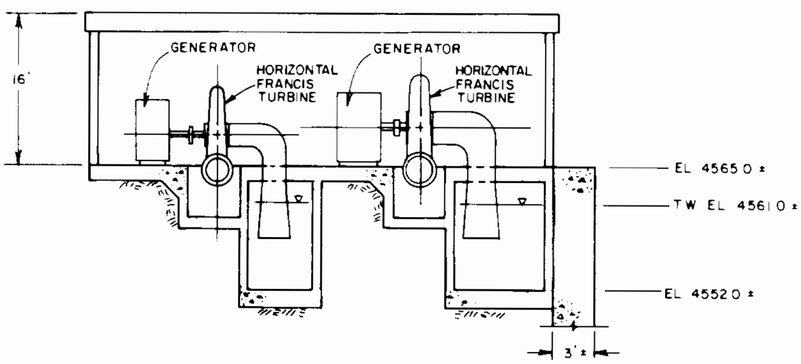
JORDAN CREEK DAM
PLAN AND SECTIONS

DRAWN BY:	DATE	SCALE: AS SHOWN	EXHIBIT NO.
APP'D BY:		DATE: MAY, 1987	1
DESIGN BY: W.M.	DATE	DWG. NO.:	
APP'D BY:			

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY



PLAN



SECTION A-A

CORPS OF ENGINEERS
JORDAN CREEK RECON. STUDY

JORDAN CREEK DAM
POWER HOUSE FACILITY DETAIL

DRAWN BY: B.R.M.	DATE	SCALE: NOT TO SCALE	EXHIBIT NO.
APP'D BY:		DATE: MAY, 1987	I A
DESIGN BY: J.B.	DATE	DWG. NO.:	
APP'D BY:			

MORRISON-KNUDSEN ENGINEERS, INC.
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SECTION 4.0

ANTELOPE FEEDER CANAL

4.1 General

The Antelope Feeder canal is currently being used to direct water from Jordan Creek into Antelope Reservoir. The canal is approximately 20 miles long and was originally constructed with horse-drawn equipment. Construction was performed on the contour, therefore, the canal is very crooked and at several locations has sharp curves which restrict flow. The canal cross section varies greatly. The upper reach of the canal below the diversion dam currently has a slope of about 0.001 ft/ft with the remainder of the canal ranging from 0.0001 to 0.0008 ft/ft. The current capacity of the canal is limited to approximately 550 cfs due to a few flat reaches and the very sharp bends. The proposed plan is to enlarge the capacity of the canal to 1,000 cfs. This would aid in flood control on Jordan Creek and also provide additional water to Antelope Reservoir for irrigation. Increasing the flow in the canal would require straightening and enlarging the canal. Field observations reveal that there is a measurable amount of seepage in some areas. For this reason, it would also be beneficial to replace the existing bank with a compacted, more impervious embankment in those critical areas. Two alternative canal alignments were also evaluated. The first would eliminate that section of canal north of Highway 95. The new canal would follow the highway along the south side. The second alternative would be to cut directly across to the reservoir approximately two miles southeast of Highway 95. The two alternate alignments are shown on Exhibit 2.

The diversion dam and canal headworks would also have to be modified for the new canal. Presently, the canal headworks and diversion dam are two separate units. A new single unit diversion dam and headworks is proposed as part of the enlargement of the canal.

4.2 Design Criteria

4.2.1 Design Flows

The new canal diversion dam was designed to pass the fifty-year flood with 1,000 cfs routed to the canal. Design flows were developed from a USGS stream gage located on Jordan Creek near Lone Tree Creek (13178000). The fifty-year flood at this location was adjusted upward to account for the larger drainage area at the diversion dam and headworks, which was approximately 476 square miles as compared to 440 square miles at the gaging station. The method used to adjust the flows was based on information in "Magnitude and Frequency of Floods in Eastern Oregon", a USGS Water Resources investigation report.

Values computed for the different flood return periods at the diversion dam are presented below:

DISCHARGE, CFS

FLOOD RETURN PERIOD YEARS	FLOOD FLOW
2	2,100
5	3,320
10	4,240
25	5,520
50	6,570
100	7,680

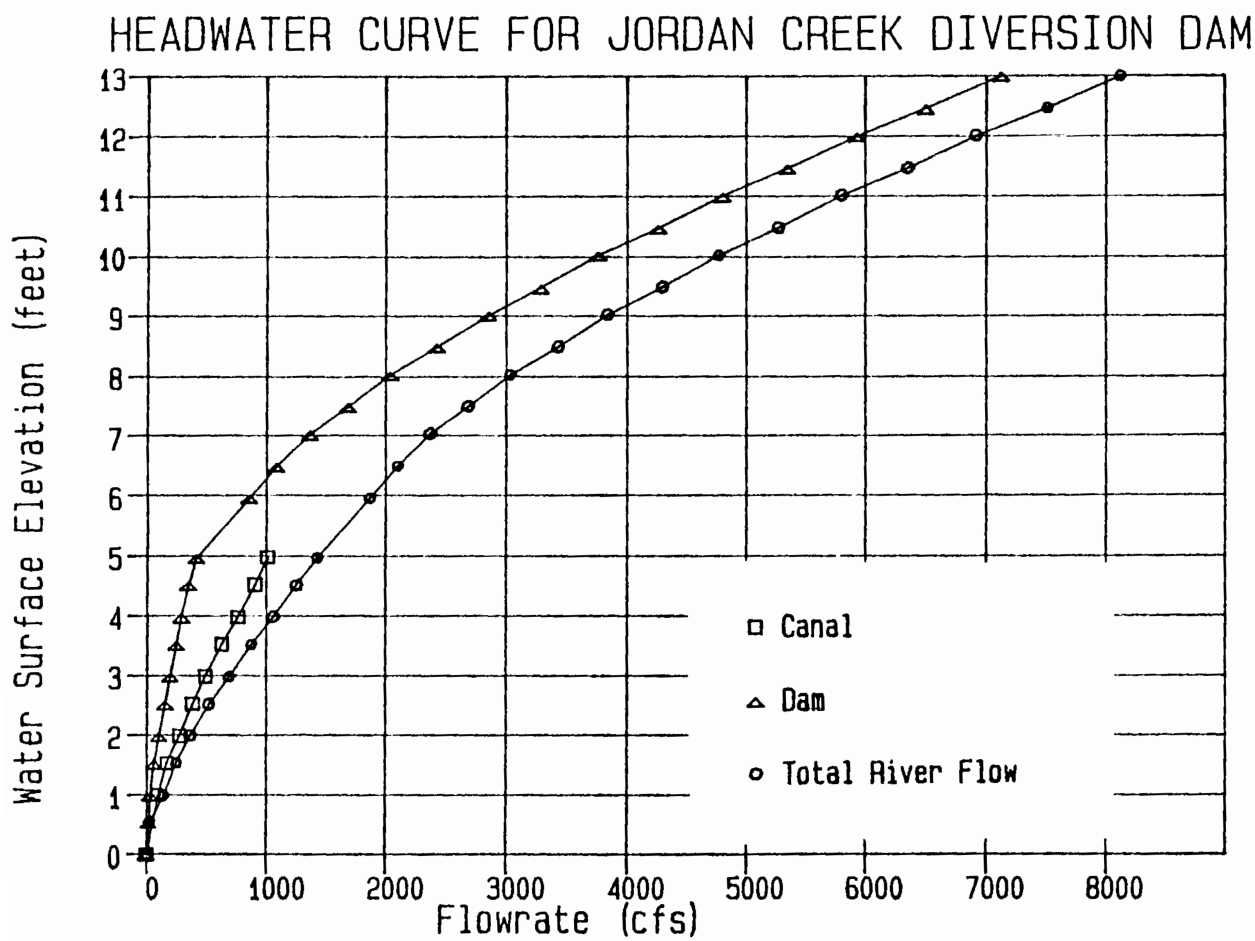
4.2.2 Conceptual Design

a) Diversion Dam and Headworks - The assumptions used in designing the diversion dam, headworks, and canals are presented below. The upstream water surface elevation above the diversion dam was computed using a discharge coefficient of 3.9 over the ogee crest. The shape of the ogee section was computed using the formula $X^2 = 2HY$, where X is the horizontal distance from the dam center line, Y is the distance below the crest, and H is the total head above the crest. The downstream concrete stilling basin length of forty feet was calculated using the USBR standard for "Basin II" stilling basins. A 25-foot riprap apron would be placed at the end of the concrete stilling basin. A proposed layout and sections are shown on Exhibits 2 and 3.

The diversion dam and headworks were designed giving consideration to current water rights needs. Prior to April 1, the canal would be given priority for everything up to 1,000 cfs. After April 1, approximately 92 cfs must be passed down the river, with the remaining available to the canal. Figure 4.1 shows the headwater versus discharge for the canal diversion. It is proposed that sluice gates be installed to regulate the flows. The gates were sized using a weir coefficient of 2.63. The ogee sections below the gates were calculated using the formula $X^2 = 4HY$, where X, H, and Y are defined above. This formula produces a flatter ogee which is needed to match the water jet coming from under the bottom of the sluice gates. The stilling basin length and riprap apron were designed the same as for the diversion dam explained above.

b) Canal - The canal was designed to utilize the existing slope and minimize excavation requirements. A slope of 0.001 ft/ft and bottom width of 26 feet was used for the first 3.5 miles below the canal headworks and a slope of 0.0005 ft/ft and bottom width of of 30 feet was used for the remaining canal alignment. The canal would be trapezoidal in cross section with side slopes of 2H to 1V. Velocities were calculated to be approximately 4.8 feet per second for the upper section and 3.7 feet per second for the lower section. These values are within the acceptable velocity range for soils with some clay content. A Manning's roughness coefficient, "n", of 0.025 was used in the design of the canal. Typical canal sections are shown on Exhibit 3.

The Jordan Valley Irrigation District (JUID) currently has underway a program of cleaning, reshaping, and reconstructing various sections of the Antelope Feeder Canal. This work will help increase the capacity of the Antelope Feeder Canal by removing many of the restrictions at



HEADWATER CURVE FOR JORDAN CREEK DIVERSION DAM
Water Surface Elevation (feet)
Flowrate (cfs)
0
1000
2000
3000
4000
5000
6000
7000
8000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Canal
Dam
Total River Flow

FIGURE 4.1

the sharp bends and sand deposits which have built up over the years. The proposed canal design cross-sections presented in this report are based on what the irrigation district is planning for the rehabilitation work.

Excavation requirements for the two alternate canal alignments were computed assuming a ten foot horizontal bench would be placed at vertical intervals of 35 feet on the sidewalls. A side slope of 2:1 was assumed. A typical cross-section for deep canal is shown on Figure 4.2.

As shown below, the excavation required for either of the two alternate alignments would exceed the amount required for enlarging the existing canal. One reason for realigning the canal would be to eliminate the two highway crossings. These two bridges across the Antelope Feeder Canal were recently replaced (1984). The bridges were designed to pass 600 cfs during normal operation with 3.2 and 3.7 feet of freeboard for the South and North crossings, respectively. The designs were checked and the bridges would be able to pass 900 cfs with freeboard of 2.0 feet for both the South and North crossings. It was assumed that the section could be modified slightly to increase the capacity to the required 1,000 cfs without constructing new bridges. Therefore, the most economical alternative would be to enlarge the existing alignment.

CANAL EXCAVATION

ALIGNMENT	QUANTITY C.Y.
Existing	245,000
(assumes 25% of canal is rebuilt)	
"A"	1,500,000
"B"	10,000,000

TYPICAL CANAL SECTION
DEEP CUT

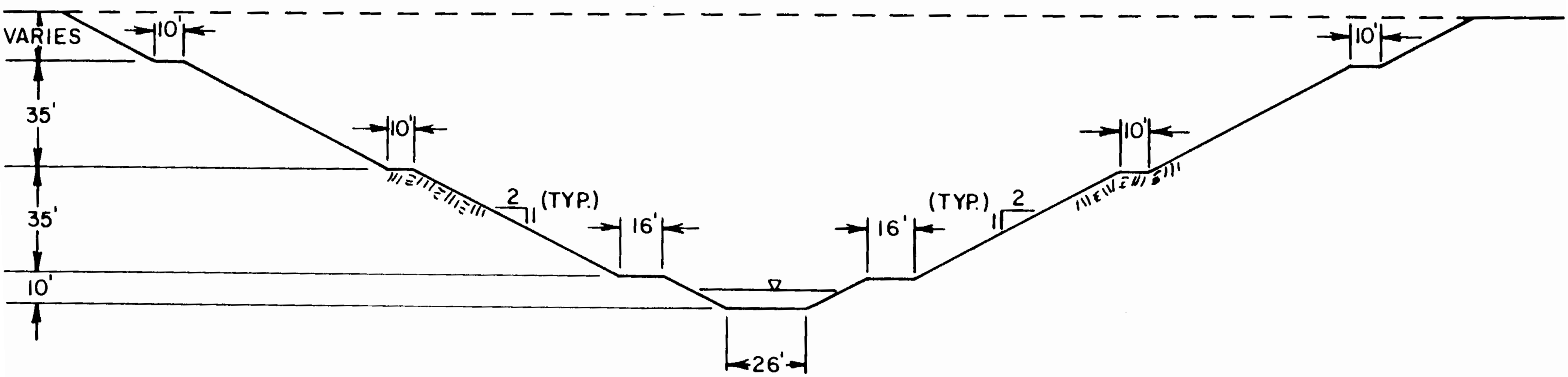


FIGURE 4.2

4.3 Cost Estimate

Cost estimates were developed for all three canal alternatives and are presented below. Information from actual past projects, MKE files, and USBR projects with similar work was used to develop units prices. The construction costs were estimated on the basis of computed quantities or work, to which the unit prices were applied. The quantities were calculated on the basis of the drawings, which are presented as exhibits. The estimates were prepared in 1987 dollars and no adjustments have been made for escalation or inflation.

