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BINGHAM CANYON
HYDROLOGIC/GEOTECHNICAL STUDY
PHASE II PROJECT REPORT

INTERIM STUDY REPORT

November 1985

International Engineering Company
a subsidiary of
Morrison-Knudsen Engineers, Inc.
180 Howard Street
San Francisco, California 94105

Project No. 4028-03

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15 November 1985

Mr. William R. Strickland
Kennecott
Utah Copper Division
P.O. Box 280
Magna, Utah 84044

Subject: Bingham Canyon Surface Water Study, Copperton, Utah
Interim Study Report - Phase II Project Report

Dear Mr. Strickland:

We are enclosing ten copies of the Interim Study Report - Phase II Project Report. These are being submitted for your approval.

This report details the results of the hydrological and meteorological study and the various trade-off studies of possible water control facilities, and includes the updated cost estimates for the water management systems. Details of the geotechnical program are included in a separate three volume report.

The primary result of this phase of the study is the identification of a water management system which satisfies all of the agreed criteria at the lowest cost of the alternatives considered. This report, along with the accompanying Geotechnical Report, should serve as the basis for the subsequent design of all project facilities.

Please accept our thanks for this opportunity to work with you on this interesting project. Please call if we can be of further service to you.

Very truly yours,

Patrick M. Griffin

REGISTERED PROFESSIONAL ENGINEER No. 7346 PATRICK M. GRIFFIN STATE OF UTAH

Patrick M. Griffin, Ph.D., P.E.
Project Manager

PMG:nw

cc: R. A. Tinstman
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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

An extensive water study was initiated by Kennecott in 1984 to evaluate the management of leach and storm water in the Bingham Canyon watershed. The objective of this study was to determine a technically and economically feasible water management plan which would maintain compliance with the State of Utah water pollution regulations and the Best Available Technology Economically Achievable (BAT) Effluent Limitations Guidelines for Copper Ore Mining and Dressing.

This interim study report describes the conceptual design and estimated costs of various water control options for managing leach and storm water in the Bingham Canyon watershed. The report does not recommend a best management plan but rather provides an evaluation of various control options which could be used in developing a best management plan. Also, the control options evaluated are consistent with present Kennecott mining and ore processing operations. If planned modernization of Kennecott's mining and ore processing facilities were implemented, the scenario of control options will change substantially, providing environmental and process advantages through the beneficial use of excess water from the watershed area.

The Bingham Canyon watershed area is located in the Oquirrh Mountains on the west side of the Salt Lake valley. The watershed area ranges in elevation from 5300 to 9200 feet, and covers an area of 25.6 square miles. Kennecott's large open pit mine is located in Bingham Canyon within the watershed area. The mining operations consists of open pit mining of low-grade copper ore, removal of overburden or waste material and dump leaching of the waste material. The total area disturbed by mining activity since mining was initiated in 1863 is 12.2 square miles.

Historically, excess water from the watershed area and mining operations flowed in Bingham Creek to the Jordan River. In the 1930's, evaporation ponds were constructed five miles east of Bingham Canyon to contain excess water flowing out of the canyon. In 1965, the Bingham Creek Reservoir was constructed to contain all surface runoff from the watershed and provide adequate surge capacity for the leach water recirculation system as well as a source of makeup water for the leaching operation. Except for a small amount of excess water routed to the evaporation ponds in 1973, 1974, and 1975, the reservoir was sufficient to contain all leach and storm water until 1983.

A major change in climatic conditions beginning in 1982 resulted in much greater than normal precipitation in the Great Basin region, and subsequent major flooding throughout the area during the Spring snowmelt in 1983, 1984, and 1985. The accumulated snowpack in the Bingham Canyon watershed was substantially greater than normal during the 1982-83 winter and the accumulation during the winter of 1983-84 was a 100-year record. Runoff from the Spring snowmelt during these record precipitation years substantially exceeded the containment capacity of the Bingham Creek Reservoir. Extensive emergency controls were implemented by Kennecott to treat and contain the storm runoff to minimize environmental impacts and prevent flooding of the adjacent downstream communities.

Due to the extensive cost of these emergency controls and the undesirability of having to implement emergency controls on an ongoing basis, Kennecott initiated the water management study. The final objective of the study is to provide an economically feasible water management plan which would minimize any detrimental environmental impact on surface and ground-water and protect the adjacent communities from flooding consistent with environmental and local regulations.

Specific water management areas evaluated in this interim study report are:

1. Diversion of uncontaminated storm runoff around the disturbed mining area and subsequent discharge to an acceptable receiving water.

2. Collection, impoundment, treatment and discharge of moderately contaminated water from storm runoff from the disturbed mining area and underground mines in the watershed.

3. Containment of dump leach water and storm runoff from the dump leach areas.

4. Interception and containment of moderately contaminated subsurface flow in the Bingham Canyon.

The study design criteria was to provide options to manage the excess water resulting from a 100-year annual precipitation event combined with a 10-year 24-hour storm event occurring during the Spring snowmelt. Storm runoff data collected during the 1984 water year was used as the basis to establish the amount of excess water resulting from the 100-year annual precipitation event. This design substantially exceeds that required by environmental regulations.

The total amount of excess water to be managed cannot be accurately determined, or any containment design finalized, until sufficient data is accumulated to provide an accurate water balance on the Bingham Creek Reservoir. The control options evaluated used an estimated reservoir loss based on limited information which may or may not be valid. Instrumentation has been installed to give continuous data for a representative period of time to provide an accurate water balance on the Bingham Creek Reservoir.

Kennecott is in the planning process to modernize the mining and ore processing facilities. Finalization of these plans will provide major changes in water management options through the beneficial use of excess water. Evaluation of these options as well as finalization of the options in this interim report will be contained in the final study report.

Kennecott is presently operating under NPDES Permit No. UT-002-4350 and a Consent Decree Civil No. CA85-C-0923A for the mining operation; and permit no. UT-000-0051 for the ore processing, smelting and refining. This interim study report is designed to satisfy the requirements stipulated under part IV 9(a) of the referenced consent decree.

The NPDES Permit No. UT-002-4350 expires March 31, 1986. Kennecott initiated permit renewal on August 9, 1985.

CHAPTER 2
SUMMARY

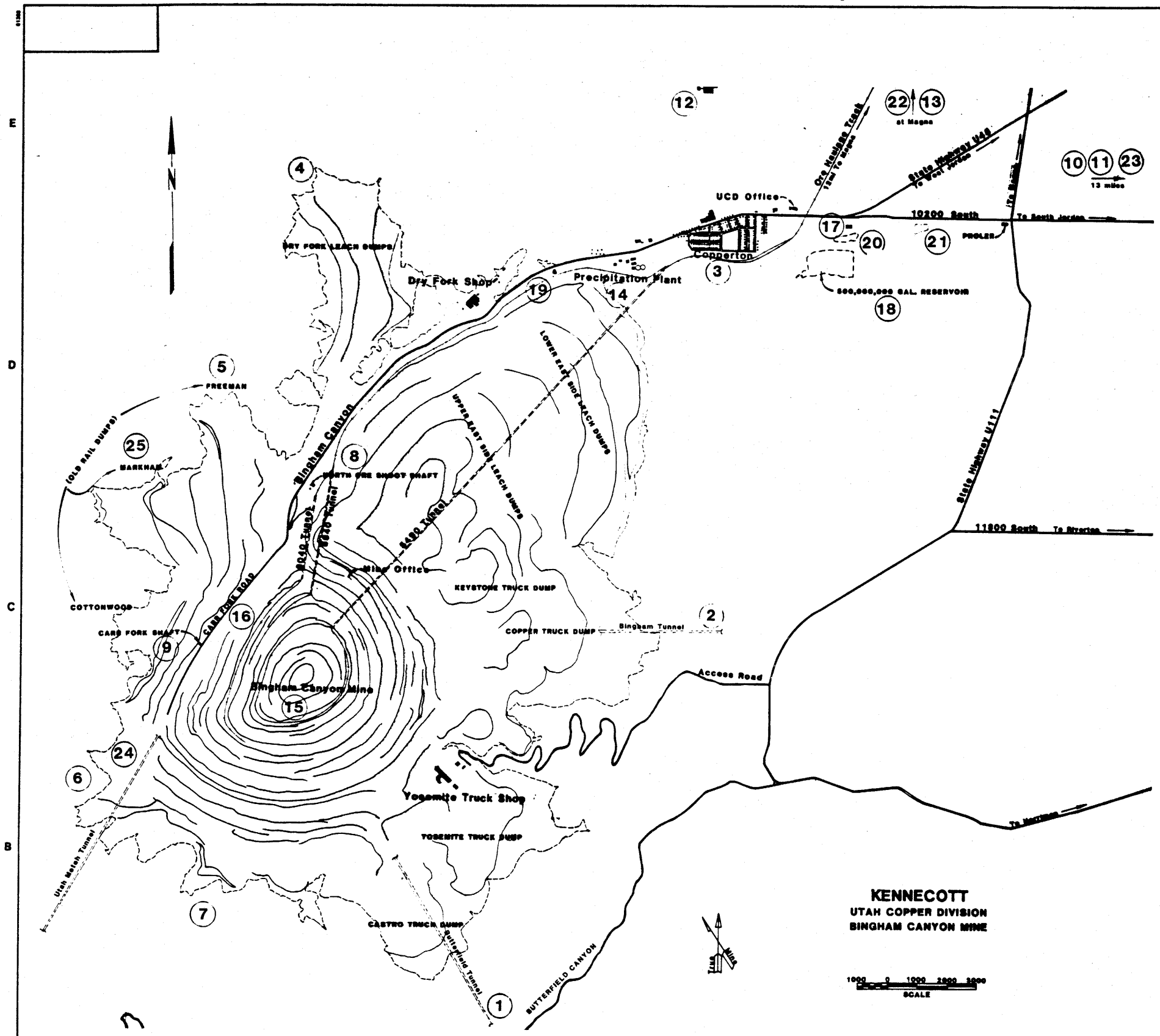
2.1 General

This Interim Study Report presents the results of a hydrological and meteorological study of the Bingham Canyon watershed, of conceptual design studies of alternative schemes for control of water, and of updated capital and operating cost estimates for various alternative facilities and sizes. Details of geotechnical investigations, which were performed concurrently with this work, are presented in a separate three volume report entitled "Phase II Geotechnical Report" (Ref. 2). A general site location map of the project area is shown in Figure 2.1-1.