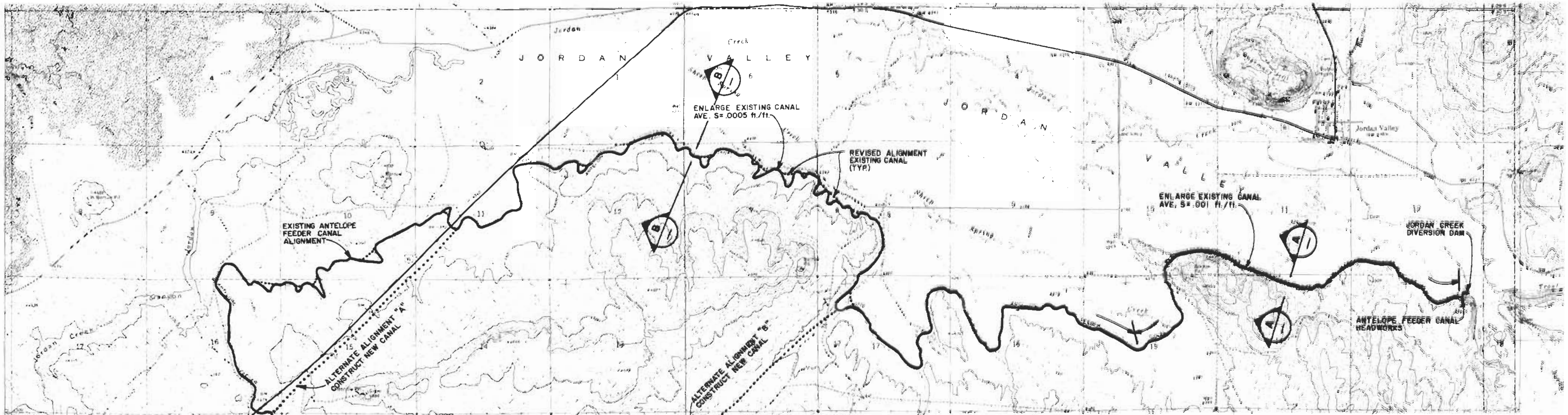
ANTELOPE FEEDER CANAL

COST SUMMARY

1. Present Alignment:	
10% Reconstruction	$ 1,539,640
25% Reconstruction	1,875,270
2. Alignment "A"	3,973,850
3. Alignment "B"	18,412,350

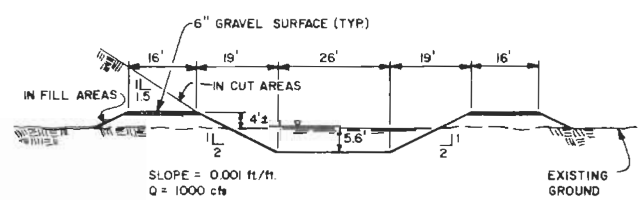
Note:

With the current rehabilitation program of the JUID, the canal will be able to handle the increased flows with only minor additional work. The ten percent reconstruction was assumed as a minimum. An estimate of 25% reconstruction was assumed as a maximum.



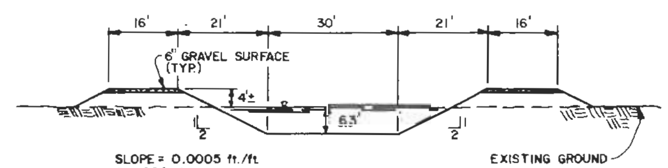
ANTELOPE FEEDER CANAL ALIGNMENT

SCALE IN FEET
2000 1000 0 2000 4000



CANAL SECTION A

SCALE IN FEET
20 10 0 20 40



CANAL SECTION B

SCALE IN FEET
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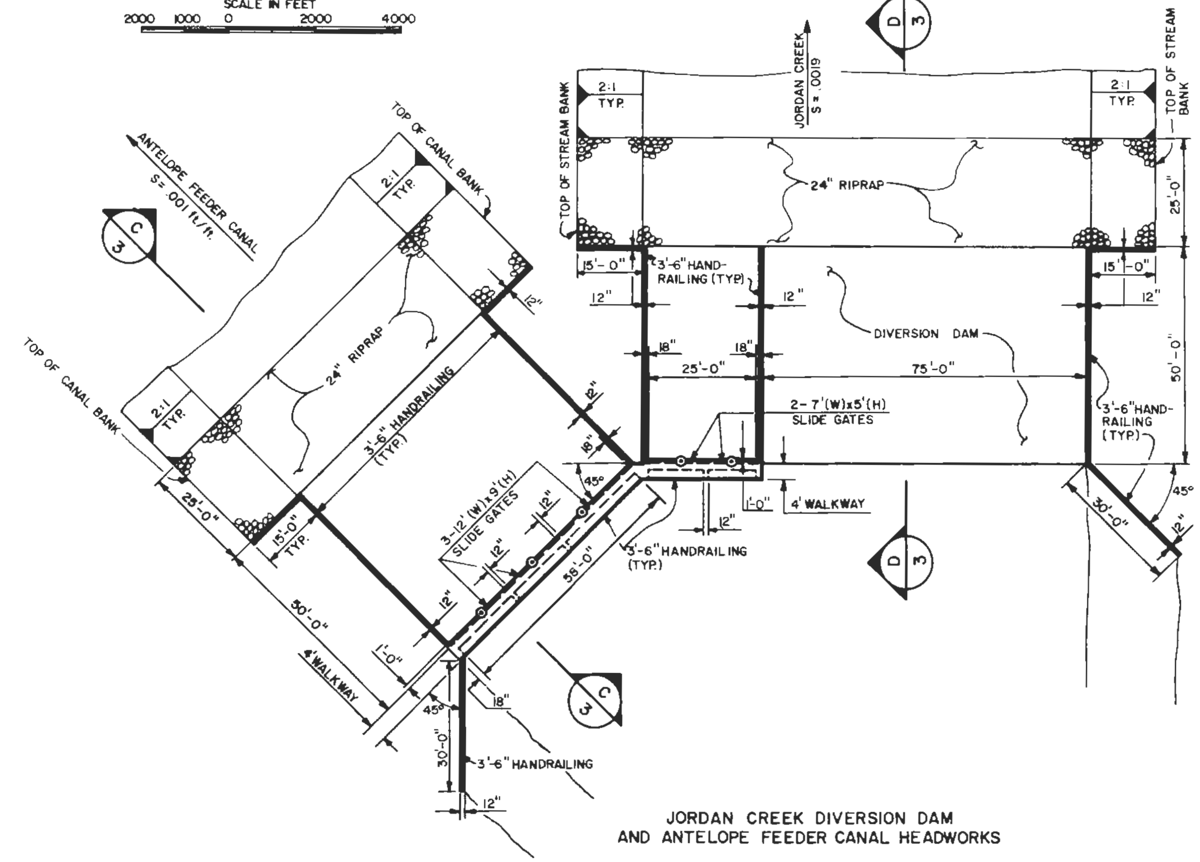

JORDAN CREEK DIVERSION DAM AND ANTELOPE FEEDER CANAL HEADWORKS

SCALE IN FEET
20 10 0 20 40

CORPS OF ENGINEERS
JORDAN CREEK RECON. STUDY

ANTELOPE CANAL
SHEET 1 OF 2

DRAWN BY: GGM	DATE	SCALE	EXHIBIT NO.
APP'D BY:			
DESIGN BY: DP	DATE	DATE MAY, 1987	2
APP'D BY:		DWG. NO.	

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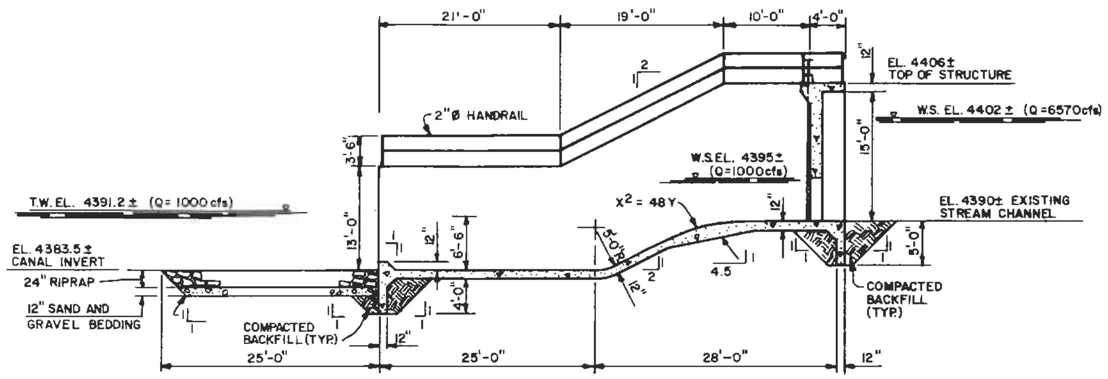
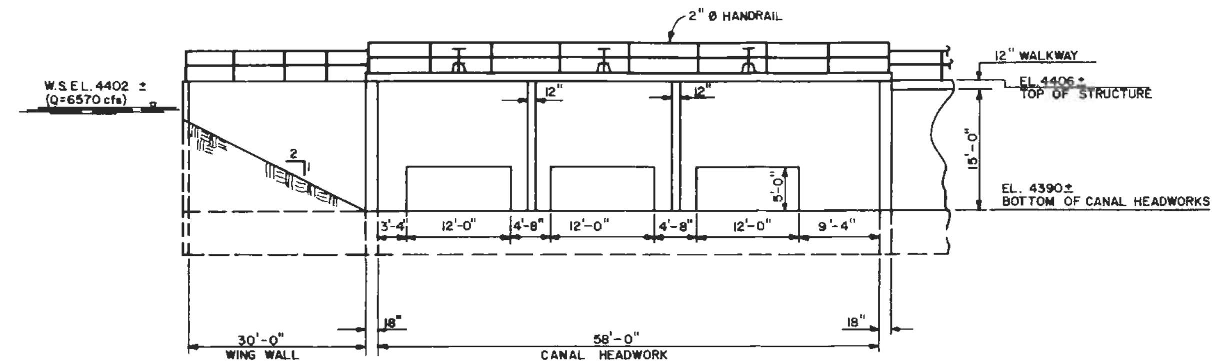
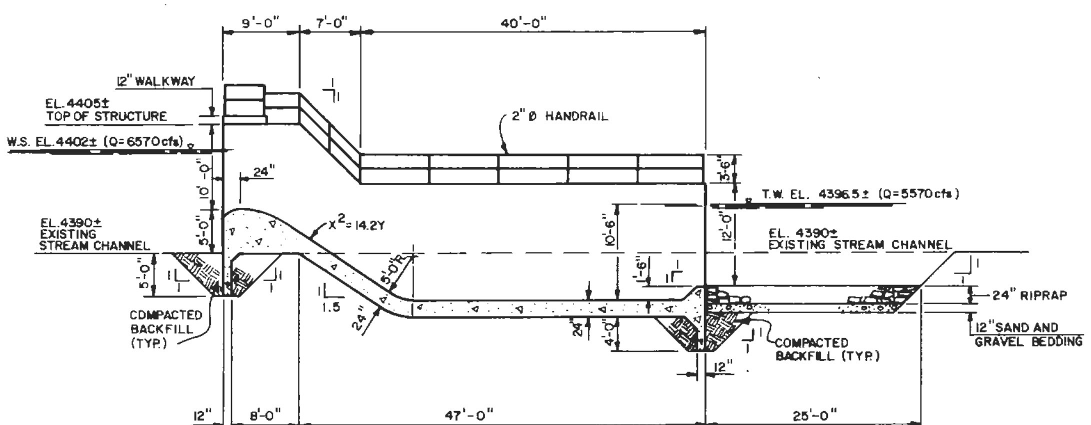


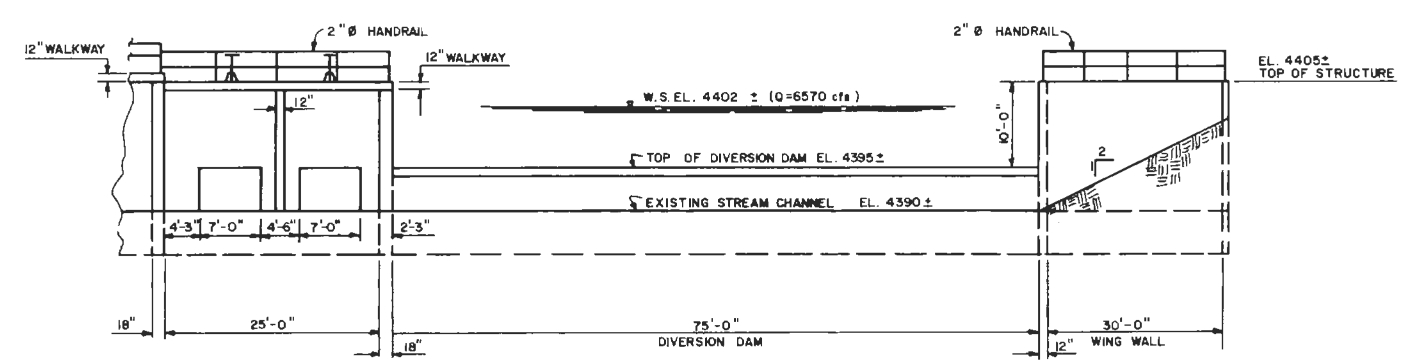
CROSS SECTION C/2
HEADWORKS



ANTELOPE FEEDER CANAL HEADWORKS
U/S ELEVATION



CROSS SECTION D/2
DIVERSION DAM



JORDAN CREEK DIVERSION DAM
U/S ELEVATION

SCALE IN FEET
10 5 0 10 20

CORPS OF ENGINEERS
JORDAN CREEK RECON. STUDY

ANTELOPE CANAL
SHEET 2 OF 2

DRAWN BY: GGM	DATE	SCALE:	EXHIBIT NO
APP'D BY:		DATE: MAY, 1987	3
DESIGN BY: DP	DATE	DWG. NO.:	
APP'D. BY:			

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

SECTION 5.0
ANTELOPE DAM ENLARGEMENT

5.1 General

Antelope Dam is located on Jack Creek in Section 32, Township 30 South, Range 45 East, W.M., approximately eleven miles to the southwest of Jordan Valley, Oregon. It is classified as a large, high-hazard dam by the State of Oregon. The dam is an engineered earthfill structure composed of compacted sandy silt core material armored with gravel and rip rap filter blankets. The crest width at elevation 4,203.5 is 24 feet with a length of approximately 640 feet. Embankment slopes are 2.75:1 upstream and 2:1 downstream. The reservoir has a storage capacity of 70,000 acre-feet. (Note: Elevations used in the report are based on information from the Phase I Dam Safety Report provided by the Oregon Water Resources Department and appears to be on a different datum than the USGS quad sheets.)

The spillway for Antelope Dam is a rock cut, trapezoidal channel in the right abutment. It has a base width of 36 feet and side slopes of 2:1 at the control section with an elevation of 4,197.9.

The outlet works consist of a five-foot by six-foot concrete lined tunnel located in the left abutment. The tunnel is approximately 300 feet in length and discharges into a rock-lined stilling basin. The stilling basin feeds the diversion structure for Jack Creek and an irrigation canal. Flow quantities are regulated by a centrally located control tower which controls two slide gates in the gate chamber.

Enlargement designs have been prepared for Antelope Dam to increase its capacity from 70,000 acre feet to 110,000 acre feet. Designs include raising the dam to provide the additional 40,000 acre feet of storage, raising the spillway control section, and raising the control tower. It should be noted that designs and cost estimates are at a reconnaissance level of detail and are based upon existing data.