Following the hydrological and meteorological study and the conceptual design of alternative water control facilities, a "trade-off" study was performed to determine the lowest cost combination of facilities which could successfully control the design water flows and volumes. This comparative study is presented in detail in Chapter 4, Section 4.1. The results of the hydrological and meteorological study are summarized below and are presented in detail in Chapter 3. The results of the various conceptual design studies and the capital and operating cost estimates are summarized in the following sections, and are presented in detail in Chapters 4 and 5 respectively.

2.2 Hydrological and Meteorological Study

The hydrological and meteorological study was performed to estimate, from the limited available data, the quantities and qualities of various water sources affecting the Bingham Canyon watershed. There was insufficient information available to perform a true water balance study, so an indirect heuristic approach was used. The hydrological study included an assessment of inflows and outflows from the existing reservoir system for three representatiave years: a wet year, an



DEFINITION OF WATER SOURCES AND LOCATIONS

ITEM NO.	DESCRIPTION
1	BUTTERFIELD TUNNEL - ABANDONED UNDERGROUND WORKINGS ORIGINALLY OPENED IN 1892 BY BUTTERFIELD MINING CO., IN 1922 USSRM LENGTHENED THE TUNNEL TO APPROX. LENGTH OF 3 1/2 MILES. PORTAL ELEVATION IS APPROX. 5987 FT.
2	BINGHAM TUNNEL - AN ABANDONED UNDERGROUND WORKINGS OF USSRM LOCATED NEAR THE OLD TOWN OF LARK. PORTAL ELEVATION IS APPROX. 5501 FT. INTERCEPTS BUTTERFIELD TUNNEL AT NIAGARA SHAFT.
3	COPPERTON AREA - A SMALL COMMUNITY AT THE BASE OF BINGHAM CANYON.
4	DRY FORK CANYON - A CANYON WHICH BRANCHES OFF BINGHAM CANYON. THE OLD BINGHAM CITY **OBTAINED DRINKING WATER (APPROX. 300 GPM) FROM THIS** CANYON.
5	FREEMAN GULCH - THIS GULCH RUNS APPROX. **PARALLEL TO DRY FORK CANYON.**
6	UPPER CARR FORK DRAINAGE - IS COMPOSED OF COTTONWOOD, SAP, ZELNORA AND LOG FORK GULCHES LOCATED TO THE WEST OF THE OPEN BINGHAM PIT.
7	MUDDY & GALENA GULCHES - AREA TO THE SOUTHWEST OF BINGHAM OPEN PIT MINE.
8	N.O.S. - NORTH ORE SHOOT IS AN EXPLORATION SHAFT BEING DEVELOPED BY KENNECOTT, APPROX. 3000+ FEET DEEP, LOCATED IN BINGHAM CANYON.
9	CARR FORK UNDERGROUND - IS A SERIES OF OLD UNDERGROUND WORKINGS, UNTIL THIS YEAR WAS OWNED BY ANACONDA MINING COMPANY, MOST OF THESE WORKINGS ARE TO THE NORTH & NORTHWEST OF KENNECOTT OPEN PIT OPERATION. ONE OF THE EXHAUST SHAFTS IS LOCATED ON THE NORTH RIM OF KENNECOTT PIT. KENNECOTT BOUGHT MOST OF THE MINE DURING THE SUMMER OF 1985.
10	JORDAN RIVER - THIS RIVER RUNS THRU THE CENTER OF SALT LAKE VALLEY, ALLOWING WATER TO FLOW FROM UTAH LAKE INTO THE GREAT SALT LAKE.
11	NORTH JORDAN CANAL - IS A CANAL FED FROM THE JORDAN RIVER WHICH IS USED FOR IRRIGATING FARM LAND IN THE SALT LAKE VALLEY.
12	NEW CONCENTRATOR SITE - KENNECOTT IS PRESENTLY LOOKING AT THE POSSIBLITY OF BUILDING A NEW COPPER CONCENTRATOR IN BARNEY CANYON.
13	C-7 CANAL - LOCATED ON THE EAST SIDE OF THE EXISTING KENNECOTT TAILINGS POND IN MAGNA. THIS CANAL DISCHARGES INTO THE GREAT SALT LAKE.
14	PRECIPITATION PLANT - THIS PLANT IS OWNED AND OPERATED BY KENNECOTT TO LEACH COPPER FROM THE MINE WASTE. THE PLANT IS LOCATED JUST WEST OF THE TOWN OF COPPERTON.
15	PIT - REFERS TO THE OPEN PIT COPPER MINE OF KENNECOTT.
16	CARR FORK DITCH - THIS DITCH RUNS ALONG THE NORTH RIM OF KENNECOTT OPEN PIT MINE.
17	EXISTING LIME STORAGE & SLAKING FACILITY - THIS FACILITY WAS BUILT BY KENNECOTT IN 1984 - 1985 TO INJECT LIME INTO THE RUNNOFF WATER & UNDER-GROUND WATER TO CONTROL PH. BEFORE THE WATER WAS DISCHARGED TO KENNECOTT EVAPORATION PONDS. LOCATED JUST EAST OF COPPERTON.
18	BINGHAM CREEK RESERVOIR - BUILT IN THE MID 1960'S TO STORAGE SURPLUS LEACH/MAKE UP WATER FOR THE PRECIPITATION PLANT. LOCATED JUST SOUTHEAST OF COPPERTON.
19	BINGHAM CANYON CUTOFF WALL - PROPOSED SLURRY WALL TO BE INSTALLED IN BINGHAM CANYON JUST WEST OF THE EXISTING PRECIPITATION PLANT.
20	20-MILLION GALLON RESERVOIR -A RESERVOIR JUST NORTH OF THE BINGHAM CREEK RESERVOIR USED TO STORAGE WATER FROM THE COPPERTON AREA & THE CARR FORK DITCH. WAS USED DURING 84 - 85 AS A TREATMENT RESERVOIR, PRESENTLY OVERFLOWS INTO THE BINGHAM CREEK RESERVOIR.
21	CEMETERY RESERVOIR - BUILT IN 1983 TO STORAGE WATER PUMPED FROM THE N.O.S. UNDERGROUND MINE, LOCATED EAST OF COPPERTON CEMETERY.
22	TAILINGS POND - THIS IS A 5000 ACRE POND USED TO STORAGE THE TAILING FROM KENNECOTT CONCENTRATOR PLANT. LOCATED IN THE TOWN OF MAGNA APPROX. 13 MILES NORTH OF THE BINGHAM CANYON.
23	UTAH-SALT LAKE CANAL - IS A CANAL FED FROM THE JORDAN RIVER WHICH IS USED FOR IRRIGATING FARM LAND IN THE SALT LAKE VALLEY.
24	UTAH METAL TUNNEL - AN EXISTING TUNNEL CONNECTING THE BINGHAM CANYON TO MIDDLE CANYON. THE TUNNEL IS USED AS A PIPE WAY TO BRING CULINARY WATER FROM THE MIDDLE CANYON AREA. APPROX. 3 1/2 MILES LONG.
25	MARKHAM GULCH - IS A GULCH JUST NORTH OF THE OPEN PIT MINE, PARALLEL FREEMAN GULCH.

PHASE II PROJECT REPORT

GENERAL SITE LOCATION MAP

DRAWN BY: RBC	APPROVED BY: PMG
DESIGN BY: ASC	DATE: 6 DEC. 1985
CHECKED BY: MPF	DWG. NO.: FIGURE 2.1-1

MORRISON-KNUDSEN ENGINEERS
A MORRISON KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

DRAWING ISSUE

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REVISION

ISSUED FOR	DATE

BY:

MICROFILM	JOB NO.

SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 2.1-1

REV. PLANT

PRELIMINARY-NOT FOR CONSTRUCTION

REFERENCE	DWG. NO.	DESCRIPTION

REFERENCE	DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

	BY	DATE		BY	DATE
APPROVED BY			DESIGN		
APPROVED BY			DRAWN		
APPROVED BY			CKD.		
APPROVED BY			CKD.		
APPROVED BY					

average year, and a dry year. The wet-year hydrological study results provided the primary basis for conceptual design and evaluation of the alternative water control facilities; and the other-year water studies served as a check of the reasonableness of the relative contributions of the various water sources for the three years.

For the purposes of this study, water was classified into three catagories according to quality, as follows:

- Uncontaminated Water - This is uncontaminated natural runoff or ground water which has not come into contact with disturbed mine areas or leaching operations.

- Moderately Contaminated Water - This is natural runoff, groundwater, or underground mine water which has become contaminated by contact with disturbed mining areas (except leach dumps).

- Contaminated Water - This is leach water and includes all other water which has been mixed with leach water, or which has been in contact with the leached waste dumps.

2.3 Diversion of Uncontaminated Runoff

One potential means of reducing the quantity of water entering the Bingham channel drainage area is by diverting and storing or discharging natural runoff from the periphery of the mine and adjacent area. Consequently, a significant portion of this study was directed at means of diversion and storage.

Based on a topographical survey and on-site reconnaissance, five areas were identified where control could be achieved with diversion canals and subsurface cutoffs to intercept underground flow. In addition to

mapping the entire route, test pits were dug by backhoe at the cutoff sites to verify underground conditions. Seismic refraction studies were also completed at several sites.

One logical storage or collection point for collected uncontaminated surface water was determined to be a new dam and reservoir in Dry Fork Canyon. Seismic refraction profiles and drilling were completed at the proposed dam location to provide data on subsurface conditions for design and estimating purposes.

Using topographical maps plotted with the final canal routing, the surface area for each portion of the diversion system was calculated. Using the meteorological criteria set for the design purposes of this study (runoff from a 100-Year Snowpack in addition to a 10-Year, 24-hour Storm Event) volumes to be intercepted were calculated. A runoff-precipitation ratio of 0.3 was used (surface runoff - 30%, evapo-transpiration - 35%, ground water infiltration - 35%). The results are summarized in the following table:

Location	Drainage Area (acres)	Design Runoff (acre-feet)
Copperton Area	860	860
Dry Fork Canyon	1,855	1,855
Freeman Gulch	819	819
Markham Gulch	403	403
Upper Carr Fork Drainage	592	592
Muddy and Galena Gulches	171	171

In the conceptual designs, runoff from the Copperton area would be collected by lined canals and subsequently discharged from an area east of the town of Copperton. All other waters would be collected by lined canals and diverted to the proposed Dry Fork reservoir and pumped through a pipeline or a new tunnel for subsequent controlled discharge. Appropriate piping was included to route discharges around and through developed areas.

Interception of ground water by use of subsurface cutoffs was evaluated for fourteen cutoff locations based on existing topography and on estimated natural permeabilities of the upper soil deposits and the underlying fractured quartzite bedrock. Based on these studies, we concluded that only 325 acre-feet of ground water could be diverted during the wet year, and that the cost would be substantial, averaging approximately $6,000 per acre-foot. Only three of the fourteen cutoff sites would divert water at a cost less than the incremental cost of storage, and these three sites represent only 77 acre-feet during the wet year. While these three cutoffs are probably worth studying further during detailed design studies, their influence on the overall water management system is so small that they were not considered further in this study.

Installation of the entire network of surface diversion facilities is estimated on a preliminary basis to cost $25.4 million. A series of trade-off studies showed that the installation of a treatment facility for Pit and Carr Fork Ditch water, coupled with an increase in reservoir size, is substantially less expensive. For example, the costs shown below are based on the installation of diversion ditches for Copperton runoff and a dam with ancillaries in Dry Fork Canyon to control runoff from that area:

	Item	Estimated Capital Cost
A.	Diversion Alternative	
	Copperton Diversion	$ 1,494,000
	Dry Fork Dam and Reservoir	7,300,000
	New Tunnel	5,763,000
	Pipeline to the Jordan River	2,251,000
	Total	$16,808,000

B. Treatment and Storage Alternative

Water Treatment Facilities (3,000 gpm design)	$ 7,212,000
Increase Reservoir Size	300,000
Total	$ 7,512,000
Net Difference	$9,296,000

With cost differences of this magnitude for equivalent control, there is little incentive to consider diversion as a viable option. Also, because the treatment facility would only need to operate during wet-year conditions, operating cost differences are not expected to significantly change this comparison.

The capital costs of the complete system of uncontaminated water diversion facilities are estimated as follows:

Item	Estimated Capital Cost
Dry Fork Dam (sized for completed system)	$ 9,000,000
New Tunnel	5,763,000
Copperton Diversion	1,494,000
Freeman and Markham Diversion (incremental cost)	4,677,000
Upper Carr Fork Diversion (incremental cost)	3,658,000
Muddy and Galena Diversion (incremental cost)	791,000
Total Estimated Capital Cost	$25,383,000

In addition to the above items, a new pipeline will be needed to convey the treated NOS, Carr Fork Underground, Bingham and Butterfield Tunnel waters because the diverted water will make full use of the existing pipeline to the Jordan River and North Jordan Irrigation Canal. The options identified and the relative costs of possible new conveyances are as follows:

Item	Estimated Capital Cost
Pipeline for 6,250 gpm to a New Concentrator	$ 1,753,000
Pipeline for 6,250 gpm to the Jordan River or North Jordan Irrigation Canal	$ 2,440,000
Pipeline for 6,250 gpm to the C-7 Canal to the Great Salt Lake	$ 6,274,000
Pipeline for 12,500 gpm to a New Concentrator	$ 2,251,000
Pipeline for 12,500 gpm to the Jordan River or North Jordan Irrigation Canal	$ 5,836,000
Pipeline for 12,500 gpm to the C-7 Canal to the Great Salt Lake	$10,606,000

2.4 Leach Water Storage - Dams and Reservoirs

Several schemes were considered for temporary storage of leach solutions during extreme hydrological conditions. The existing 1,200 acre-foot reservoir was found to be too small to handle situations such as that which existed during the peak runoff season in 1984. The criteria for sizing of the required storage reservoir(s) was to contain without discharge the sum of the following:

1. Runoff including snowmelt from simulated operations during the 1:100 wet year.

2. Runoff from a 10-year, 24-hour storm event.

3. Solutions generated from a 24-hour Precipitation Plant shutdown.

4. Minimum 500 acre-foot working volume and sediment allowance.

In addition, the following two special cases were considered for comparison:

Case 1. Storage of the runoff from the probable maximum flood (PMF) instead of the 10-year, 24-hour storm event.

Case 2. Storage outside of the Bingham channel, diverting up to a 100-year, 24-hour storm from Bingham Creek, and storing the runoff from a PMF in the new reservoir drainage basin.

The criteria for conceptual design also called for a single impermeable liner system constructed with either compacted clay or a synthetic membrane material.

Geotechnical investigations were conducted to confirm subsurface conditions and material properties. Field exploration included exploratory drill holes, test pits, and seismic refraction surveys.

Laboratory testing for classification, permeability, compaction characteristics and shear strength was performed on representative samples of foundation and potential borrow materials. The results of these investigations, which are presented in the Phase II Geotechnical Report (Ref. 2), were used in site selection and conceptual designs.

The various reservoir schemes were sized for many possible operating conditions, ranging from the total storage of contaminated waters (excluding NOS, Carr Fork Underground, Bingham Tunnel, and Butterfield Tunnel waters), to separate treatment and/or discharge of runoff from above the disturbed areas, the Pit, and Carr Fork Ditch waters. The storage requirements for these alternatives ranged between 13,058 and 6,439 acre-feet. For comparison, the effect of separate treatment and discharge of a side stream of leach water was also considered, which would reduce required storage by an additional 1,626 acre-feet.

After a comprehensive matrix of possible water management schemes was analyzed, the scheme involving separate treatment and discharge of Pit and Carr Fork Ditch water (but not of runoff from undisturbed areas) was found to be the most economical. This scheme required a new

reservoir in the Bingham channel capable of storing 10,375 acre-feet of leach solution.

The capital costs for this 10,375 acre-foot storage reservoir were estimated as follows:

Item	Estimated Capital Cost
New Dam, Reservoir, Spillway, and Pumping Plant	$28,000,000
Breach Existing Dam/Remove Sediments	3,220,000
Total Estimated Capital Cost	$31,220,000

For this same water management scheme, the costs of the two special storage cases are presented in the following paragraphs.

Case 1. Storage of the runoff from a PMF:

Item	Estimated Capital Cost
New Dam, Reservoir, and Pumping Plant (no Spillway)	$29,600,000
Breach Existing Dam/Remove Sediments	3,220,000
Total Estimated Capital Costs	$32,820,000

Case 2. Storage out of the Bingham channel:

Item	Estimated Capital Cost
New Dams, Reservoirs, and Pumping Plant	$38,860,000
Breach Existing Dam/Remove Sediments	3,220,000
Total Estimated Capital Costs	$42,080,000

2.5 Bingham Canyon Ground-Water Intercept

Ground water and subsurface conditions in the Bingham Canyon channel were investigated with six exploration drill holes, three production/observation wells, and numerous seismic refraction lines. Two distinct aquifers were identified, corresponding to the geologic conditions encountered. These two aquifers were markedly different in both quality and yield, but both produced moderately contaminated water. Details of these investigations and tests are presented in the Phase II Geotechnical Report (Ref. 2).

A 35-foot thick upper aquifer was identified in the alluvium which fills the canyon floor to a maximum depth of approximately 130 feet. Below this, a fractured bedrock aquifer was identified in the highly jointed quartzite underlying the alluvium. This lower aquifer extends to a depth below the surface of at least 200 feet, and probably to a considerably greater depth. Generally, the lower aquifer is of lower permeability and better quality than the upper aquifer, and the lower aquifer exerts slight artesian pressure on the upper aquifer. Water samples from the two aquifers were analyzed by Kennecott, with the following results:

Item	Units	Measured Values	
		Alluvium	Bedrock
pH	-	3.45	6.11
Total Suspended Solids	mg/l	26.4	5.4
Total Dissolved Solids	mg/l	24,000	5,880
Copper	mg/l	242	1.68
Arsenic	mg/l	0.013	0.004
Sulfate	mg/l	12,000	3,500
Zinc	mg/l	70	39
Lead	mg/l	0.38	0.19
Magnesium	mg/l	1,450	560
Aluminum	mg/l	770	< 1
Iron	mg/l	99	1
Mercury	mg/l	< .0001	<.0001

Several conceptual schemes were explored for interception and control of this moderately contaminated water. Each of these schemes provides for interception and recovery of all of the contaminated water in the alluvial aquifer, and for recovery of the water in the upper portion of the bedrock aquifer. From the information currently available, we have tentatively concluded that this captured water will represent more than 95% of the contamination currently flowing down-gradient.

The following alternative ground-water control systems were identified and studied:

1. Construction of a slurry or asphalt membrane diaphragm wall, a line of upstream alluvial wells, and a line of downstream bedrock wells.

2. Construction of a chemical grout curtain, plus upstream and downstream wells as described above.

3. Construction of a dewatering shaft with dewatering adits through both bedrock and alluvium, and an underground pump station to remove the collected water.

4. Construction of a large open excavation to bedrock, a water collection sump, pump station, and downstream bedrock wells.

Based upon the relative technical advantages and disadvantages of the various alternative schemes and their relative costs, we concluded that Alternative No. 2 was the most attractive. However, the effectiveness of this scheme will need to be confirmed with a field test. The principal components of this scheme and the estimated capital costs are as follows:

Item	Estimated Capital Cost
Chemical Grout Curtain	$ 654,600
Alluvial Wells	222,200
Alluvial Pumps	69,600
Bedrock Wells	314,100
Bedrock Pumps	51,500
Total Estimated Capital Cost	$1,312,000

These costs do not include the costs of pumps and pipelines for conveying the collected waters to the appropriate treatment facility. Those conveyance costs are included in the treatment plant costs summarized in Section 2.6 below.