5.2 Hydrology

The general storm and thunderstorm probable maximum floods (PMF) were provided in the Oregon Water Resources Department (OWRD) inspection report for Antelope Dam dated September 24, 1980. The thunderstorm PMF of 50,511 cfs was used for the designs since it was the largest of the two storms.

The OWRD inspection report stated that by routing the PMP through the reservoir the spillway design flood would be 1562 cfs, assuming that the reservoir was full at the start of the PMF. This peak flow design of 1562 cfs is conservative since the attenuation of peak inflow should be greater due to the additional surface area and storage volume provided by the dam enlargement. The spillway design capacity was based upon this peak flow.

Another hydrologic requirement was to provide an additional 40,000 acre feet of storage. This requires raising the spillway elevation to increase the total storage to 110,000 acre feet. The new maximum pool elevation would be 4,210 which is shown on Figure 5.1. This required raising the spillway approximately 12 feet.

5.3 Dam Design

By raising the dam crest to elevation 4,219 feet, adequate freeboard would be provided to pass the PMF across the spillway. The conceptual enlargement of the dam could be achieved by continuing the upstream face upward at a 2.75:1 slope and keeping the crest at a 24-foot width at elevation 4,219 feet MSL. The downstream slope would remain at 2:1. It is proposed that a rip rap ballast be constructed in the central portion of the dam toe. Conceptual dimensions are presented in Exhibit 4.

Slope stability analyses were preformed to assure the conceptual design would be safe. Physical properties were taken form the Oregon Water Resources Department report on Antelope Dam. Total and effective stress conditions were evaluated. Physical properties used for each material are illustrated in Table 5.1. Effective stress conditions for rapid drawdown and earthquake loading conditions developed the lowest factors of safety (FOS). The FOS for earthquake loadings on the downstream face was 1.12

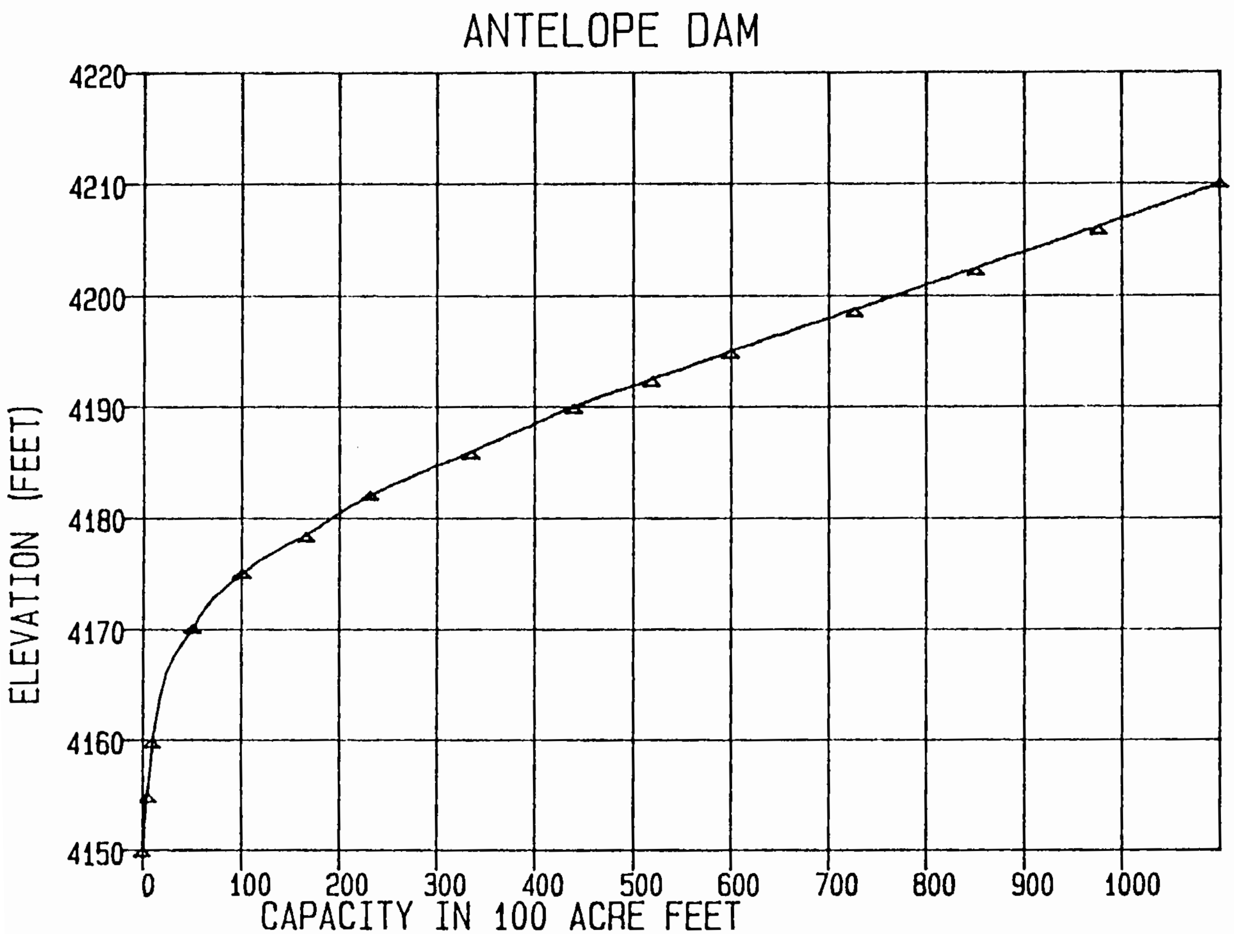

ANTELOPE DAM
ELEVATION (FEET)
4220
4210
4200
4190
4180
4170
4160
4150
0
100
200
300
400
500
600
700
800
900
1000
CAPACITY IN 100 ACRE FEET

FIGURE 5.1

with the riprap ballast and 0.97 without the ballast. The rapid drawdown condition on the upstream face created a FOS of 1.29. While the upstream face would be stable with the original slope, it is proposed that the downstream slope be constructed with a riprap ballast to assure safe conditions.

TABLE 5.1

SOIL TYPE		Ø	C	O'	C'	SET
COMMON	USGS	DEG	PSF	DEG	PSF	PCF
SANDY SILT	ML-SM	0	1,500	31	200	120
GRAVEL	GW	36	0	36	-	140
ROCK RIPRAP		36	0	36	-	140

Foundation conditions for the dam were estimated from the 1923 drawings. For conservative estimates on slope stability, the bedrock was assumed to be 20 feet below the ground surface, although it appears to be considerably shallower. The foundation drawing from 1923 shows that the bedrock was shallow enough for construction of a concrete cutoff wall to be installed into bedrock. Overlying the bedrock is a hardpan which was cleaned and roughened for a well-bonded interface between the engineered core material and bedrock. No phreatic water surface is illustrated in these drawings.

A typical cross-section, showing the existing and proposed dam is illustrated in Exhibit 4. The section consists primarily of an engineered sandy-silt core material and a gravel and riprap filter blankets and toe drain. The central portion of the tow includes some additional riprap ballast for slope stabilization.

The material borrow areas are located on Exhibit 4. The areas appear to contain adequate quantities of sandy silt, gravel, and riprap to expand the dam to the conceptual dimensions.

The existing control tower will need to be extended to be operable with the increase in reservoir storage. It is assumed that the existing facility is capable of supporting the additional 12 feet of structure. Extension materials required include reinforced rectangular conduit, two drive stems, and a new surface cap for the tower. Other possible materials include rip rap for the walkway from the dam crest. It is envisioned that the existing tower would be extended without need for rehabilitation to the existing structure.

5.4 Reservoir Leakage

There are two primary faults located near the dam that appear to continue into the reservoir where cavities have developed. While the faults are cited as inactive, some concern does exist due to the development of cavernous areas in the reservoir bottom which are a source of substantial water loss. These cavernous areas have been most recently cited as moving away from the dam, and yet prior reports claimed they were moving towards the dam.

An alternative cause of the problem might be seepage into cavities caused by tubes or sag flow-outs in the volcanic bedrock rather than faults. If so, the seepage might not pose a threat to the safety of the dam.

What is needed is an in-depth geotechnical evaluation of the problem. The objective would be to determine the nature of the cavities, their cause, and to delineate the area affected and to accurately estimate leakage. The study would have to include subsurface exploration by boreholes and trenching.

The solution that has been selected and used in the past to reduce seepage might be effective if applied over a large enough area. This method excavated surrounding loose material, followed by backfilling with compacted material, in sequence of rock, gravel and the soil. A plastic membrane was placed about two feet below the surface and covered with a final layer of soil. An alternative solution, and potentially expensive one, would be to try grouting the cavities. Another alternative if bedrock is not too deep would be to excavate the surface of the fault and construct an engineered backfill similar to what has been done in the past, or seal the surface with concrete.

5.5 Hydropower

With the enlargement of Antelope Dam, the possibility of adding hydropower was evaluated. The power plant would be located at the base of the dam and would be connected to the existing outlet works. It was assumed that a five foot diameter steel liner would be installed inside of the existing outlet and grouted to provide a pressure conduit for the new power facilities. Since the releases are dedicated to irrigation, it was also assumed that the operation of the reservoir would not change.

5.5.1 Stream Flow and Reservoir Content

Stream flow data for the proposed hydroelectric plant at the Antelope Reservoir Dam site was obtained from the 1973 USBR Jordan Creek Study. Actual outflow data from gaging stations located below Antelope Reservoir for Jack Creek and South Antelope Canal were also obtained from the Oregon Water Resources Department. This information was used only as a check for the USBR data. The reservoir outflow from the USBR's study was computed from consumptive use calculations, and included irrigation efficiencies and canal losses.

Two hydroplant evaluations were performed; the first using existing outflow data from the 1973 USBR study, and second, assuming that the enlarged reservoir and feeder canal would provide additional carry over and would be able to satisfy the irrigation requirement every year. Figure 5.2 shows the average monthly irrigation releases for both alternatives.

Reservoir water surface elevation and tailwater rating curves were used to calculate available heads for each month. The elevation of the outlet was assumed to be 63 feet below the crest of the existing dam. This distance is the maximum height of the dam. It was also assumed that the tailwater elevation would be constant at an elevation

AVERAGE MONTHLY OUTFLOWS

ANTELOPE RESERVOIR DAM SITE

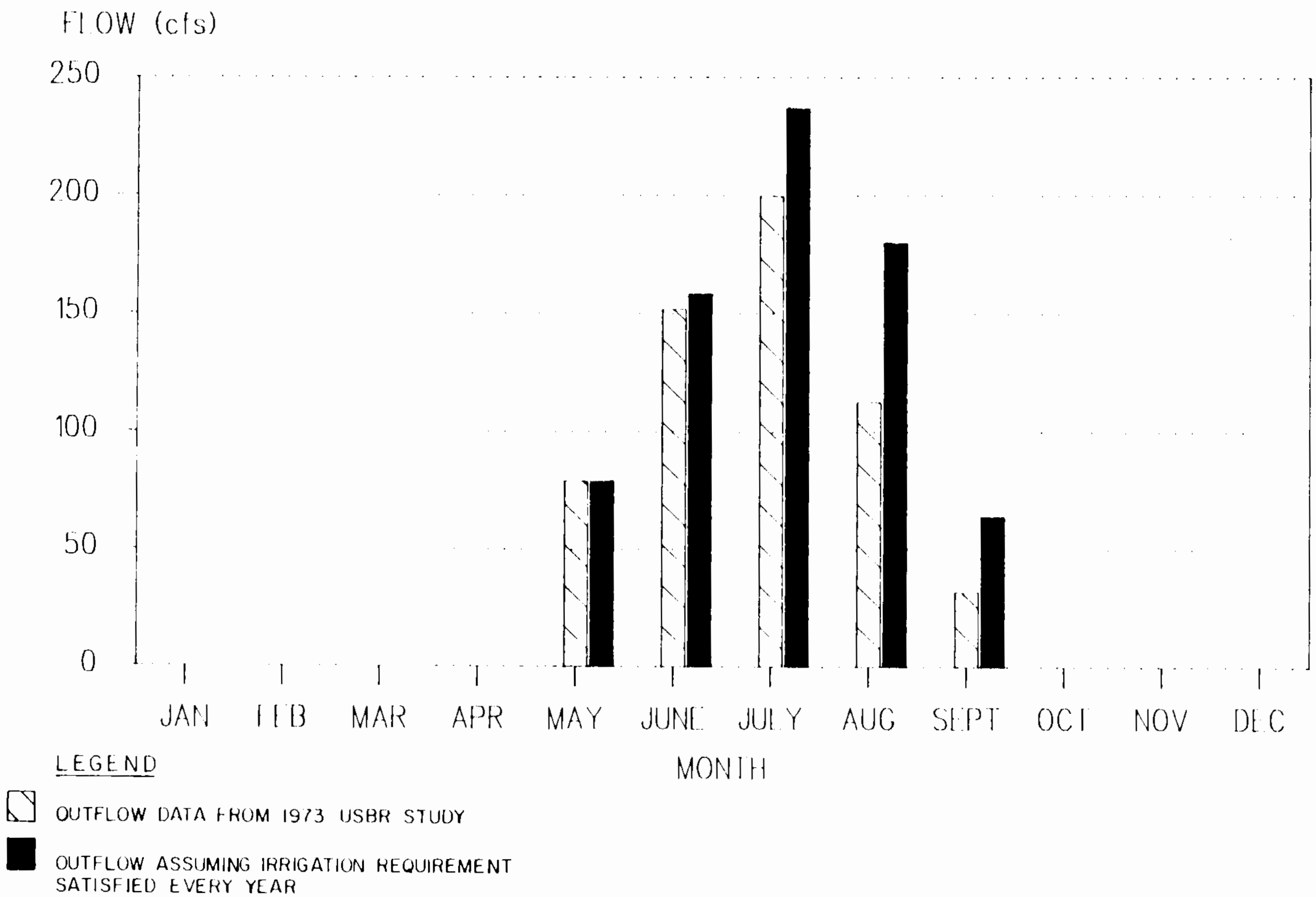


FIGURE 5.2

of 4,141 feet. With the enlargement of the reservoir, there would be a corresponding increase in available head of 12 feet, making the maximum available head of 69 feet. The design head for the hydro power plant was computed as 80 percent of the maximum head, less five percent for head loss, giving a design head of 53 feet.