2.6 Water Treatment and Discharge

Several water treatment plant and discharge schemes were considered to aid in minimizing storage requirements during extreme hydrological conditions. In all cases, the treatment process selected uses conventional lime neutralizing with sludge recycle in an agitated system, followed by flocculation and clarification to produce waters which meet regulatory discharge standards. Appropriate instrumentation and sampling would be included to assure optimal operation and to satisfy regulatory monitoring and reporting requirements.

The following water treatment systems were conceptually designed and costed:

1. A modular plant adjacent to the existing lime storage and slaking facility. The first module would be designed to handle up to 6,250 gallons per minute (gpm) of existing NOS and Carr Fork Underground waters.

2. A second 6,250 gpm module for the above plant intended to treat future flows from Bingham Tunnel, Butterfield Tunnel, Bingham Canyon Cutoff, and additional NOS waters.

3. A 3,000 gpm plant near the existing tailings dam in Magna for treatment of Pit and Carr Fork Ditch waters.

4. A 1,500 gpm side stream treatment of leach water at the 3,000 gpm plant (for comparative purposes only).

Discharge conveyances for treated water were conceptually designed and costed for the following schemes:

1. Discharge to a New Concentrator

2. Discharge to the Jordan River

3. Discharge to the North Jordan Irrigation Canal

4. Discharge to the C-7 Canal into the Great Salt Lake

Following the comprehensive matrix analysis of possible water management schemes, we concluded that all three of the moderately contaminated water treatment schemes were economically feasible. The capital costs of the different treatment facilities are estimated as follows:

Item	Estimated Capital Cost
1. New 6,250 gpm Treatment Facility:	
Treatment Plant	$ 2,215,000
Carr Fork Underground Pumps and Pipeline	1,481,000
Line Existing 20-Million-Gallon Reservoir	358,000
Line Existing Cemetery Reservoir	425,000
Total Estimated Capital Cost	$ 4,479,000

2. New 6,250 gpm Second Module (future expansion):

Treatment Plant	$ 2,215,000
New Lined Feed Reservoir	442,000
New Lined Discharge Reservoir	442,000
Bingham Tunnel Pipeline	774,000
Butterfield Tunnel Pipeline	908,000
Total Estimated Capital Cost (Incremental)	$ 4,781,000

3. New 3,000 gpm Treatment Facility:

Pipeline to Existing Tailings Dam Area	$ 3,342,000
Treatment Plant	2,034,000
Lined Settling Ponds	884,000
Surge Pond	750,000
Sludge Reclaim	202,000
Total Estimated Capital Cost	$ 7,212,000

4. A 1,500 gpm Side Stream Treatment (for comparison only):

Pipeline (92,000 feet)	$ 2,655,000
Treatment Plant	1,552,000
Two Settling Ponds	884,000
Sludge Reclaim	202,000
Total Estimated Capital Cost	$ 5,293,000

The capital cost estimates for discharge conveyances were summarized earlier in Section 2.3.

In addition to the items listed above, the following features will be required to prevent contaminated water infiltration into the ground water system:

Item	Estimated Capital Cost
1. Lining of the Bingham Creek drainage channel from the foot of the Carr Fork Ditch to the New Reservoir (22,000 feet)	$1,746,000
2. Lining of the Carr Fork Ditch	$ 423,000

2.7 Lowest Cost Alternative System

A matrix analysis was performed of various alternative schemes for a water management system to control wet-year waters, and the lowest cost scheme was identified. This scheme provides for 10,375 acre-feet of leach water storage; treatment of NOS and Carr Fork Underground water and discharge via the existing pipeline to the North Jordan Canal; treatment of Pit and Carr Fork Ditch water during wet years and discharge to the C-7 Canal near the Great Salt Lake; and no separate diversion of uncontaminated runoff. The estimated capital cost for this scheme, excluding the future 6,250 gpm treatment module, is as follows:

Item	Estimated Capital Cost
New Dam and Reservoir	$28,000,000
Breaching Existing Reservoir	3,220,000
Treatment Module No. 1 (6,250 gpm)	4,479,000
Lining Bingham Channel Drainage	1,746,000
Lining Carr Fork Ditch	423,000
Pipeline to North Jordan Canal and Jordan River	-0- (existing)
Treatment and Discharge from Pit and Carr Fork Ditch	7,212,000
Bingham Channel Groundwater Intercept	1,312,000
Total Estimated Capital Cost	$46,392,000

If the second 6,250 gpm treatment module was constructed at the same time as the basic system, the incremental cost would be $4,781,000. If for some reason the existing pipeline to the North Jordan Canal were unusable for the planned purpose, a new pipeline would be needed. The cost for a new pipeline is summarized in Section 2.3 above.

CHAPTER 3
HYDROLOGICAL AND METEOROLOGICAL STUDY

3.1 PURPOSE AND SCOPE

The primary purpose of the hydrological and meteorological study is to assist in formulating the overall long-range water management plan of the Bingham Canyon watershed. This study compliments other investigations and studies which were made during Phase II on geotechnical conditions and ground water, canal route siting and sizing, treatment plant sizing, dams and reservoirs, and overall design of the project facilities. The intention of this study is to first quantify the various sources of surface and ground water and separate these into uncontaminated, moderately contaminated, and contaminated categories. Then, given the various water demands of the operation of the plant facilities, perform a water budget of supply/demand, indicating excesses or shortages. This study is to serve, in part, as the basis for the economic selection of water conveyance and recycle systems; leach water and treatment plant facilities; storage reservoir(s); storm water diversion and mine pit drainage amounts.

The scope of this study and the investigations of the different sources of water were confined to the Bingham Canyon watershed. Importation of fresh (uncontaminated) water from other sources outside Bingham Canyon, such as from other watersheds, by developing deep wells four miles east of Copperton, or by water exchange with the Salt Lake City Water Conservancy District, was not part of this study. Evaluating the movements and firm yields of the ground water for the entire Bingham Canyon ground water regime also was not part of this study.

The hydrological study was a simplified, material balance type of accounting. It did not involve modeling of different alternatives, demands and water availability, nor did it involve optimizing the size of the various mine facilities. The study differentiated between uncontaminated, moderately contaminated, and contaminated waters.

Other aspects of water quality and environmental issues were not considered.

3.2 CLASSIFICATIONS OF WATER

In this study, water from the land surface, subsurface, mine pit, present and future plant facilities, and reservoirs are classified as follows:

A. Uncontaminated Water

The surface water from rain or snowmelt originating from the undisturbed (natural) part of a watershed or subarea is regarded as uncontaminated (fresh) water. This also applies to the ground water from the undisturbed water-bearing formations that can be intercepted by proposed cutoff walls and the water collected before flowing into the mine pit or dump areas. This water can be used for the different mine operations and if in excess, be diverted away from Bingham Canyon watershed without water treatment.

B. Moderately Contaminated Water

Surface runoff from undisturbed areas of the watershed that directly drains into the mine pit and the ground water from the undisturbed subsurface formation which reappears into the mine pit are assumed to be moderately contaminated. Water from the dewatering of the deep underground mine of the North Ore Shoot (NOS) Project was included in this classification. Moderately contaminated water implies that this water can be treated with moderate efforts, after which the water can be discharged into other drainages such as irrigation canals or into the proposed new concentrator.

C. Contaminated Water

Surface and ground water flowing on top of, into, or out of the dump sites, or having been mixed with leach water are all considered

contaminated water. The existing large Bingham Creek Reservoir receives and stores waters from the precipitation plant, the overflow from the East Side leach collection system, the waters from the mine pit water pipeline, and (on occasion) from the NOS. It also recycles the water which is used as make-up process water. On an emergency basis, the small Bingham Canyon reservoir receives water from the Precipitation Plant and Copperton before treatment and discharge into the existing evaporation ponds. All the water in the reservoirs is contaminated water. Storm or snowmelt runoffs into these reservoirs and the evaporation ponds are therefore also contaminated. The water from the reservoirs and evaporation ponds cannot be released downstream except under emergency or specially permitted conditions, and then only after treatment to meet regulatory discharge limitations.

D. Leach Water

This is the water from leaching activities and for use in the Precipitation Plant. This water is contaminated and is recycled for mine use.

3.3 BASIC INFORMATION AND DATA

Listed below are the relevent basic information and data that were used in the hydrological and meteorological study. Some information and data had already been collected during the Phase I investigations (Ref. 1). In recent years, Kennecott UCD personnel have been collecting hydrologic and meteorologic data at the perimeter of Bingham Canyon Mine for their water and environmentally related studies. These data and studies were obtained from Kennecott for use in this study:

- Capacities, sizes, flow rates, average and peak usage demands of the various processing and recycle facilities such as leaching application and collection systems, precipitation plant pumping rates, and water treatment plant(s), reservoir(s), storage tanks and evaporation ponds;

- Description of mine drainage tunnels and pipelines, areas drained, and flow rates;

- Central Pump Station daily flows from historic operation records;

- The latest plans for the Bingham Canyon Mine operations, and the locations and sizes of the dump sites;

- Daily and monthly precipitation at six Kennecott measuring stations in the watershed area for the period of record;

- Snowpack data and snow-water equivalents, including previous calculations of April and May 1984 Bingham Canyon snow-water equivalents versus watershed elevations and the 1955-1984 (30-year) average water equivalents versus elevation;

- U.S. Soil Conservation Service, "Snow Survey Data" for Rocky Basin, Middle Canyon, and Bevan's Cabin for the period of record;

- Kennecott flow measurements and flow data (ten spot measurements for April, May, and June 1985) of all measuring sites on the different gulches, canals, collection points, and tunnels;

- Equation-derived (based on data obtained from a salt company) pan evaporation rates and net evaporation for Dike Station (Kennecott Concentrator Tailings Pond at Magna) for November 1979 through May 1985;

- Salt Lake City Annual Precipitation (Water-Years 1875 through 1984);

- Salt Lake City long-term (30-year, 1951-1980) average monthly pan evaporation rates (obtained from National Weather Service);

- Bingham Canyon Reservoir historic daily water levels, volume remaining and water discharged out of small reservoir, treated and diverted to evaporation ponds;

- Bingham Canyon Reservoir area-capacity tables based on June 1980 data, which were superceded by 19 July 1985 data;

- Miscellaneous Kennecott UCD prior memos on UCD Modernization Project containing data on flow rates, water usages, and expansion alternatives for the various mine facilities;

- Dames and Moore 1973 Study Report; and

- IECO 1984 Bingham Canyon Hydrologic/Geotechnical Study, Phase I Report.