5.5.2 Power and Energy Estimate

Power and energy estimates were developed based on an average water year. Power plant capacity was obtained using the formula:

$$P = \frac{Qh}{14}$$

Where:

P = power plant capacity in kW
Q = maximum power plant flow, in cfs
h = power plant design head, in feet

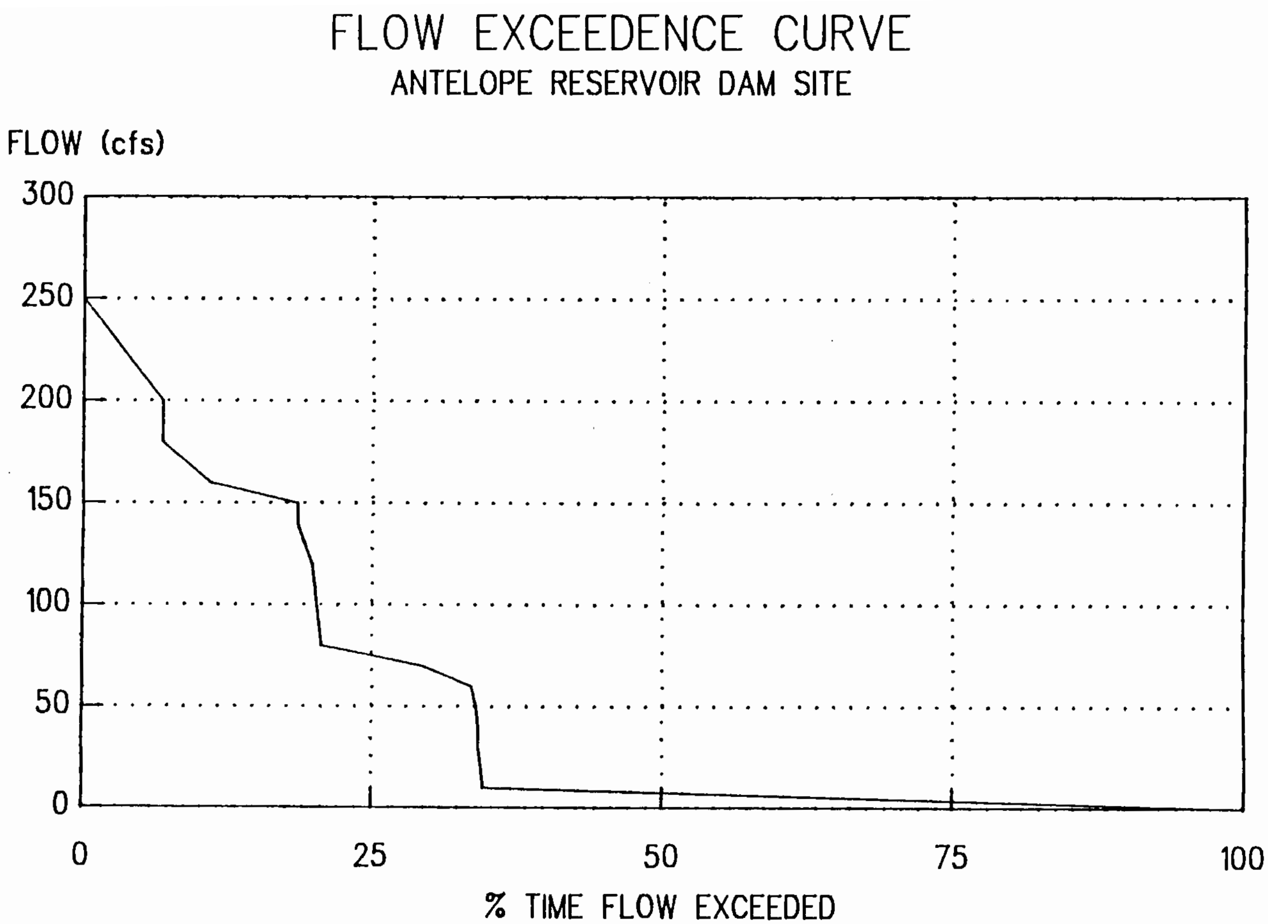
Average annual energy generation was obtained using the formula:

$$E = \frac{Q'h'}{14} \times 8{,}760 \times 0.95$$

Where:

E = average annual energy, in kW
Q' = Average annual power plant flow, in cfs
h' = power plant design head, in feet

The average annual power plant flow, Q', was calculated using two methods. For the first method, the flow exceedance curve (Figure 5.3) for irrigation releases was used. This curve was developed using the USBR's reservoir outflow data. Using this method, an average annual power plant flow of 24 cfs was obtained. For the second method, it



FLOW EXCEEDENCE CURVE
ANTELOPE RESERVOIR DAM SITE
FLOW (cfs)
300
250
200
150
100
50
0
0
25
50
75
100
% TIME FLOW EXCEEDED

FIGURE 5.3

was assumed that with the enlarged reservoir and feeder canal, the required irrigation releases would be met every year. Using this method, an average annual power plant flow of 60 cfs was obtained. It was assumed that the minimum power plant flows would be 30 percent of the maximum power plant flows. The selection of the optimum size power plant was similar to that outlined in Section 3.5.3 for the Jordan Creek Dam. Only a single turbine power plant was analyzed since the range of flows from minimum to maximum were within the operating range of a single unit.

5.5.3 Power Plant Cost Estimates

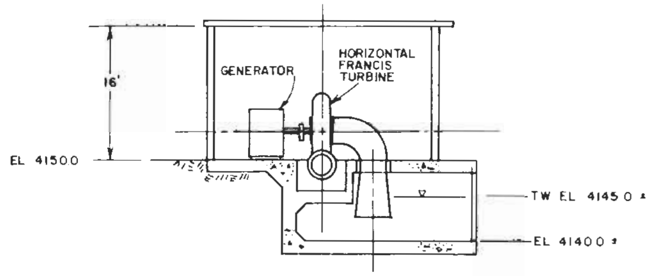
The EPRI "Simplified Methodology for Economic Screening of Potential Small-Capacity Hydroelectric Sites" was used for estimating costs. As stated earlier, two different analyses were performed, the difference being in the way the average annual flow was calculated. Data and cost estimates from the analyses are presented below.

ANTELOPE RESERVOIR

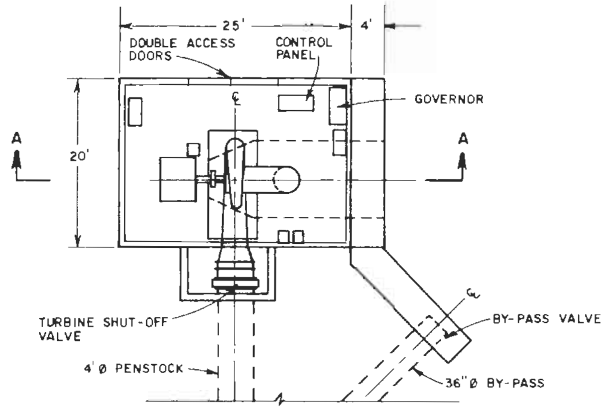
	POWER PLANT CAPACITY (kW)	AVERAGE ANNUAL ENERGY MW-HOUR	CAPITAL COST (MILLION $)	ANNUAL COST PER kW HOUR
1 TURBINE (160 cfs) 10% Exceedance Based on Flow Exceedance Curve - Outflow Data	606	769	1.80	$.246
1 TURBINE (237 cfs) Based on Assumption That Required Irrigation Releases Can Be Met Every Year	897	1,890	2.10	$.117

5.6 Cost Estimate

A reconnaissance level construction cost estimate was prepared for the Antelope Dam enlargement project. The cost estimate was derived from the bid item list representing quantities for major work items necessary to construct the project. Unit costs were assigned to each bid item based on recent construction bids and MKE's experience with similar work and cost curves for the hydropower facilities. The estimates were prepared in 1987 dollars and no adjustments were made for escalation or inflation. A 25 percent contingency factor was added to the cost estimate. The bid item lists for the three alternatives are in Appendix B. The estimated cost to enlarge Antelope Dam ranges from $1,401,000 with no power facilities to $4,155,000 including the 897 kw power plant.



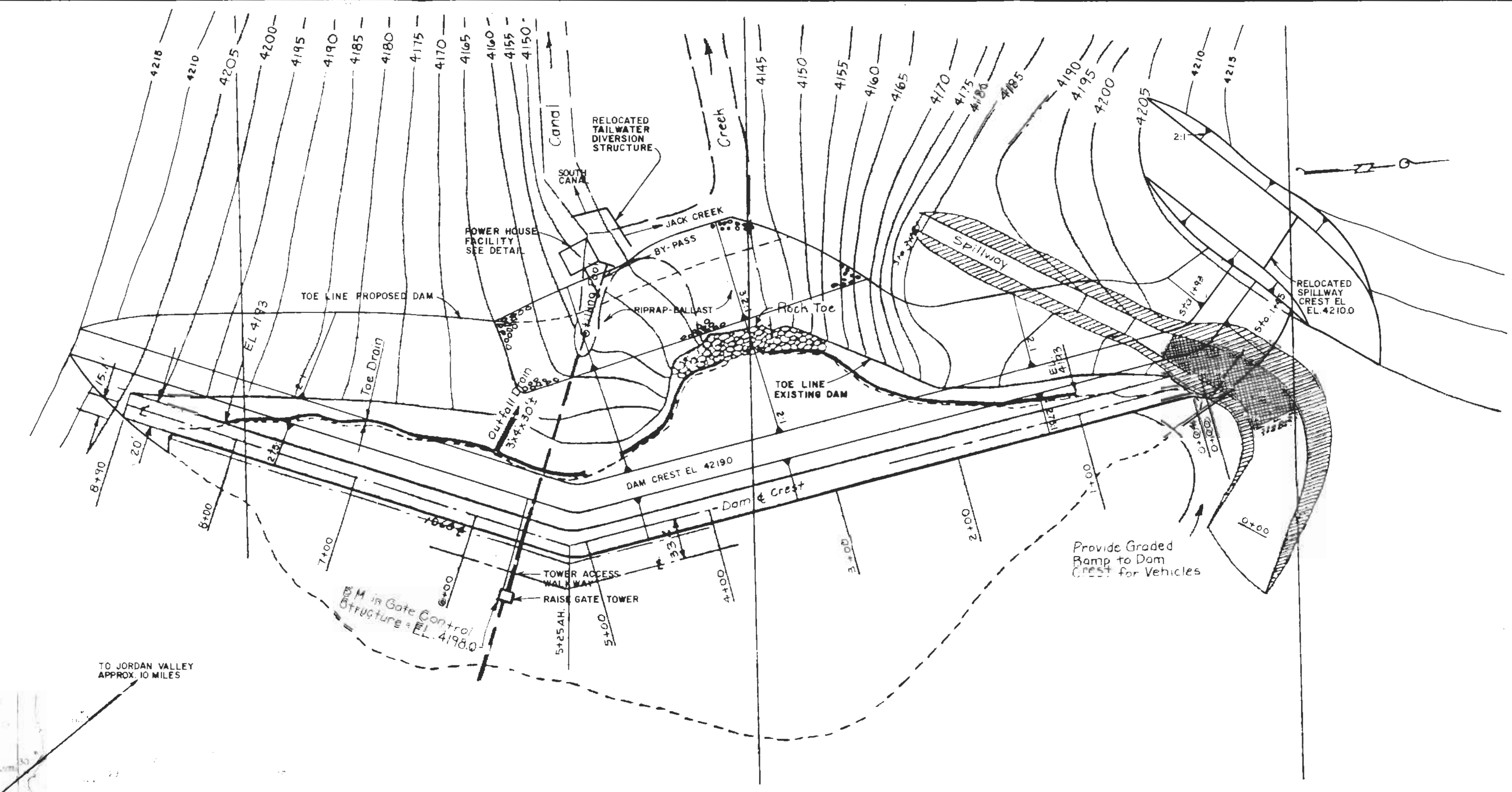
SECTION A-A



PLAN

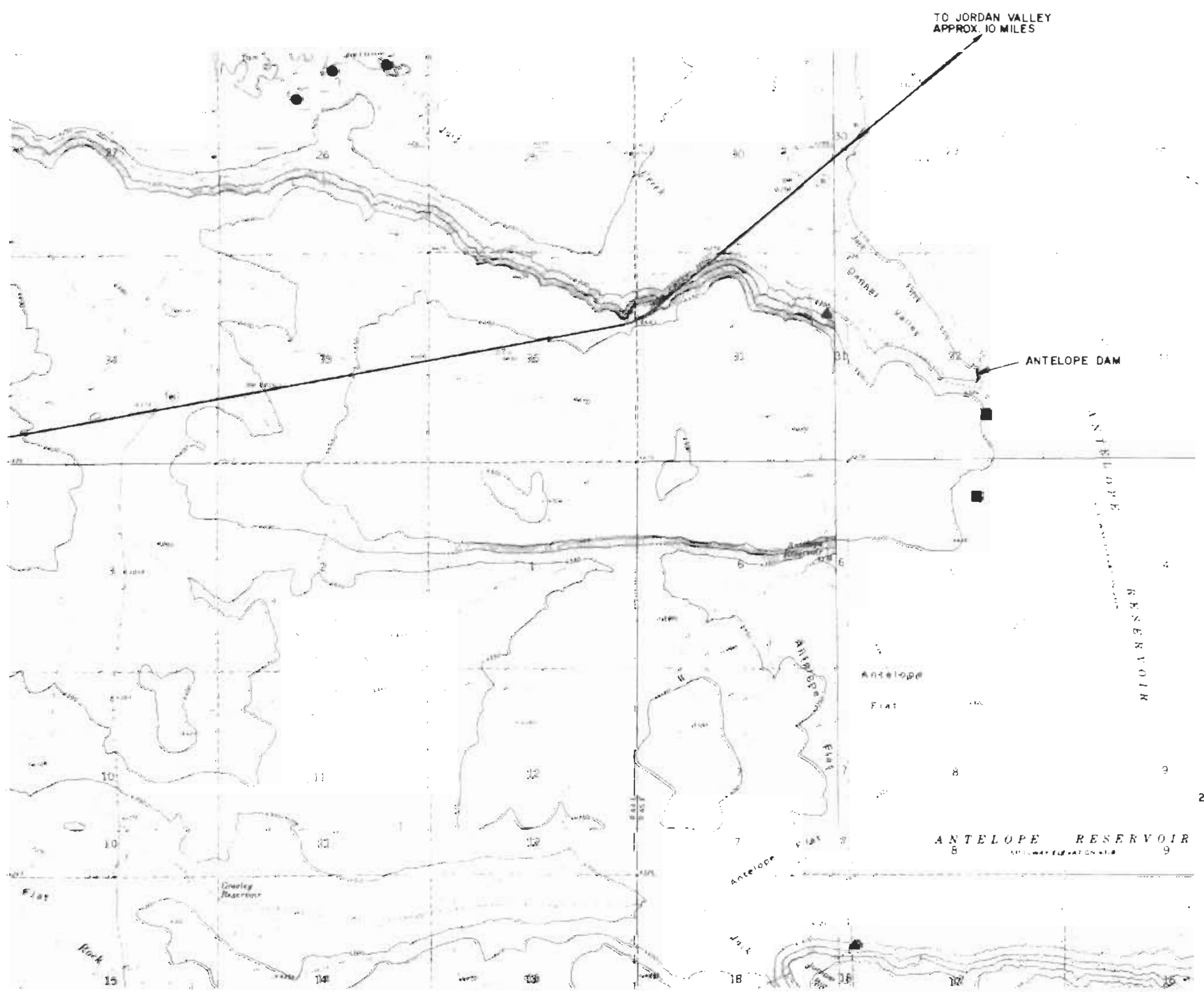
POWER HOUSE FACILITY DETAIL

N.T.S.



ANTELOPE DAM PLAN

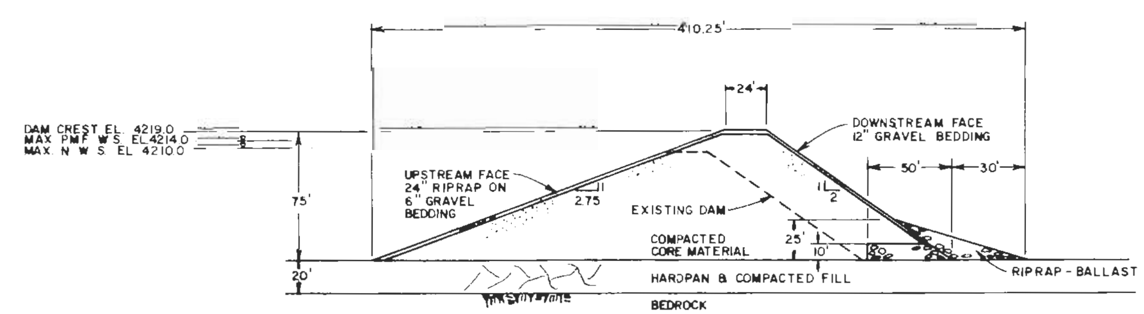
SCALE IN FEET
50 25 0 50 100



POTENTIAL BORROW AREAS

- ▲ RIPRAP SOURCE
- ● GRAVEL SOURCE
- ■ SANDY SILT SOURCE (CORE)

SCALE IN FEET
2000 0 2000 4000



MAXIMUM DAM SECTION

SCALE IN FEET
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CORPS OF ENGINEERS JORDAN CREEK RECON. STUDY		
ANTELOPE DAM PLAN AND SECTIONS		
DRAWN BY: B.R.M.	SCALE: AS SHOWN	EXHIBIT NO. 4
DESIGN BY: L.H.	DATE: MAY, 1987	

MORRISON-KNUDSEN ENGINEERS, INC.

APPENDIX

A REFERENCES

B COST ESTIMATES

C FLOW DATA

APPENDIX A
LIST OF REFERENCES

APPENDIX A

REFERENCES

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APPENDIX B
COST ESTIMATES

JORDAN CREEK DAM

JORDAN CREEK DAM
CONSTRUCTION COST ESTIMATE
RCC DAM

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT $	TOTAL $
1	Mobilization/Demobilization	1	LS	$1,000,000	$1,000,000
2	Diversion and Care of Water	1	LS	300,000	300,000
3	Excavation	80,000	CY	7	560,000
4	Backfill	10,000	CY	5	50,000
5	Foundation Preparation	6,000	SY	10	60,000
6	Grout Curtain	3,600	LF	30	108,000
7	Drain Curtain	9,000	LF	15	135,000
8	Drainage Gallery	500	LF	250	125,000
9	Precast Concrete Panels	64,000	SF	12	768,000
10	Facing and Bedding Concrete	7,500	CY	100	750,000
11	Structural Concrete	3,920	CY	250	980,000
12	Roller Compacted Concrete	150,000	CY	25	3,750,000
13	Steel Lined Outlet Conduit/Penstock (72"Ø)	125	LF	400	50,000
14	Road Relocation	7	MI	300,000	2,100,000
15	Access Road	1	MI	200,000	200,000
16	Reclamation	1	LS	50,000	50,000
SUBTOTAL					$10,~~425~~ 956,000
25% CONTINGENCY					2,~~606~~ 777,000
TOTAL					$13,~~031~~ 733,000

1556h/33

JORDAN CREEK DAM
CONSTRUCTION COST ESTIMATE
RCC DAM W/HYDROPOWER

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT $	TOTAL $
1	Mobilization/Demobilization	1	LS	$1,000,000	$1,000,000
2	Diversion and Care of Water	1	LS	300,000	300,000
3	Excavation	80,000	CY	7	560,000
4	Backfill	10,000	CY	5	50,000
5	Foundation Preparation	6,000	SY	10	60,000
6	Grout Curtain	3,600	LF	30	108,000
7	Drain Curtain	9,000	LF	15	135,000
8	Drainage Gallery	500	LF	250	125,000
9	Precast Concrete Panels	64,000	SF	12	768,000
10	Facing and Bedding Concrete	7,500	CY	100	750,000
11	Structural Concrete	3,920	CY	250	980,000
12	Roller Compacted Concrete	150,000	CY	25	3,750,000
13	Steel Lined Outlet Conduit/Penstock (72"Ø)	125	LF	400	50,000
14	Hydropower Facilities 1.4 mw		LS		3,030,000
15	Road Relocation	7	MI	300,000	2,100,000
16	Access Road	1	MI	200,000	200,000
17	Reclamation	1	LS	50,000	50,000
SUBTOTAL					14,016,000 $~~13,818,000~~
25% CONTINGENCY					504 3,~~455~~,000
TOTAL					520 $17,~~273~~,000

1556h/34

ANTELOPE FEEDER CANAL

ANTELOPE FEEDER CANAL

CONSTRUCTION COST ESTIMATE

REBUILD 10% CANAL

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	DIVERSION DAM AND HEADWORKS				
1	EXCAVATION	9,000	C.Y.	6	54,000
2	BACKFILL	1,000	C.Y.	4	4,000
3	RIPRAP	300	C.Y.	25	7,500
4	SAND AND GRAVEL BED	150	C.Y.	15	2,250
5	CONCRETE	935	C.Y.	350	327,250
6	REINFORCED STEEL	93,500	LBS	0.5	46,750
7	SLUICE GATES (W7' X H5') (Manual operating)	2	EA	7000	14,000
8	SLUICE GATES (W12' X H8' (Manual operating)	2	EA	16000	32,000
9	SLUICE GATES (W12' X H8' (Electric operating)	1	EA	18000	18,000
10	CARE OF RIVER	1	LS		76,000
				SUBTOTAL	581,750
	CANAL				
11	EXCAVATION	98,200	C.Y.	1.3	127,660
12	COMPACT EMBANKMENT	78,600	C.Y.	0.55	43,230
13	GRAVEL ROAD SERVICE	31,600	C.Y.	10	316,000
	BRIDGES				
13	FARM	2	EA	52000	104,000
				SUBTOTAL	590,890
14	MOBILIZATION/ DEMOBILIZATION		L.S.		59,000
				SUBTOTAL	1,231,640
				25% CONTINGENCY	308,000
				TOTAL	$1,539,640

ANTELOPE FEEDER CANAL

CONSTRUCTION COST ESTIMATE

REBUILD 25% CANAL

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	DIVERSION DAM AND HEADWORKS				
1	EXCAVATION	9,000	C.Y.	6	54,000
2	BACKFILL	1,000	C.Y.	4	4,000
3	RIPRAP	300	C.Y.	25	7,500
4	SAND AND GRAVEL BED	150	C.Y.	15	2,250
5	CONCRETE	935	C.Y.	350	327,250
6	REINFORCED STEEL	93,500	LBS	0.5	46,750
7	SLUICE GATES (W7' X H5') (Manual operating)	2	EA	7000	14,000
8	SLUICE GATES (W12' X H8' (Manual operating)	2	EA	16000	32,000
9	SLUICE GATES (W12' X H8' (Electric operating)	1	EA	18000	18,000
10	CARE OF RIVER	1	LS		76,000
				SUBTOTAL	581,750
	CANAL				
10	EXCAVATION	245,400	C.Y.	1.3	319,020
11	COMPACT EMBANKMENT	196,300	C.Y.	0.55	108,000
12	GRAVEL ROAD SERVICE	31,600	C.Y.	10	316,000
	BRIDGES				
13	FARM	2	EA	52000	104,000
				SUBTOTAL	847,020
14	MOBILIZATION/ DEMOBILIZATION		L.S.		71,500
				SUBTOTAL	1,500,270
				25% CONTINGENCY	375,000
				TOTAL	$1,875,270

ANTELOPE FEEDER CANAL

CONSTRUCTION COST ESTIMATE

ALIGNMENT "A"

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	DIVERSION DAM AND HEADWORKS				
1	EXCAVATION	9,000	C.Y.	6	54,000
2	BACKFILL	1,000	C.Y.	4	4,000
3	RIPRAP	300	C.Y.	25	7,500
4	SAND AND GRAVEL BED	150	C.Y.	15	2,250
5	CONCRETE	935	C.Y.	350	327,250
6	REINFORCED STEEL	93,500	LBS	0.5	46,750
7	SLUICE GATES (W7' X H5') (Manual operating)	2	EA	7000	14,000
8	SLUICE GATES (W12' X H8' (Manual operating)	2	EA	16000	32,000
9	SLUICE GATES (W12' X H8' (Electric operating)	1	EA	18000	18,000
10	CARE OF RIVER	1	LS		76,000
				SUBTOTAL	581,750
	CANAL				
10	EXCAVATION	1,493,000	C.Y.	1.3	1,940,900
11	COMPACT EMBANKMENT	154,000	C.Y.	0.55	84,700
12	GRAVEL ROAD SERVICE	31,600	C.Y.	10	316,000
	BRIDGES				
13	FARM	2	EA	52000	104,000
				SUBTOTAL	2,445,600
14	MOBILIZATION/ DEMOBILIZATION		L.S.		151,500
				SUBTOTAL	3,178,850
				25% CONTINGENCY	795,000
				TOTAL	$3,973,850

ANTELOPE FEEDER CANAL

CONSTRUCTION COST ESTIMATE

ALIGNMENT "B"

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	DIVERSION DAM AND HEADWORKS				
1	EXCAVATION	9,000	C.Y.	6	54,000
2	BACKFILL	1,000	C.Y.	4	4,000
3	RIPRAP	300	C.Y.	25	7,500
4	SAND AND GRAVEL BED	150	C.Y.	15	2,250
5	CONCRETE	935	C.Y.	350	327,250
6	REINFORCED STEEL	93,500	LBS	0.5	46,750
7	SLUICE GATES (W7' X H5') (Manual operating)	2	EA	7000	14,000
8	SLUICE GATES (W12' X H8' (Manual operating)	2	EA	16000	32,000
9	SLUICE GATES (W12' X H8' (Electric operating)	1	EA	18000	18,000
10	CARE OF RIVER	1	LS		76,000
				SUBTOTAL	581,750
	CANAL				
10	EXCAVATION	9,990,000	C.Y.	1.3	12,987,000
11	COMPACT EMBANKMENT	72,000	C.Y.	0.55	39,600
12	GRAVEL ROAD SERVICE	31,600	C.Y.	10	316,000
	BRIDGES				
13	FARM	2	EA	52000	104,000
				SUBTOTAL	13,446,600
14	MOBILIZATION/ DEMOBILIZATION		L.S.		701,500
				SUBTOTAL	14,729,850
				25% CONTINGENCY	3,682,500
				TOTAL	$18,412,350

ANTELOPE DAM ENLARGEMENT

ANTELOPE DAM AND FACILITIES EXPANSION
CONSTRUCTION COST ESTIMATES

OPTION 1
(NO POWER PLANT)

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	ENLARGED DAM				
1	EXCAVATION	8000	C.Y.	6	48,000
2	BACKFILL, COMPACTED SILT	132000	C.Y.	5	660,000
3	WALKWAY, CONTROL TOWER	1	LS	3000	3,000
4	RIPRAP	4000	C.Y.	25	100,000
5	SAND AND GRAVEL FILTER	15300	C.Y.	15	229,500
6	CONCRETE	60	C.Y.	350	21,000
7	REINFORC. STEEL	8000	LBS	0.50	4,000
8	GATE STEMS (12' X 2.5")	2	EA	150	300
				SUBTOTAL	1,066,000
9	MOBILIZATION/ DEMOBILIZATION		LS		55,000
				25% CONTINGENCY	280,000
				OPTION 1 TOTAL	$1,401,000

ANTELOPE DAM AND FACILITIES EXPANSION
CONSTRUCTION COST ESTIMATES

OPTION 2
(WITH 606 kW POWER PLANT)

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	ENLARGED DAM				
1	EXCAVATION	8000	C.Y.	6	48,000
2	BACKFILL, COMPACTED SILT	132000	C.Y.	5	660,000
3	WALKWAY, CONTROL TOWER	1	LS	3000	3,000
4	RIPRAP	4000	C.Y.	25	100,000
5	SAND AND GRAVEL FILTER	15300	C.Y.	15	229,500
6	CONCRETE	60	C.Y.	350	21,000
7	REINFORC. STEEL	8000	LBS	0.50	4,000
8	GATE STEMS (12' X 2.5")	2	EA	150	300
				SUBTOTAL	1,066,000
	POWERHOUSE AND EQUIPMENT				
9	TOTAL POWER PLANT		LS		1,800,000
				SUBTOTAL	1,800,000
10	MOBILIZATION/ DEMOBILIZATION		LS		143,000
				OPTION 2 SUBTOTAL	3,009,000
				25% CONTINGENCY	752,000
				OPTION 2 TOTAL	$3,761,000

ANTELOPE DAM AND FACILITIES EXPANSION
CONSTRUCTION COST ESTIMATES

OPTION 3
(WITH 897 kW POWER PLANT)

BID ITEM	DESCRIPTION	QUANTITY	UNIT	COST/UNIT ($)	COST ($)
	ENLARGED DAM				
1	EXCAVATION	8000	C.Y.	6	48,000
2	BACKFILL, COMPACTED SILT	132000	C.Y.	5	660,000
3	WALKWAY, CONTROL TOWER	1	LS	3000	3,000
4	RIPRAP	4000	C.Y.	25	100,000
5	SAND AND GRAVEL FILTER	15300	C.Y.	15	229,500
6	CONCRETE	60	C.Y.	350	21,000
7	REINFORC. STEEL	8000	LBS	0.50	4,000
8	GATE STEMS (12' X 2.5")	2	EA	150	300
				SUBTOTAL	1,066,000
	POWERHOUSE AND EQUIPMENT				
9	TOTAL POWER PLANT		LS		2,100,000
				SUBTOTAL	2,100,000
10	MOBILIZATION/ DEMOBILIZATION		LS		158,000
				OPTION 3 SUBTOTAL	3,324,000
				25% CONTINGENCY	831,000
				OPTION 3 TOTAL	$4,155,000