3.4 HYDROLOGICAL AND METEOROLOGICAL STUDY

A. Study Approach

The hydrological study was performed on a monthly basis. As mentioned previously, it was an accounting type of a balance, divided into the following parts:

- Bingham Canyon Reservoir Data
- Inflows to the Reservoir
- Outflows from the Reservoir
- Balance
- Analysis of Precipitation/Runoff

This study was for the present level of project development. Monthly balance and budgeting were performed for a complete water-year, starting with October of a preceeding year and ending with September of the subject year. The water-year basis was chosen (instead of a calendar-year basis) because October usually indicates the end of the "dry" season and the beginning of the "wet" season (when the winter rains and snowfalls begin).

Three water-years were selected for this study, representing "wet", "average", and "dry" years. The starting conditions for each of these water-years were the recorded (beginning-of-the-month) reservoir water level and the corresponding storage and surface area for the years chosen. The inflows and outflows for the various mine facilities were estimated from Kennecott records. It was assumed that the leach applications at the various dump sites have reached an inflow-outflow equilibrium. Where data or information were lacking, estimates were made for these data after discussions with Kennecott UCD personnel.

A first-cut balance was then made and presented to Kennecott for review and comment. The generally agreed-upon estimates of the missing data were then incorporated into the final hydrological study. This step was necessary since the results of this study served as the basis for the trade-off studies for the future project conditions and the evaluation of the various alternatives for water diversion and storage of water versus treatment.

A quick review of the data and information obtained for the study indicated that the recent years (where most of the data are either available or the information is still fresh in the memory of Kennecott personnel) should be used for analysis. Initially, a direct approach to a water balance study was attempted. It was hoped that by using the recorded basin precipitation as input, the inflows, outflows, infiltration and seepage losses, and changes in the reservoir levels could be calibrated against the Kennecott flow measurements. However, this was not possible since at the time of this study there were only ten spot measurements/observations made during April, May, and June

1985 for this calibration. Some of these measurements and observations were either registering zero flows or were not read. Furthermore, the data indicated that flows were either recession flows (baseflows) or the observations were made neither during nor immediately after a precipitation event, in order to measure the direct runoff. Therefore, the handful of observations made did not reflect any hydrologically active periods which are necessary for calibration.

Thus, an indirect heuristic approach was used in the hydrological study. Since all inflows, outflows, losses (such as evaporation and seepage) and return flows (surface and ground water) are reflected in the Bingham Canyon Reservoir recorded water levels and corresponding storages, the reservoir was selected as the central "clearing house" for the balance. Monthly accounting of all the sources of inflow, outflow, and losses were then computed. After which, the net runoff volumes and ratios of precipitation to runoff and leach return flow were determined. The heuristically derived precipitation to net runoff monthly ratios reflect the complex hydrologic process of rainfall, snow accumulation, snow melt, infiltration, losses, surface runoff, surface-subsurface interflow and the time-delayed runoff into the reservoir. The balance portion of the analysis indicates the behavior of the reservoir under the various supply and demand constraints. Results of the hydrological study serve as the basis for the trade-off studies for evaluating the different project alternatives. This same algorithm was used again in the trade-off studies in which future project facilities and configurations and the projected supplies and demands were imposed upon the water balance algorithm.

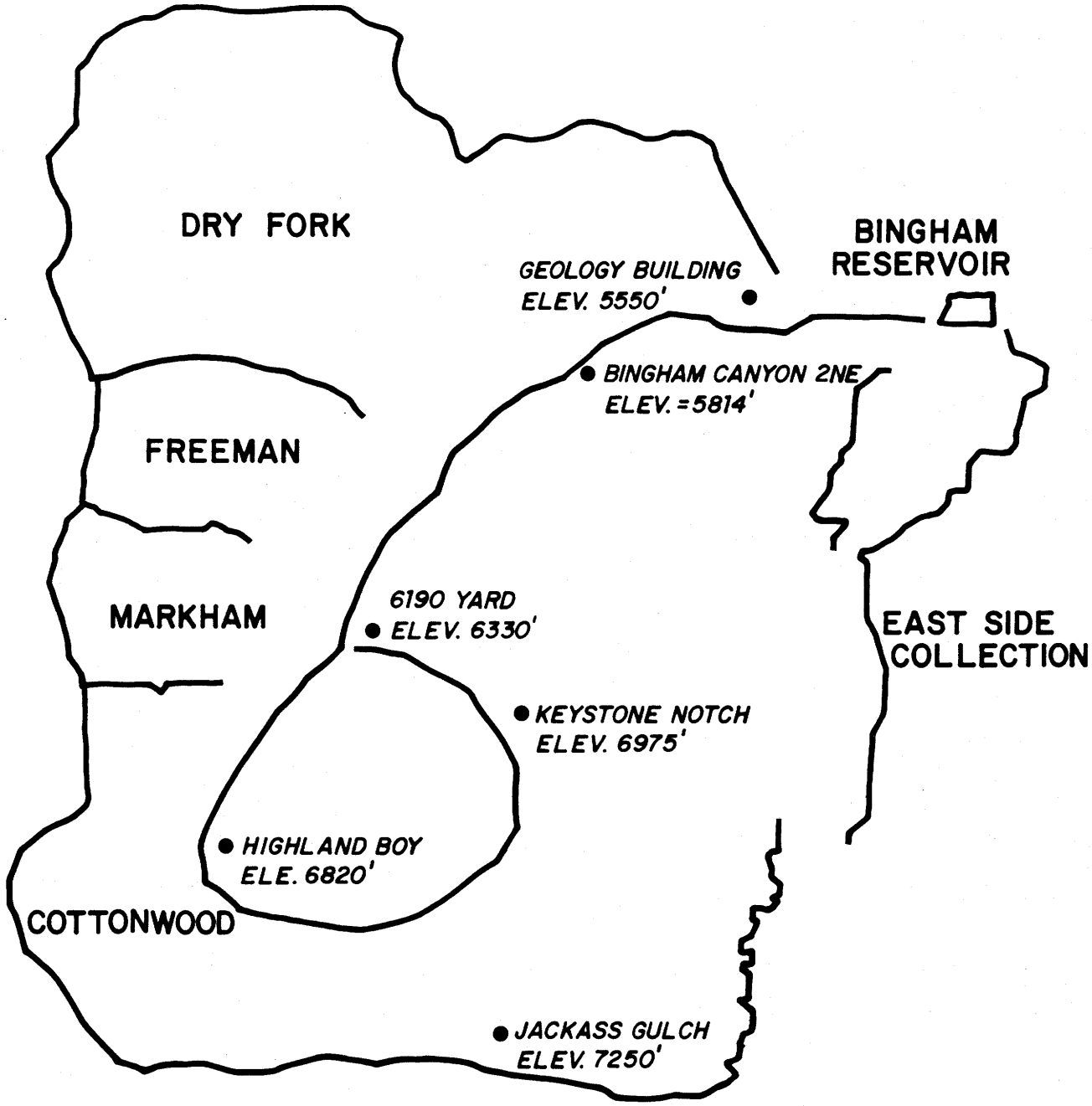
B. Bingham Canyon Basin Precipitation and Frequency

Six precipitation stations are located in the Bingham Canyon drainage. The station names, elevations and data available are:

Measuring Station	Elevation (feet)	Period of Data
Geology Building	5,550	Oct. 1974-present
Bingham Canyon 2NE	5,814	Oct. 1974-present
6190 Yard	6,330	Oct. 1964-present
Keystone Notch	6,975	Jan. 1973-present
Highland Boy	6,820	Mar. 1972-present
Jackass Gulch	7,250	Oct. 1964-present

The locations of the stations are shown on Figure 3.4-1. All the six stations registered precipitation data from water-year 1974 to present (June 1985 as of Phase II studies) for a data length of about 11-1/2 years. Between October 1964 and October 1973, only two stations were in operation. The data available were too short for an accurate frequency analysis for frequencies (return periods) up to 100-year recurrence intervals. Therefore, a correlation study was made to extend the precipitation data-base. Long-term annual precipitation (water-year basis) at Salt Lake City was available, spanning 110 years (Water-years 1875 through June 1985). In addition, NOAA published monthly precipitation data for Salt Lake City from January 1945 through June 1985 were readily available. Monthly and water-year totals for Salt Lake City were used in the common-period correlation with Bingham Canyon precipitation data.

For determining the average Bingham Canyon precipitation, all data from the six stations were used. An arithmetic average was used instead of other weighted average methods. The six stations are fairly well lined up in a north-easterly direction, and at different elevations ranging from 5,550 to 7,250 feet. Weighting these data by area and/or Theissan polygon methods will not give accurate weighted averages because the areal spread and elevation variations are too wide. For example: using data from the Geology Building and Bingham Canyon 2NE stations to obtain average precipitation for Dry Fork drainage, and the latter with the 6190 Yard station for Freeman Gulch drainage will not give average precipitations for the respective drainages that have elevations above 8,000 feet. The arithmetic average of the elevations at the six stations is at about elevation 7,000 feet, which is very close to the average basin elevation. Therefore, a 6-station arithmetic average was used for obtaining the average basin precipitation.



LOCATION MAP
BINGHAM CANYON PRECIPITATION STATIONS

FIGURE 3.4-1

It had been suggested that data from the station with the lowest and highest recorded data should be discarded in determining the average basin precipitation. Further review of the recorded data indicated that there are no inconsistencies found in these data. Generally, as expected, as elevations are increased, precipitation amounts also increased (e.g, Geology Building and Highland Boy data). In obtaining the average basin precipitation for use in the water balance for the Bingham Canyon watershed, there is no justification in discarding data from any one of these six stations. Moreover, only 11 years of data are available for correlation with Salt Lake City data. Similarly, in the absence of other data, the recorded data at the two stations that were in operation prior to October 1973 were used to obtain the arithmetic average basin precipitation.