APPENDIX C
FLOW DATA

JORDAN CREEK DAM

OWYHEE RIVER BASIN
JORDAN CREEK DAM SITE
DATA FROM CORPS OF ENGINEERS STUDY

AVERAGE MONTHLY DISCHARGES (CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL RUNOFF (FT^3)	ANNUAL RUNOFF (ACRE-FEET)
1927	42	198	215	701	610	215	76.5	11.3	7.6	12.2	13	75.5	5.7214E9	131,346
1928	99	67	679	697	675	196	39.9	12.7	3	5.3	15.6	12.2	6.5744E9	150,929
1929	15	31	78	633	440	95	37.7	8.4	5.9	2.4	14.2	11.4	3.6056E9	82,774
1930	17	10	139	157	64	17	11.3	12	2.6	7.1	15.4	8.4	1.2109E9	27,800
1931	4	4	88	209	426	105	18.4	2.2	2.7	0.9	9.6	7.5	2.3055E9	52,928
1932	10	0	185	728	488	159	38.4	10.9	3.5	1.8	8.4	8.3	4.3133E9	99,021
1933	5	0	65	394	511	215	51.1	8.5	2.2	2.2	19.6	9.9	3.3730E9	77,434
1934	21	13	46	112	175	30	3.7	2.6	0.9	1.7	8.6	8.7	1.1121E9	25,532
1935	15	0	62	822	273	45	11.3	7.2	1.9	1.7	11.8	8.6	3.3099E9	75,986
1936	14	2	115	1232	302	41	15.5	17.1	3.1	5.2	11.9	11.5	4.6523E9	106,803
1937	12	0	74	526	287	50	10.2	9.8	0.9	2.2	11.5	14	2.6216E9	60,186
1938	31	21	168	1210	896	311	74.1	23.8	1.1	4.4	13.7	28.5	7.3126E9	167,876
1939	26	45	336	490	395	52	21.2	17.8	0.9	9.9	10.3	15.9	3.7317E9	85,669
1940	22	97	322	363	227	29	6.3	13.3	3.1	3.6	13.4	10.9	2.9186E9	67,003
1941	19	95	334	447	761	285	93.7	52	3.8	12.3	22.1	23	5.6446E9	129,584
1942	65	41	230	1529	526	142	57.2	10.1	3.6	8.5	30.5	151.7	7.3442E9	168,600
1943	309	166	601	2252	819	398	115.7	24.5	3.3	14.1	10.8	15.8	1.242E10	285,315
1944	53	28	112	418	543	112	38.7	20.1	8.2	3.5	10	12.4	3.5711E9	81,983
1945	31	218	294	823	309	117	69	20.8	3.5	11.1	30	67.3	5.2394E9	120,281
1946	100	94	460	1234	589	181	53.7	29.2	6.2	14.6	27	41.2	7.4369E9	170,730
1947	30	114	222	404	253	87	24	12.9	2.7	8	19.5	27.2	3.1649E9	72,656
1948	71	58	88	514	564	214	56	27.3	4	6.7	12.9	14.9	4.2857E9	98,387
1949	17	23	164	747	444	116	22.9	10.4	1.9	8.3	13	13	4.1535E9	95,352
1950	47	109	288	700	557	255	59.7	30.7	4.4	10.3	37.5	145	5.8964E9	135,364
1951	135	596	365	1140	591	165	45.6	26.8	4	13.2	24.8	46.2	8.2850E9	190,198
1952	42	99	211	1966	1492	424	124.3	43.2	5.6	9.8	18	22.9	1.171E10	268,942
1953	108	115	150	563	598	472	114.4	45.5	3.9	3.2	12.6	16.7	5.7876E9	132,866
1954	65	37	158	267	256	70	15.1	47	2.7	3.8	11.2	16.6	2.4950E9	57,278
1955	30	25	70	345	761	247	61.7	16.9	2	3.7	16	163.3	4.5769E9	105,072
1956	269	126	592	993	737	230	49.4	26.8	2.8	15.2	34	75.9	8.2810E9	190,108
1957	29	361	514	697	971	275	56	22.8	3.5	11.4	20.9	28.4	7.8577E9	180,388
1958	35	286	180	774	1013	274	63.2	38.7	2.8	5.8	16.5	26.5	7.1363E9	163,828
1959	38	44	88	313	227	79	16.1	8	6.3	30.8	18.4	14.2	2.3199E9	53,260
1960	18	73	490	574	331	107	15.2	10.4	1.7	2.5	14.1	16.3	4.3446E9	99,739
1961	17	74	192	379	278	86	12.6	6	2	4.8	13.1	15.5	2.8382E9	65,157
1962	35	125	162	672	392	151	23.7	8.9	1.1	5.2	14.8	23.1	4.2410E9	97,361
1963	33	281	107	258	386	243	57.4	16.4	1.7	4.9	32.2	25.4	3.8000E9	87,238
1964	25	31	188	893	707	361	78.6	23.8	4.1	9.1	22.6	686.8	7.9654E9	182,862
1965	537	561	268	918	741	343	92.9	47.8	18.2	20.1	23.4	17.6	9.4292E9	216,466
1966	24	25	156	361	184	42	15.5	10.9	1.6	2.4	13.9	24.6	2.2624E9	51,939
1967	149	104	135	240	907	652	108.8	33.3	4	4.4	16.8	25.5	6.2541E9	143,575
1968	21	164	146	123	151	46	12.6	39.1	6	13.8	44.5	42.3	2.1268E9	48,826
1969	337	134	306	1485	694	219	87.1	19.3	2.7	16.7	21.5	26.6	8.8009E9	202,041
1970	282	185	250	334	1029	377	99.4	13.4	11.7	19.2	107	246.1	7.7625E9	178,204

OWYHEE RIVER BASIN
JORDAN CREEK DAM SITE
DATA FROM CORPS OF ENGINEERS STUDY

AVERAGE MONTHLY DISCHARGES (CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL RUNOFF (FT^3)	ANNUAL RUNOFF (ACRE-FEET)
1971	791	408	736	926	841	289	106.8	39.8	5.1	19.5	34.1	150.2	1.142E10	262,227
1972	296	144	1655	502	625	244	57.4	30.2	4.9	9.7	12.9	107.8	9.6944E9	222,553
1973	297	105	162	613	301	74	20.6	11.4	2.7	19.7	305.8	55.8	5.1719E9	118,731
1974	272	105	859	914	843	262	79	23.4	2.1	8.7	16.9	30.6	8.9764E9	206,071
1975	50	84	174	813	1545	398	107.7	10.7	1.5	17	44.5	314.7	9.3559E9	214,783
1976	157	321	190	823	738	193	32	72.4	9.6	25.4	11.4	14.4	6.7991E9	156,087
1977	17	48	97	291	124	35	14.1	6.7	1.7	10.7	10.7	18.6	1.7725E9	40,693
1978	53	114	570	616	409	160	36.4	14.6	8.3	17.4	27.4	21	5.3797E9	123,503
1979	34	80	507	332	581	140	49.1	43.7	1	10.8	10.4	52	4.8381E9	111,069
1980	106	246	541	595	528	292	119.8	27.2	3.7	22.9	29	31.9	6.6816E9	153,390
1981	157	99	161	364	303	102	28.4	14.8	5.9	23	100.2	111.1	3.8615E9	88,650
1982	76	581	864	932	987	520	172	20.2	5.7	36.7	28	77.4	1.130E10	259,421
1983	130	382	711	1137	1394	589	102.3	38.3	5.2	27.1	675	208.7	1.419E10	325,761
1984	69	162	499	1370	1492	533	113.7	32.2	9.8	45.3	548.2	756.4	1.479E10	339,597
1985	486	178	366	420	633	227	55.5	13.7	3.3	8.9	16.3	29	6.4036E9	147,008
1986	82	165	552	704	427	192	55.3	48	4.8	18.1	39.8	32.8	6.0990E9	140,015
AVE. MONTHLY FLOWS (CFS)	106	135	312	700	589	210	55	22	4	11	47	72		

MAX ANNUAL RUNOFF	1.479E10 FT^3	339,597 AC-FT
MIN ANNUAL RUNOFF	1.1121E9 FT^3	25,532 AC-FT
AVERAGE ANNUAL RUNOFF	5.9492E9 FT^3	136,576 AC-FT

JORDAN CREEK DAM

OUTFLOWS (100 ACRE-FEET PER MONTH)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										14	15	29
1928	43	98	240	287	190	74	121	82	30	4	8	29
1929	47	72	240	241	251	104	121	82	30	2	3	5
1930	3	58	84	14	62	74	121	82	30	3	4	4
1931	6	3	54	7	39	13	14	1	1	2	3	3
1932	6	3	204	297	300	234	121	82	30	4	4	12
1933	12	2	21	204	251	128	121	82	30	3	4	6
1934	10	25	33	7	41	73	121	80	1	2	3	14
1935	8	41	112	275	320	189	121	82	30	3	4	6
1936	26	71	204	275	306	189	121	82	30	4	8	6
1937	5	6	112	296	158	88	121	82	30	3	20	47
1938	15	6	204	297	331	128	123	83	30	7	11	16
1939	10	5	167	268	53	74	121	83	30	6	8	8
1940	17	73	204	165	62	74	121	82	30	8	22	10
1941	15	151	204	165	300	138	123	83	30	9	19	18
1942	17	58	102	275	320	234	122	83	30	9	15	47
1943	144	89	167	297	190	223	123	83	30	8	15	14
1944	11	14	54	204	88	234	123	83	30	7	11	18
1945	29	113	102	296	331	234	132	83	30	7	18	42
1946	62	52	221	267	243	107	123	83	30	9	16	25
1947	18	63	137	156	90	79	121	82	30	5	12	17
1948	44	34	54	170	262	122	123	83	30	4	8	9
1949	10	13	101	268	190	93	121	82	30	5	8	8
1950	29	61	177	272	251	138	123	83	30	6	22	89
1951	83	208	204	242	173	104	122	83	30	8	15	29
1952	26	57	102	234	321	226	132	83	30	6	11	14
1953	67	25	54	31	121	234	122	82	30	2	3	9
1954	10	70	96	15	41	74	121	82	25	2	2	2
1955	2	2	2	117	320	136	123	77	1	2	10	78
1956	144	73	167	296	247	127	122	83	30	9	20	47
1957	18	89	266	283	235	144	123	82	30	7	12	18
1958	21	151	111	241	331	150	123	83	30	4	10	16
1959	24	25	54	101	62	78	121	82	30	19	11	9
1960	11	38	204	204	121	88	121	82	30	2	8	10
1961	11	41	112	133	88	83	121	82	30	3	8	10
1962	21	70	98	287	158	100	121	69	1	3	9	14
1963	17	113	66	75	155	130	123	51	1	3	19	16
1964	16	18	68	295	306	200	123	82	30	6	13	103
1965	176	218	165	167	167	180	124	84	31	12	14	11
1966	15	14	96	129	53	74	121	82	30	2	8	15
1967	88	58	84	60	300	296	128	83	30			
MAXIMUMS	176	218	266	297	331	296	132	84	31	19	22	103
MINIMUMS	2	2	2	7	39	13	14	1	1	2	2	2
AVERAGES	33.4	59.5	128.7	197.8	195.7	136.7	119.8	79.1	26.3	5.6	10.9	22.1

OVERALL AVE 84.6
AC-FT/MONTH

JORDAN CREEK DAM

OUTFLOWS (CFS)

YEAR		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927	________										24	25	49
1928	________	72	165	403	482	319	124	203	138	50	7	13	49
1929	________	79	121	403	405	422	175	203	138	50	3	5	8
1930	________	5	97	141	24	104	124	203	138	50	5	7	7
1931	________	10	5	91	12	66	22	24	2	2	3	5	5
1932	________	10	5	343	499	504	393	203	138	50	7	7	20
1933	________	20	3	35	343	422	215	203	138	50	5	7	10
1934	________	17	42	55	12	69	123	203	134	2	3	5	24
1935	________	13	69	188	462	538	318	203	138	50	5	7	10
1936	________	44	119	343	462	514	318	203	138	50	7	13	10
1937	________	8	10	188	497	266	148	203	138	50	5	34	79
1938	________	25	10	343	499	556	215	207	139	50	12	18	27
1939	________	17	8	281	450	89	124	203	139	50	10	13	13
1940	________	29	123	343	277	104	124	203	138	50	13	37	17
1941	________	25	254	343	277	504	232	207	139	50	15	32	30
1942	________	29	97	171	462	538	393	205	139	50	15	25	79
1943	________	242	150	281	499	319	375	207	139	50	13	25	24
1944	________	18	24	91	343	148	393	207	139	50	12	18	30
1945	________	49	190	171	497	556	393	222	139	50	12	30	71
1946	________	104	87	371	449	408	180	207	139	50	15	27	42
1947	________	30	106	230	262	151	133	203	138	50	8	20	29
1948	________	74	57	91	286	440	205	207	139	50	7	13	15
1949	________	17	22	170	450	319	156	203	138	50	8	13	13
1950	________	49	103	297	457	422	232	207	139	50	10	37	150
1951	________	139	350	343	407	291	175	205	139	50	13	25	49
1952	________	44	96	171	393	539	380	222	139	50	10	18	24
1953	________	113	42	91	52	203	393	205	138	50	3	5	15
1954	________	17	118	161	25	69	124	203	138	42	3	3	3
1955	________	3	3	3	197	538	229	207	129	2	3	17	131
1956	________	242	123	281	497	415	213	205	139	50	15	34	79
1957	________	30	150	447	476	395	242	207	138	50	12	20	30
1958	________	35	254	187	405	556	252	207	139	50	7	17	27
1959	________	40	42	91	170	104	131	203	138	50	32	18	15
1960	________	18	64	343	343	203	148	203	138	50	3	13	17
1961	________	18	69	188	224	148	139	203	138	50	5	13	17
1962	________	35	118	165	482	266	168	203	115	2	5	15	24
1963	________	29	190	111	126	260	218	207	86	2	5	32	27
1964	________	27	30	114	496	514	336	207	138	50	10	22	173
1965	________	296	366	277	281	281	302	208	141	52	20	24	18
1966	________	25	24	161	217	89	124	203	138	50	3	13	25
1967	________	148	97	141	101	504	497	215	139	50			
	MAXIMUMS	296	366	447	499	556	497	222	141	52	32	37	173
	MINIMUMS	3	3	3	12	66	22	24	2	2	3	3	3
	AVERAGES	56	100	216	332	329	230	201	133	44	9	18	37
	OVERALL AVERAGE	142											

JORDAN CREEK DAM

STORAGES (100 ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										388	388	388
1928	388	394	394	505	551	491	366	281	250	248	248	248
1929	248	260	260	480	535	499	375	290	259	257	257	257
1930	257	257	257	292	333	274	151	69	39	39	39	39
1931	39	39	39	69	39	33	20	19	19	19	19	19
1932	19	19	117	498	650	624	503	417	385	383	383	383
1933	383	383	383	519	573	542	418	333	302	300	300	300
1934	300	300	300	328	304	236	114	34	33	33	33	33
1935	33	33	39	635	650	621	498	412	380	378	378	378
1936	378	378	399	650	650	621	498	413	381	379	379	379
1937	379	379	385	650	650	604	480	394	362	360	360	360
1938	360	360	382	650	650	618	505	420	389	387	387	387
1939	387	387	585	650	649	588	465	381	352	349	349	349
1940	352	352	374	497	537	477	354	269	239	237	237	237
1941	237	245	267	391	613	584	474	390	360	357	357	357
1942	360	360	389	650	650	624	508	424	393	391	391	391
1943	412	524	650	650	650	632	522	439	408	406	406	406
1944	406	406	406	541	587	562	452	369	338	336	336	336
1945	336	379	408	650	650	624	529	448	418	415	415	415
1946	415	415	478	650	650	617	502	418	388	385	385	385
1947	385	385	385	469	497	452	332	248	217	215	215	215
1948	215	215	215	350	399	367	254	172	142	141	141	141
1949	141	141	141	318	365	319	200	117	87	86	86	86
1950	86	86	86	230	287	259	149	68	40	39	39	39
1951	39	165	186	622	650	614	497	413	381	379	379	379
1952	379	379	408	650	650	632	536	455	425	422	422	422
1953	422	422	422	496	541	516	400	316	284	282	282	282
1954	282	282	282	346	325	266	144	61	36	36	36	36
1955	36	36	36	124	238	207	98	21	21	21	21	43
1956	65	65	263	560	650	618	502	418	386	384	384	384
1957	384	496	547	650	650	622	507	422	391	388	388	388
1958	388	397	397	616	650	620	507	423	392	389	389	389
1959	389	389	389	473	513	465	343	258	229	228	228	228
1960	228	232	330	466	512	467	344	260	228	227	227	227
1961	227	227	233	325	371	322	201	117	87	86	86	86
1962	86	86	88	201	249	212	94	25	24	24	24	24
1963	27	71	71	149	196	170	60	10	10	10	10	10
1964	10	10	58	295	388	361	253	170	141	140	140	460
1965	615	650	650	650	650	625	518	440	416	413	413	413
1966	413	413	413	497	520	460	337	253	222	220	220	220
1967	223	223	223	305	527	577	477	393	362			
	615	650	650	650	650	632	536	455	425	422	422	460
	10	10	36	69	39	33	20	10	10	10	10	10
AVERAGES	268.2	281.0	308.4	468.7	510.0	475.6	362.2	282.0	255.4	254.4	254.4	263.0

OVERALL AVERAGE 331.9 *100 ACRE-FEET

JORDAN CREEK DAM

ELEVATIONS (Feet)

YEAR		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927	________										4658	4658	4658
1928	________	4658	4659	4659	4671	4676	4670	4655	4646	4643	4643	4643	4643
1929	________	4643	4644	4644	4669	4674	4671	4656	4647	4644	4643	4643	4643
1930	________	4643	4643	4643	4647	4652	4645	4629	4606	4590	4590	4590	4590
1931	________	4590	4590	4590	4606	4590	4587	4578	4577	4577	4577	4577	4577
1932	________	4577	4577	4622	4671	4684	4682	4671	4661	4658	4657	4657	4657
1933	________	4657	4657	4657	4673	4678	4675	4661	4652	4648	4648	4648	4648
1934	________	4648	4648	4648	4651	4649	4641	4621	4587	4587	4587	4587	4587
1935	________	4587	4587	4590	4683	4684	4682	4671	4661	4657	4657	4657	4657
1936	________	4657	4657	4659	4684	4684	4682	4671	4661	4657	4657	4657	4657
1937	________	4657	4657	4658	4684	4684	4681	4669	4659	4655	4655	4655	4655
1938	________	4655	4655	4657	4684	4684	4682	4671	4662	4658	4658	4658	4658
1939	________	4658	4658	4679	4684	4684	4679	4667	4657	4654	4654	4654	4654
1940	________	4654	4654	4656	4670	4675	4668	4654	4645	4642	4641	4641	4641
1941	________	4641	4642	4645	4658	4681	4679	4668	4658	4655	4654	4654	4654
1942	________	4655	4655	4658	4684	4684	4682	4672	4662	4659	4658	4658	4658
1943	________	4661	4673	4684	4684	4684	4683	4673	4664	4660	4660	4660	4660
1944	________	4660	4660	4660	4675	4679	4677	4665	4656	4652	4652	4652	4652
1945	________	4652	4657	4660	4684	4684	4682	4674	4665	4661	4661	4661	4661
1946	________	4661	4661	4668	4684	4684	4682	4671	4661	4658	4658	4658	4658
1947	________	4658	4658	4658	4667	4670	4665	4652	4643	4639	4639	4639	4639
1948	________	4639	4639	4639	4654	4659	4656	4643	4633	4628	4627	4627	4627
1949	________	4627	4627	4627	4650	4655	4650	4637	4622	4613	4612	4612	4612
1950	________	4612	4612	4612	4641	4647	4644	4629	4605	4591	4590	4590	4590
1951	________	4590	4632	4635	4682	4684	4681	4670	4661	4657	4657	4657	4657
1952	________	4657	4657	4660	4684	4684	4683	4675	4666	4662	4662	4662	4662
1953	________	4662	4662	4662	4670	4675	4672	4659	4650	4646	4646	4646	4646
1954	________	4646	4646	4646	4653	4651	4644	4628	4602	4589	4589	4589	4589
1955	________	4589	4589	4589	4624	4641	4638	4616	4579	4579	4579	4579	4593
1956	________	4604	4604	4644	4677	4684	4682	4671	4661	4658	4658	4658	4658
1957	________	4658	4670	4676	4684	4684	4682	4672	4662	4658	4658	4658	4658
1958	________	4658	4659	4659	4682	4684	4682	4672	4662	4658	4658	4658	4658
1959	________	4658	4658	4658	4668	4672	4667	4653	4644	4640	4640	4640	4640
1960	________	4640	4641	4651	4667	4672	4667	4653	4644	4640	4640	4640	4640
1961	________	4640	4640	4641	4651	4656	4650	4637	4622	4613	4612	4612	4612
1962	________	4612	4612	4613	4637	4643	4638	4615	4582	4581	4581	4581	4581
1963	________	4583	4607	4607	4629	4636	4633	4602	4570	4570	4570	4570	4570
1964	________	4570	4570	4601	4648	4658	4655	4643	4633	4627	4627	4627	4666
1965	________	4682	4684	4684	4684	4684	4682	4673	4664	4661	4661	4661	4661
1966	________	4661	4661	4661	4670	4673	4666	4652	4643	4640	4639	4639	4639
1967	________	4640	4640	4640	4649	4674	4678	4668	4659	4655			

JORDAN CREEK DAM

AVAILABLE HEADS (Feet)

YEAR		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927	________										96	96	96
1928	________	96	97	97	109	114	108	93	84	81	81	81	81
1929	________	81	82	82	107	112	109	94	85	82	81	81	81
1930	________	81	81	81	85	90	83	67	44	28	28	28	28
1931	________	28	28	28	44	28	25	16	15	15	15	15	15
1932	________	15	15	60	109	122	120	109	99	96	95	95	95
1933	________	95	95	95	111	116	113	99	90	86	86	86	86
1934	________	86	86	86	89	87	79	59	25	25	25	25	25
1935	________	25	25	28	121	122	120	109	99	95	95	95	95
1936	________	95	95	97	122	122	120	109	99	95	95	95	95
1937	________	95	95	96	122	122	119	107	97	93	93	93	93
1938	________	93	93	95	122	122	120	109	100	96	96	96	96
1939	________	96	96	117	122	122	117	105	95	92	92	92	92
1940	________	92	92	94	108	113	106	92	83	80	79	79	79
1941	________	79	80	83	96	119	117	106	96	93	92	92	92
1942	________	93	93	96	122	122	120	110	100	97	96	96	96
1943	________	99	111	122	122	122	121	111	102	98	98	98	98
1944	________	98	98	98	113	117	115	103	94	90	90	90	90
1945	________	90	95	98	122	122	120	112	103	99	99	99	99
1946	________	99	99	106	122	122	120	109	99	96	96	96	96
1947	________	96	96	96	105	108	103	90	81	77	77	77	77
1948	________	77	77	77	92	97	94	81	71	66	65	65	65
1949	________	65	65	65	88	93	88	75	60	51	50	50	50
1950	________	50	50	50	79	85	82	67	43	29	28	28	28
1951	________	28	70	73	120	122	119	108	99	95	95	95	95
1952	________	95	95	98	122	122	121	113	104	100	100	100	100
1953	________	100	100	100	108	113	110	97	88	84	84	84	84
1954	________	84	84	84	31	89	82	66	40	27	27	27	27
1955	________	27	27	27	62	79	76	54	17	17	17	17	31
1956	________	42	42	82	115	122	120	109	99	95	96	96	96
1957	________	96	108	114	122	122	120	110	100	95	96	96	96
1958	________	96	97	97	120	122	120	110	100	96	96	96	96
1959	________	96	96	96	106	110	105	91	82	78	78	78	78
1960	________	78	79	89	105	110	105	91	82	78	78	78	78
1961	________	78	78	79	89	94	88	75	60	51	50	50	50
1962	________	50	50	51	75	81	76	53	20	19	19	19	19
1963	________	21	45	45	67	74	71	40	8	8	8	8	8
1964	________	8	8	39	86	96	93	81	71	65	65	65	104
1965	________	120	122	122	122	122	120	111	102	99	99	99	99
1966	________	99	99	99	108	111	104	90	81	78	77	77	77
1967	________	78	78	78	87	112	116	106	97	93			
	AVERAGES (Feet)	76	78	83	103	108	104	91	78	74	73	73	75
	OVERALL AVERAGE (Feet)	85											
	MAXIMIMS	120	122	122	122	122	121	113	104	100	100	100	104
	MINIMUMS	8	8	27	44	28	25	16	8	8	8	8	8

JORDAN CREEK DAM

FLOW EXCEEDENCE CALCULATIONS

FLOW RANGE	TOTAL MONTH	CUM. TOTAL	% TIME FLOW EXCEEDED
0	12	480	100
10	50	430	90
20	56	374	78
30	36	338	70
40	17	321	67
50	13	308	64
60	37	271	56
70	6	265	55
80	7	258	54
90	4	254	53
100	9	245	51
110	7	238	50
120	7	231	48
130	12	219	46
140	40	179	37
150	11	168	35
160	2	166	35
180	14	152	32
200	7	145	30
250	55	90	19
300	19	71	15
350	18	53	11
400	11	42	9
450	13	29	6
	29		

HEAD EXCEEDENCE CALCULATIONS

FLOW RANGE	TOTAL MONTH	CUM. TOTAL	% TIME HEAD EXCEEDED
0	12	480	100
5	0	480	100
10	7	473	99
15	0	473	99
20	17	456	95
25	8	448	93
30	22	426	89
35	1	425	89
40	2	423	88
45	8	415	86
50	0	415	86
55	16	399	83
60	4	395	82
65	1	394	82
70	15	379	79
75	6	373	78
80	39	334	70
85	37	297	62
90	23	274	57
95	54	220	46
100	102	118	25
105	13	105	22
110	29	76	16
115	19	57	12
120	18	39	8
125	39	0	0
	0		

ANTELOPE RESERVOIR

ANTELOPE RESERVOIR

OUTFLOWS (100 ACRE-FEET PER MONTH)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										0	0	0
1928	0	0	0	0	47	94	141	107	38	0	0	0
1929	0	0	0	0	47	94	141	107	38	0	0	0
1930	0	0	0	0	47	82	0	0	0	0	0	0
1931	0	0	0	0	47	34	0	0	0	0	0	0
1932	0	0	0	0	47	94	141	107	38	0	0	0
1933	0	0	0	0	47	94	141	60	0	0	0	0
1934	0	0	0	0	47	34	0	0	0	0	0	0
1935	0	0	0	0	47	94	141	107	38	0	0	0
1936	0	0	0	0	47	94	141	107	38	0	0	0
1937	0	0	0	0	47	94	141	79	0	0	0	0
1938	0	0	0	0	47	94	141	107	38	0	0	0
1939	0	0	0	0	47	94	141	28	0	0	0	0
1940	0	0	0	0	47	94	139	0	0	0	0	0
1941	0	0	0	0	47	94	141	107	38	0	0	0
1942	0	0	0	0	47	94	141	107	38	0	0	0
1943	0	0	0	0	47	94	141	107	38	0	0	0
1944	0	0	0	0	47	94	141	55	0	0	0	0
1945	0	0	0	0	47	94	141	107	38	0	0	0
1946	0	0	0	0	47	94	141	107	38	0	0	0
1947	0	0	0	0	47	94	122	0	0	0	0	0
1948	0	0	0	0	47	94	141	73	0	0	0	0
1949	0	0	0	0	47	94	141	68	0	0	0	0
1950	0	0	0	0	47	94	141	107	38	0	0	0
1951	0	0	0	0	47	94	141	107	38	0	0	0
1952	0	0	0	0	47	94	141	107	38	0	0	0
1953	0	0	0	0	47	94	141	7	0	0	0	0
1954	0	0	0	0	47	79	0	0	0	0	0	0
1955	0	0	0	0	47	94	141	45	0	0	0	0
1956	0	0	0	0	47	94	141	107	38	0	0	0
1957	0	0	0	0	47	94	141	107	38	0	0	0
1958	0	0	0	0	47	94	141	107	38	0	0	0
1959	0	0	0	0	47	94	17	0	0	0	0	0
1960	0	0	0	0	47	94	141	50	0	0	0	0
1961	0	0	0	0	47	94	77	0	0	0	0	0
1962	0	0	0	0	47	94	141	77	0	0	0	0
1963	0	0	0	0	47	94	126	0	0	0	0	0
1964	0	0	0	0	47	94	141	107	38	0	0	0
1965	0	0	0	0	47	94	141	107	38	0	0	0
1966	0	0	0	0	47	94	45	0	0	0	0	0
1967	0	0	0	0	47	94	141	107	38			
MAXIMUMS	0	0	0	0	47	94	141	107	38	0	0	0
MINIMUMS	0	0	0	0	47	34	0	0	0	0	0	0
AVERAGES	0.0	0.0	0.0	0.0	47.0	90.3	118.9	67.1	19.0	0.0	0.0	0.0