Graphical correlation was used for extending the average monthly basin precipitation data. The following data for Salt Lake City were correlated with the computed average Bingham Canyon watershed precipitations:

- Water-year totals for the period of record
- Maximum monthlies at either Salt Lake City or the average basin precipitation versus corresponding month values
- Cumulative maximum 2-month, 3-month, and/or 4-month precipitation for each year

Results of the graphical correlation indicated that the correlation was surprisingly good. Where there was maximum precipitation shown in the Salt Lake City data, corresponding maximums were also found (almost to the same dates) in the computed average Bingham Canyon precipitation. A logarithmic equation was used to determine the relationships, as follows:

$$X = C_1 \times (Y)^{C_2}$$

where: X = Six-station average basin precipitation (inches)
Y = Salt Lake City precipitation (inches)
C_1 and C_2 are regression coefficients

The derived equation indicated that there is a straight-line relationship between the average basin precipitation and Salt Lake City precipitation:

$$X = 1.39 \times (Y)$$

where: $C_1 = 1.39$
$C_2 = 1.00$

That is, the Bingham Canyon average monthly and annual precipitation is 1.39 times the Salt Lake City precipitation. Monthly precipitation and water-year totals for Salt Lake City, and the recorded and estimated six-station average basin precipitation are shown in Tables 3.4-1 and 3.4-2, respectively. The graphical correlation is shown in Figure 3.4-2.

An annual (water-year basis) precipitation frequency curve was determined for the Bingham Canyon average precipitation using both the recorded data and correlated values. The United States Geological Survey (USGS) method was used in the frequency analysis. The formula for determining annual frequencies is:

$$T = \frac{n + 1}{m}$$

where: T = Recurrence interval, in years
n = number of years of record
m = magnitude, the highest being 1

The annual precipitation values and corresponding computed annual frequencies are shown in Table 3.4-3. The computed frequencies for each of the 110 annual precipitation values were then plotted on Gumbel paper. The Bingham Canyon average basin precipitation annual frequency curve is shown in Figure 3.4-3.

TABLE 3.4-1

SALT LAKE CITY MONTHLY AND ANNUAL PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1875													16.73
1876													24.60
1877													17.69
1878													22.16
1879													10.22
1880													12.49
1881													15.48
1882													16.50
1883													13.37
1884													19.71
1885													18.06
1886													18.46
1887													14.60
1888													10.71
1889													14.21
1890													16.73
1891													13.43
1892													13.78
1893													17.43
1894													17.27
1895													10.95
1896													16.75
1897													16.81
1898													15.81
1899													17.39
1900													12.96
1901													16.57
1902													11.40
1903													14.16
1904													17.76
1905													14.51
1906													19.53
1907													18.90
1908													20.26
1909													20.05
1910													10.55
1911													15.65
1912													17.99
1913													18.29
1914													17.19
1915													14.53
1916													13.38
1917													18.46
1918													14.41
1919													12.13
1920													19.42
1921													16.68
1922													19.40
1923													21.72
1924													11.25

TABLE 3.4-1

SALT LAKE CITY MONTHLY AND ANNUAL PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925													20.97
1926													14.54
1927													18.90
1928													13.69
1929													17.17
1930													14.23
1931													9.27
1932													14.54
1933													11.28
1934													8.16
1935													13.65
1936													13.37
1937													13.42
1938													12.87
1939													12.00
1940													11.34
1941													18.17
1942													15.49
1943													12.14
1944				1.67	1.11	3.67	4.90	1.67	2.78	0.04	.00	0.52	18.85
1945	0.18	1.44	0.51	0.39	1.19	1.49	1.37	0.90	2.73	1.92	3.28	0.64	16.04
1946	0.58	2.30	0.92	1.01	0.12	1.43	1.59	2.59	0.01	0.55	0.95	0.30	12.35
1947	3.61	1.44	1.91	0.95	0.81	0.58	2.32	1.88	2.93	0.01	1.38	1.01	18.83
1948	2.43	1.88	0.79	0.34	0.86	2.30	1.56	0.26	2.47	0.39	0.49	0.59	14.36
1949	0.87	1.71	2.63	2.31	0.64	2.95	1.25	2.66	0.17	0.30	0.70	0.64	16.83
1950	2.79	0.88	1.41	1.80	1.19	0.98	1.29	2.18	0.16	1.06	0.03	1.73	15.50
1951	0.58	2.00	0.49	1.69	0.64	1.26	2.60	0.87	0.09	2.17	1.79	.00	14.18
1952	1.90	1.59	2.90	2.20	1.84	3.56	1.86	1.07	1.07	1.09	0.19	0.02	19.29
1953	0.00	1.08	1.16	2.73	0.39	0.86	2.77	1.05	0.51	0.81	0.88	0.13	12.37
1954	0.32	0.96	0.91	0.90	0.81	1.50	0.65	0.63	1.23	0.91	1.77	0.59	11.18
1955	0.54	1.61	0.69	1.34	1.31	0.20	2.04	1.35	0.95	0.80	0.44	0.97	12.24
1956	0.90	2.24	1.09	2.39	1.10	0.10	1.50	2.33	0.63	0.08	0.03	0.14	12.53
1957	1.86	0.56	1.67	1.37	0.72	2.18	3.24	3.37	1.47	0.31	1.69	0.33	18.77
1958	0.78	1.37	1.61	0.87	2.20	2.19	2.92	0.30	0.04	0.05	0.23	0.25	12.81
1959	.00	1.13	0.54	1.60	1.41	0.79	1.61	2.05	1.38	0.19	1.76	1.66	14.12
1960	0.22	0.10	1.05	0.96	1.58	2.45	1.11	0.73	0.39	0.02	1.33	0.49	10.43
1961	1.19	1.73	0.39	0.09	2.06	1.85	0.95	0.24	0.09	0.54	1.20	1.10	11.43
1962	1.60	1.15	0.88	0.84	1.43	2.34	2.48	2.12	0.49	2.52	0.26	0.27	16.38
1963	0.93	0.44	0.28	0.53	0.67	2.11	3.86	0.23	1.67	.00	0.54	1.08	12.34
1964	1.05	1.56	0.79	0.94	0.35	2.26	2.69	2.77	2.61	0.26	0.17	0.13	15.58
1965	0.45	1.56	0.79	0.94	0.35	2.26	2.69	2.77	2.61	0.26	0.17	0.13	14.98
1966	0.39	1.13	1.81	0.41	1.19	1.21	1.43	0.51	0.07	0.33	0.22	0.83	9.53
1967	1.18	0.75	0.86	2.05	0.67	1.94	2.08	2.15	2.73	1.14	0.07	0.73	16.35
1968	0.66	0.66	1.64	0.46	2.32	2.21	2.82	2.18	1.58	0.09	3.66	0.56	18.84
1969	1.64	1.32	2.27	1.69	2.84	0.57	1.38	0.18	2.83	1.51	0.34	0.18	16.75
1970	1.96	0.92	1.69	1.24	0.94	1.01	3.25	0.89	1.63	0.86	0.57	2.80	17.76
1971	1.61	2.27	2.80	1.06	2.13	1.01	2.16	1.34	0.64	0.94	2.15	1.75	19.86
1972	3.23	1.03	1.35	1.22	0.49	1.18	3.62	0.14	0.15	0.06	0.21	1.36	14.04
1973	2.74	1.36	3.22	1.49	0.91	2.67	1.64	1.74	0.19	1.07	1.16	4.07	22.26
1974	0.67	2.52	2.26	1.80	1.65	0.97	4.57	0.39	0.28	0.18	0.32	0.03	15.64

TABLE 3.4-1

SALT LAKE CITY MONTHLY AND ANNUAL PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1975	2.03	0.90	1.34	1.28	1.24	3.44	2.46	2.58	1.81	0.28	0.10	0.08	17.54
1976	1.91	1.71	1.03	0.63	1.90	1.90	2.47	0.99	1.24	1.55	0.82	0.16	16.31
1977	0.57	0.03	0.08	0.76	0.64	3.10	0.59	4.76	0.06	0.61	1.85	1.85	14.90
1978	0.83	1.20	1.42	2.33	1.96	3.47	2.90	1.57	0.06	0.06	0.92	2.51	19.23
1979	.00	1.73	0.58	0.72	1.05	0.80	1.04	0.84	0.35	0.40	0.63	0.05	8.19
1980	1.29	0.98	0.55	2.87	2.25	2.46	0.89	2.70	0.42	1.34	0.26	0.72	16.73
1981	1.74	1.17	0.37	0.64	0.81	2.11	0.45	3.68	1.03	0.33	0.23	0.48	13.04
1982	3.91	1.03	1.89	1.08	0.53	2.39	1.63	1.86	0.66	2.57	0.56	7.04	25.15
1983	1.87	0.75	1.92	1.19	1.36	3.97	1.63	2.58	0.62	1.02	2.64	1.03	20.58
1984	1.62	2.23	4.37	0.50	0.95	1.76	4.43	1.17	1.86	1.72	1.49	1.72	23.82
1985	3.70	1.45	0.80	0.91	0.85	1.80	0.64	2.95	1.30				
TOTAL	56.33	53.87	55.66	52.19	49.46	79.28	89.33	69.22	45.99	30.34	37.48	40.67	1721.60
													15.65
AVERAGE	1.37	1.31	1.36	1.24	1.18	1.89	2.13	1.65	1.10	0.74	0.91	0.99	15.87

TABLE 3.4-2

BINGHAM CANYON AVERAGE BASIN PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1875													23.25
1876													34.19
1877													24.59
1878													30.80
1879													14.21
1880													17.36
1881													21.52
1882													22.94
1883													18.58
1884													27.40
1885													25.10
1886													25.66
1887													20.29
1888													14.89
1889													19.75
1890													23.25
1891													18.67
1892													19.15
1893													24.23
1894													24.01
1895													15.22
1896													23.28
1897													23.37
1898													21.98
1899													24.17
1900													18.01
1901													23.03
1902													15.85
1903													19.68
1904													24.69
1905													20.17
1906													27.15
1907													26.27
1908													28.16
1909													27.87
1910													14.66
1911													21.75
1912													25.01
1913													25.42
1914													23.89
1915													20.20
1916													18.60
1917													25.66
1918													20.03
1919													16.86
1920													26.99
1921													23.19
1922													26.97
1923													30.19
1924													15.64