OVERALL AVE 28.5
AC-FT/MONTH

ANTELOPE RESERVOIR

OUTFLOWS (CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										0	0	0
1928	0	0	0	0	79	158	237	180	64	0	0	0
1929	0	0	0	0	79	158	237	180	64	0	0	0
1930	0	0	0	0	79	138	0	0	0	0	0	0
1931	0	0	0	0	79	57	0	0	0	0	0	0
1932	0	0	0	0	79	158	237	180	64	0	0	0
1933	0	0	0	0	79	158	237	101	0	0	0	0
1934	0	0	0	0	79	57	0	0	0	0	0	0
1935	0	0	0	0	79	158	237	180	64	0	0	0
1936	0	0	0	0	79	158	237	180	64	0	0	0
1937	0	0	0	0	79	158	237	133	0	0	0	0
1938	0	0	0	0	79	158	237	180	64	0	0	0
1939	0	0	0	0	79	158	237	47	0	0	0	0
1940	0	0	0	0	79	158	234	0	0	0	0	0
1941	0	0	0	0	79	158	237	180	64	0	0	0
1942	0	0	0	0	79	158	237	180	64	0	0	0
1943	0	0	0	0	79	158	237	180	64	0	0	0
1944	0	0	0	0	79	158	237	92	0	0	0	0
1945	0	0	0	0	79	158	237	180	64	0	0	0
1946	0	0	0	0	79	158	237	180	64	0	0	0
1947	0	0	0	0	79	158	205	0	0	0	0	0
1948	0	0	0	0	79	158	237	123	0	0	0	0
1949	0	0	0	0	79	158	237	114	0	0	0	0
1950	0	0	0	0	79	158	237	180	64	0	0	0
1951	0	0	0	0	79	158	237	180	64	0	0	0
1952	0	0	0	0	79	158	237	180	64	0	0	0
1953	0	0	0	0	79	158	237	12	0	0	0	0
1954	0	0	0	0	79	133	0	0	0	0	0	0
1955	0	0	0	0	79	158	237	76	0	0	0	0
1956	0	0	0	0	79	158	237	180	64	0	0	0
1957	0	0	0	0	79	158	237	180	64	0	0	0
1958	0	0	0	0	79	158	237	180	64	0	0	0
1959	0	0	0	0	79	158	29	0	0	0	0	0
1960	0	0	0	0	79	158	237	84	0	0	0	0
1961	0	0	0	0	79	158	129	0	0	0	0	0
1962	0	0	0	0	79	158	237	129	0	0	0	0
1963	0	0	0	0	79	158	212	0	0	0	0	0
1964	0	0	0	0	79	158	237	180	64	0	0	0
1965	0	0	0	0	79	158	237	180	64	0	0	0
1966	0	0	0	0	79	158	76	0	0	0	0	0
1967	0	0	0	0	79	158	237	180	64			
MAXIMUMS	0	0	0	0	79	158	237	180	64	0	0	0
MINIMUMS	0	0	0	0	79	57	0	0	0	0	0	0
AVERAGES	0	0	0	0	79	152	200	113	32	0	0	0

OVERALL AVERAGE 48

ANTELOPE RESERVOIR

STORAGES (100 ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										107	99	107
1928	123	197	392	600	607	423	213	70	26	30	39	62
1929	96	150	352	533	607	447	234	86	38	40	42	45
1930	45	94	154	138	87	0	0	0	0	3	7	11
1931	17	20	74	74	34	0	0	0	0	2	4	8
1932	14	17	226	491	636	599	367	197	120	97	82	78
1933	76	65	74	243	349	240	62	0	0	3	7	14
1934	25	50	74	74	34	0	0	0	0	2	5	21
1935	29	68	167	441	596	518	296	137	73	63	58	56
1936	73	126	303	561	689	604	372	201	123	100	87	77
1937	68	64	165	428	420	267	83	0	0	3	25	69
1938	71	66	256	517	691	547	321	158	89	78	75	77
1939	73	66	241	456	349	196	28	0	0	6	14	23
1940	42	104	285	396	303	156	0	0	0	9	33	43
1941	53	197	363	464	612	484	266	112	55	57	68	73
1942	79	118	198	468	620	585	355	186	111	96	91	116
1943	234	296	434	678	678	628	394	220	138	115	106	97
1944	88	85	120	281	226	233	56	0	0	8	19	38
1945	66	165	235	490	666	627	398	223	141	117	109	128
1946	158	178	369	599	660	499	279	122	63	62	69	80
1947	83	129	237	334	275	135	0	0	0	5	18	36
1948	73	94	128	264	376	259	76	0	0	4	13	22
1949	34	47	137	366	397	252	71	0	0	5	14	22
1950	53	105	255	467	547	425	215	71	27	34	55	128
1951	183	367	512	700	695	528	305	144	78	72	74	87
1952	94	129	206	473	675	628	400	225	143	117	102	94
1953	140	136	159	151	147	167	7	0	0	2	5	15
1954	26	91	166	145	84	0	0	0	0	2	4	6
1955	8	10	12	120	315	219	45	0	0	2	13	95
1956	217	246	390	627	700	554	328	163	93	84	87	113
1957	106	189	417	621	700	571	343	176	103	88	83	84
1958	88	224	288	477	654	534	310	148	82	70	68	72
1959	82	92	125	184	124	18	0	0	0	20	32	41
1960	50	78	273	414	372	226	51	0	0	2	11	21
1961	33	71	170	252	201	80	0	0	0	3	12	22
1962	44	104	179	411	406	265	81	0	0	3	13	28
1963	47	150	181	210	226	139	0	0	0	3	24	41
1964	53	64	127	387	531	471	255	103	49	49	57	187
1965	337	511	597	700	700	607	375	203	125	109	100	89
1966	85	84	161	240	163	45	0	0	0	2	10	27
1967	116	147	197	211	388	442	232	85	37			
	337	511	597	700	700	628	400	225	143	117	109	187
	8	10	12	74	34	0	0	0	0	2	4	6
AVERAGES	84.6	129.9	235.0	392.2	438.5	340.5	170.5	75.8	42.9	41.9	45.9	61.3

OVERALL AVERAGE 171.5 *100 ACRE-FEET

ANTELOPE RESERVOIR

ELEVATIONS

(Feet)

YEAR		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927	________										4178	4177	4178
1928	________	4179	4181	4189	4197	4197	4191	4182	4173	4163	4164	4167	4172
1929	________	4177	4180	4187	4196	4197	4192	4182	4175	4166	4167	4167	4168
1930	________	4168	4176	4180	4180	4176	4153	4153	4153	4153	4154	4156	4158
1931	________	4160	4161	4174	4174	4165	4153	4153	4153	4153	4154	4155	4156
1932	________	4159	4160	4182	4194	4198	4197	4188	4181	4179	4177	4175	4174
1933	________	4174	4172	4174	4182	4187	4182	4172	4153	4153	4154	4156	4159
1934	________	4163	4169	4174	4174	4165	4153	4153	4153	4153	4154	4155	4161
1935	________	4164	4173	4181	4192	4197	4195	4184	4179	4174	4172	4171	4171
1936	________	4174	4179	4184	4196	4199	4197	4188	4181	4179	4177	4176	4174
1937	________	4173	4172	4181	4191	4190	4183	4175	4153	4153	4154	4163	4173
1938	________	4173	4172	4183	4195	4199	4196	4185	4180	4176	4174	4174	4174
1939	________	4174	4172	4182	4192	4187	4181	4163	4153	4153	4156	4159	4162
1940	________	4167	4177	4184	4189	4184	4180	4153	4153	4153	4157	4165	4168
1941	________	4170	4181	4187	4193	4198	4194	4183	4178	4170	4171	4173	4174
1942	________	4174	4178	4181	4193	4198	4197	4187	4181	4178	4177	4176	4178
1943	________	4182	4184	4191	4199	4199	4198	4189	4182	4180	4178	4177	4177
1944	________	4176	4175	4179	4184	4182	4182	4171	4153	4153	4156	4161	4166
1945	________	4172	4181	4182	4194	4198	4198	4189	4182	4180	4178	4178	4179
1946	________	4180	4181	4188	4197	4198	4194	4183	4179	4172	4172	4173	4175
1947	________	4175	4179	4182	4186	4183	4179	4153	4153	4153	4155	4160	4166
1948	________	4174	4176	4179	4183	4188	4183	4174	4153	4153	4155	4158	4162
1949	________	4165	4169	4179	4187	4189	4183	4173	4153	4153	4155	4159	4162
1950	________	4170	4177	4183	4193	4196	4191	4182	4173	4163	4165	4170	4179
1951	________	4181	4188	4195	4199	4199	4195	4184	4180	4174	4173	4174	4176
1952	________	4176	4179	4182	4193	4199	4198	4189	4182	4180	4178	4177	4176
1953	________	4180	4179	4180	4180	4180	4181	4156	4153	4153	4154	4155	4159
1954	________	4163	4176	4181	4180	4175	4153	4153	4153	4153	4154	4155	4156
1955	________	4156	4157	4158	4179	4185	4182	4168	4153	4153	4154	4158	4176
1956	________	4182	4182	4189	4198	4199	4196	4186	4180	4176	4175	4176	4178
1957	________	4177	4181	4190	4198	4199	4197	4186	4181	4177	4176	4175	4175
1958	________	4176	4182	4184	4193	4198	4196	4185	4180	4175	4173	4173	4173
1959	________	4175	4176	4179	4181	4179	4160	4153	4153	4153	4161	4165	4167
1960	________	4169	4174	4183	4190	4188	4182	4170	4153	4153	4154	4158	4161
1961	________	4165	4173	4181	4183	4181	4175	4153	4153	4153	4154	4158	4162
1962	________	4168	4177	4181	4190	4190	4183	4175	4153	4153	4154	4158	4163
1963	________	4169	4180	4181	4182	4182	4180	4153	4153	4153	4154	4162	4167
1964	________	4170	4172	4179	4189	4196	4193	4183	4177	4169	4169	4171	4181
1965	________	4186	4195	4197	4199	4199	4197	4188	4181	4179	4178	4177	4176
1966	________	4175	4175	4180	4182	4180	4168	4153	4153	4153	4154	4157	4163
1967	________	4178	4180	4181	4182	4189	4192	4182	4175	4166			

ANTELOPE RESERVOIR
AVAILABLE HEADS (Feet)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1927										37	36	37
1928	38	40	48	56	56	50	41	32	22	23	26	31
1929	36	39	46	55	56	51	41	34	25	26	26	27
1930	27	35	39	39	35	12	12	12	12	13	15	17
1931	19	20	33	33	24	12	12	12	12	13	14	15
1932	18	19	41	53	57	56	47	40	38	36	34	33
1933	33	31	33	41	46	41	31	12	12	13	15	18
1934	22	28	33	33	24	12	12	12	12	13	14	20
1935	23	32	40	51	56	54	43	38	33	31	30	30
1936	33	38	43	55	58	56	47	40	38	36	35	33
1937	32	31	40	50	49	42	34	12	12	13	22	32
1938	32	31	42	54	58	55	44	39	35	33	33	33
1939	33	31	41	51	46	40	22	12	12	15	18	21
1940	26	36	43	48	43	39	12	12	12	16	24	27
1941	29	40	46	52	57	53	42	37	29	30	32	33
1942	33	37	40	52	57	56	46	40	37	36	35	37
1943	41	43	50	58	58	57	48	41	39	37	36	36
1944	35	34	38	43	41	41	30	12	12	15	20	25
1945	31	40	41	53	57	57	48	41	39	37	37	38
1946	39	40	47	56	57	53	42	38	31	31	32	34
1947	34	38	41	45	42	38	12	12	12	14	19	25
1948	33	35	38	42	47	42	33	12	12	14	17	21
1949	24	28	38	46	48	42	32	12	12	14	18	21
1950	29	36	42	52	55	50	41	32	22	24	29	38
1951	40	47	54	58	58	54	43	39	33	32	33	35
1952	35	38	41	52	58	57	48	41	39	37	36	35
1953	39	38	39	39	39	40	15	12	12	13	14	18
1954	22	35	40	39	34	12	12	12	12	13	14	15
1955	15	16	17	38	44	41	27	12	12	13	17	35
1956	41	41	48	57	58	55	45	39	35	34	35	37
1957	36	40	49	57	58	56	45	40	36	35	34	34
1958	35	41	43	52	57	55	44	39	34	32	32	32
1959	34	35	38	40	38	19	12	12	12	20	24	26
1960	28	33	42	49	47	41	29	12	12	13	17	20
1961	24	32	40	42	40	34	12	12	12	13	17	21
1962	27	36	40	49	49	42	34	12	12	13	17	22
1963	28	39	40	41	41	39	12	12	12	13	21	26
1964	29	31	38	48	55	52	42	36	28	28	30	40
1965	45	54	56	58	58	56	47	40	38	37	36	35
1966	34	34	39	41	39	27	12	12	12	13	16	22
1967	37	39	40	41	48	51	41	34	25			
AVERAGES (Feet)	31	35	41	48	49	43	32	25	22	23	25	28
OVERALL AVERAGE (Feet)	34											
MAXIMIMS	45	54	56	58	58	57	48	41	39	37	37	40
MINIMUMS	15	16	17	33	24	12	12	12	12	13	14	15

ANTELOPE RESERVOIR

FLOW EXCEEDENCE CALCULATIONS

FLOW RANGE	TOTAL MONTH	CUM. TOTAL	% TIME FLOW EXCEEDED
0	326	480	100
10	0	166	35
20	1	165	34
30	1	164	34
40	0	164	34
50	1	163	34
60	2	161	34
70	20	141	29
80	42	99	21
90	1	98	20
100	1	97	20
110	1	96	20
120	1	95	20
130	3	92	19
140	3	89	19
150	0	89	19
160	36	53	11
180	20	33	7
200	0	33	7
250	33	0	0
300	0	0	0

HEAD EXCEEDENCE CALCULATIONS

FLOW RANGE	TOTAL MONTH	CUM. TOTAL	% TIME HEAD EXCEEDED
0	12	480	100
5	0	480	100
10	0	480	100
15	79	401	84
20	25	376	78
25	25	351	73
30	32	319	66
35	72	247	51
40	89	158	33
45	67	91	19
50	31	60	13
55	23	37	8
60	37	0	0