TABLE 3.4-2

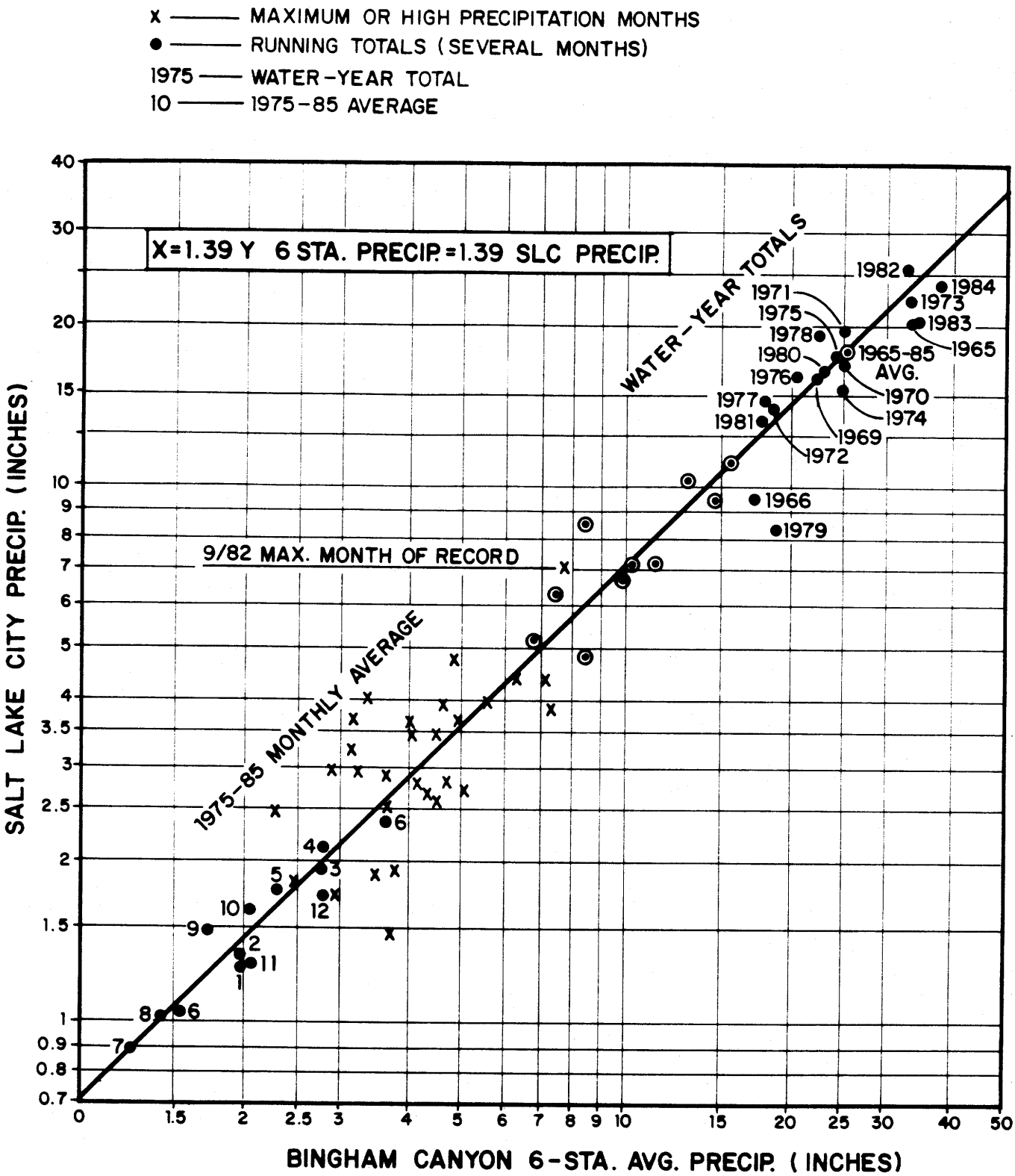
BINGHAM CANYON AVERAGE BASIN PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925													29.15
1926													20.21
1927													26.27
1928													19.03
1929													23.87
1930													19.78
1931													12.89
1932													20.21
1933													15.68
1934													11.34
1935													18.97
1936													18.58
1937													18.65
1938													17.89
1939													16.68
1940													15.76
1941													25.26
1942													21.53
1943													16.87
1944				2.32	1.54	5.10	6.81	2.32	3.86	0.06	.00	0.72	26.20
1945	0.25	2.00	0.71	0.54	1.65	2.07	1.90	1.25	3.79	2.67	4.56	0.89	22.30
1946	0.81	3.20	1.28	1.40	0.17	1.99	2.21	3.60	0.01	0.76	1.32	0.42	17.17
1947	5.02	2.00	2.65	1.32	1.13	0.81	3.22	2.61	4.07	0.01	1.92	1.40	26.17
1948	3.38	2.61	1.10	0.47	1.20	3.20	2.17	0.36	3.43	0.54	0.68	0.82	19.96
1949	1.21	2.38	3.66	3.21	0.89	4.10	1.74	3.70	0.24	0.42	0.97	0.89	23.39
1950	3.88	1.22	1.96	2.50	1.65	1.36	1.79	3.03	0.22	1.47	0.04	2.40	21.55
1951	0.81	2.78	0.68	2.35	0.89	1.75	3.61	1.21	0.13	3.02	2.49	.00	19.71
1952	2.64	2.21	4.03	3.06	2.56	4.95	2.59	1.49	1.49	1.52	0.26	0.03	26.81
1953	0.00	1.50	1.61	3.79	0.54	1.20	3.85	1.46	0.71	1.13	1.22	0.18	17.19
1954	0.44	1.33	1.26	1.25	1.13	2.09	0.90	0.88	1.71	1.26	2.46	0.82	15.54
1955	0.75	2.24	0.96	1.86	1.82	0.28	2.84	1.88	1.32	1.11	0.61	1.35	17.01
1956	1.25	3.11	1.52	3.32	1.53	0.14	2.09	3.24	0.88	0.11	0.04	0.19	17.42
1957	2.59	0.78	2.32	1.90	1.00	3.03	4.50	4.68	2.04	0.43	2.35	0.46	26.09
1958	1.08	1.90	2.24	1.21	3.06	3.04	4.06	0.42	0.06	0.07	0.32	0.35	17.81
1959	.00	1.57	0.75	2.22	1.96	1.10	2.24	2.85	1.92	0.26	2.45	2.31	19.63
1960	0.31	0.14	1.46	1.33	2.20	3.41	1.54	1.01	0.54	0.03	1.85	0.68	14.50
1961	1.65	2.40	0.54	0.13	2.86	2.57	1.32	0.33	0.13	0.75	1.67	1.53	15.89
1962	2.22	1.60	1.22	1.17	1.99	3.25	3.45	2.95	0.68	3.50	0.36	0.38	22.77
1963	1.29	0.61	0.39	0.74	0.93	2.93	5.37	0.32	2.32	.00	0.75	1.50	17.15
1964	1.46	2.17	1.10	1.31	0.49	3.14	3.74	3.85	3.63	0.36	0.24	0.18	21.66
1965	0.49	2.34	7.49	3.34	2.50	1.38	3.00	2.50	1.74	1.48	4.26	3.22	33.74
1966	0.72	1.76	2.54	1.48	1.75	1.61	2.34	1.19	0.12	1.30	0.84	1.64	17.29
1967	2.78	1.25	2.55	3.50	0.75	1.63	2.50	2.52	5.08	1.17	0.90	1.00	25.63
1968	1.57	0.74	1.60	0.42	2.91	1.95	2.95	3.37	2.20	0.10	5.10	0.80	23.71
1969	1.53	1.80	1.43	4.75	2.24	1.20	2.40	0.40	4.57	0.74	0.68	0.40	22.14
1970	3.22	1.04	2.32	2.49	1.06	2.24	3.17	1.58	2.61	2.06	0.73	1.82	24.34
1971	2.88	2.97	4.14	1.69	2.69	1.80	2.09	1.97	0.95	0.62	1.57	1.68	25.05
1972	1.90	1.40	1.86	1.66	0.70	1.30	4.96	0.47	1.88	0.05	0.60	1.69	18.47
1973	4.03	2.74	3.72	2.39	2.52	4.58	3.67	2.39	0.66	1.99	1.37	3.34	33.40
1974	1.52	3.73	4.64	1.90	2.20	1.78	6.40	0.24	1.31	0.76	0.04	0.10	24.62

TABLE 3.4-2

BINGHAM CANYON AVERAGE BASIN PRECIPITATION (INCHES)

WTR-YR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1975	2.16	0.74	2.18	1.85	2.02	4.48	3.01	2.74	2.85	0.84	0.54	0.63	24.04
1976	3.06	2.16	1.66	1.18	2.35	2.84	2.24	1.11	0.67	1.43	0.89	0.81	20.40
1977	0.74	0.52	0.22	0.97	1.55	2.79	0.68	4.88	0.31	1.57	1.80	1.80	17.83
1978	0.90	0.83	1.83	2.65	2.82	4.12	3.15	1.46	0.16	0.04	1.60	2.76	22.32
1979	0.00	2.97	2.42	1.74	2.16	2.64	1.56	1.81	0.31	1.39	1.81	0.05	18.86
1980	2.08	1.39	0.59	3.64	2.76	3.39	1.39	4.32	0.44	1.71	0.40	0.92	23.03
1981	1.10	1.74	0.67	1.31	1.14	2.62	0.96	4.02	0.82	0.79	1.23	1.20	17.60
1982	4.61	1.91	3.42	2.41	1.42	3.67	1.52	1.82	0.68	1.91	1.30	7.74	32.41
1983	2.41	2.12	3.76	1.61	2.40	5.66	2.83	3.64	1.72	2.69	4.02	0.95	33.81
1984	1.96	6.06	7.07	1.22	2.18	2.93	6.30	1.34	2.46	1.72	2.44	1.94	37.62
1985	3.14	3.68	1.84	0.83	1.16	3.45	1.07	4.01	1.80				
TOTAL	73.84	81.66	89.39	80.45	72.46	109.56	120.13	91.22	66.52	43.85	58.68	51.99	2414.65
													21.95
AVERAGE	1.80	1.99	2.18	1.92	1.73	2.61	2.86	2.17	1.58	1.07	1.43	1.27	22.61



SALT LAKE CITY PRECIPITATION VS.
BINGHAM CANYON 6-STATION AVERAGE PRECIPITATION

FIGURE 3.4-2

TABLE 3.4-3

(Page 1 of 5)

ANNUAL PRECIPITATION FREQUENCY

BINGHAM CANYON 6-STATION AVERAGE ANNUAL PRECIPITATION

IN INCHES, WATER-YEAR TOTALS

Water Year	Annual Precipitation[1]	Rank	Recurrence Interval (Yrs)
1875	23.3	44	2.52
1876	34.2	2	55.5
1877	24.6	32	3.47
1878	30.8	7	15.9
1879	14.2	108	1.03
1880	17.4	88	1.26
1881	21.5	59	1.88
1882	22.9	49	2.27
1883	18.6	81	1.37
1884	27.4	12	9.25
1885	25.1	27	4.11
1886	25.7	23	4.83
1887	20.3	61	1.82
1888	14.9	105	1.06
1889	19.8	68	1.63
1890	22.3	51	2.18
1891	18.7	77	1.44
1892	19.2	73	1.52
1893	24.2	34	3.26

1 Water-Years 1875 thru 1964 estimated by correlation with Salt Lake City precipitation data.

$$X = C_1 \times (Y)^{C_2}$$

where: X = Bingham Canyon 6-Station Average Precipitation
Y = Salt Lake City Precipitation
C_1 = 1.39
C_2 = 1.00

TABLE 3.4-3

(Page 2 of 5)

ANNUAL PRECIPITATION FREQUENCY

BINGHAM CANYON 6-STATION AVERAGE ANNUAL PRECIPITATION

IN INCHES, WATER-YEAR TOTALS

Water Year	Annual Precipitation[1]	Rank	Recurrence Interval (Yrs)
1894	24.0	37	3.00
1895	15.2	104	1.07
1896	23.3	45	2.47
1897	23.4	43	2.58
1898	22.0	54	2.06
1899	24.2	35	3.17
1900	18.0	83	1.34
1901	23.0	48	2.31
1902	15.8	101	1.10
1903	19.7	70	1.59
1904	24.7	30	3.70
1905	20.2	63	1.76
1906	27.1	13	8.54
1907	26.3	17	6.53
1908	28.2	10	11.1
1909	27.9	11	10.1
1910	14.7	106	1.05
1911	21.8	55	2.02
1912	25.0	29	3.83
1913	25.4	25	4.44
1914	23.9	38	2.92
1915	20.2	64	1.73
1916	18.6	80	1.39
1917	25.7	22	5.05
1918	20.0	66	1.68

TABLE 3.4-3

(Page 3 of 5)

ANNUAL PRECIPITATION FREQUENCY

BINGHAM CANYON 6-STATION AVERAGE ANNUAL PRECIPITATION

IN INCHES, WATER-YEAR TOTALS

Water Year	Annual Precipitation[1]	Rank	Recurrence Interval (Yrs)
1919	16.9	95	1.17
1920	27.0	15	7.4
1921	23.2	46	2.41
1922	27.0	14	7.93
1923	30.2	8	13.9
1924	15.6	103	1.08
1925	29.1	9	12.3
1926	20.2	62	1.79
1927	26.3	18	6.17
1928	19.0	74	1.50
1929	23.9	39	2.85
1930	19.8	69	1.61
1931	12.9	109	1.02
1932	20.2	65	1.71
1933	15.7	102	1.09
1934	11.3	110	1.01
1935	19.0	75	1.48
1936	18.6	79	1.41
1937	18.7	78	1.42
1938	17.9	84	1.32
1939	16.7	97	1.14
1940	15.8	100	1.11
1941	25.3	26	4.27
1942	21.5	58	1.91
1943	16.9	96	1.16

TABLE 3.4-3

(Page 4 of 5)

ANNUAL PRECIPITATION FREQUENCY

BINGHAM CANYON 6-STATION AVERAGE ANNUAL PRECIPITATION

IN INCHES, WATER-YEAR TOTALS

Water Year	Annual Precipitation[1]	Rank	Recurrence Interval (Yrs)
1944	26.2	19	5.84
1945	22.3	52	2.13
1946	17.2	92	1.21
1947	26.2	20	5.55
1948	20.0	67	1.66
1949	23.4	42	2.64
1950	21.5	57	1.95
1951	19.7	71	1.56
1952	26.8	16	6.94
1953	17.2	93	1.19
1954	16.4	98	1.13
1955	17.0	94	1.18
1956	17.4	89	1.25
1957	26.1	21	5.29
1958	17.8	86	1.29
1959	19.6	72	1.54
1960	14.5	107	1.04
1961	15.9	99	1.12
1962	23.5	41	2.71
1963	17.3	90	1.23
1964	21.7	56	1.98
1965	33.74	4	27.8
1966	17.29	91	1.22
1967	25.63	24	4.62
1968	23.71	40	2.78

TABLE 3.4-3

(Page 5 of 5)

ANNUAL PRECIPITATION FREQUENCY

BINGHAM CANYON 6-STATION AVERAGE ANNUAL PRECIPITATION

IN INCHES, WATER-YEAR TOTALS

Water Year	Annual Precipitation[1]	Rank	Recurrence Interval (Yrs)
1969	22.14	53	2.09
1970	24.34	33	3.36
1971	25.05	28	3.96
1972	18.47	82	1.35
1973	33.40	5	22.2
1974	24.62	31	3.58
1975	24.04	36	3.08
1976	20.40	60	1.85
1977	17.83	85	1.31
1978	22.32	50	2.22
1979	18.86	76	1.46
1980	23.03	47	2.36
1981	17.60	87	1.28
1982	32.41	6	18.5
1983	33.81	3	37.0
1984	37.62	1	111

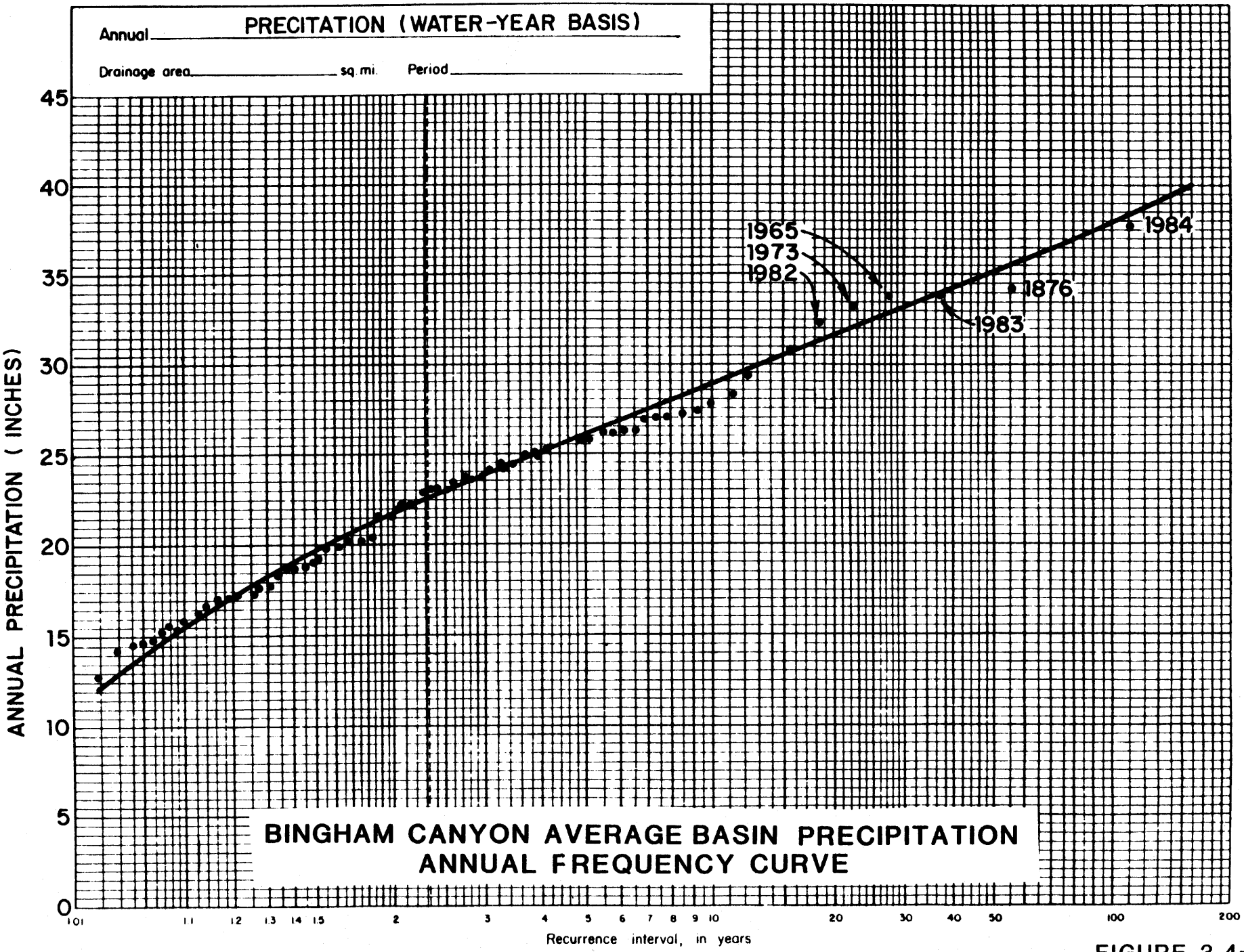

Annual PRECITATION (WATER-YEAR BASIS)
Drainage area sq. mi. Period
ANNUAL PRECIPITATION (INCHES)
45
40
35
30
25
20
15
10
5
0
1965
1973
1982
1984
1876
1983
BINGHAM CANYON AVERAGE BASIN PRECIPITATION
ANNUAL FREQUENCY CURVE
1.01
1.1
1.2
1.3
1.4
1.5
2
3
4
5
6
7
8
9
10
20
30
40
50
100
200
Recurrence interval, in years

FIGURE 3.4-3

C. Bingham Canyon Reservoir Area-Capacity Data

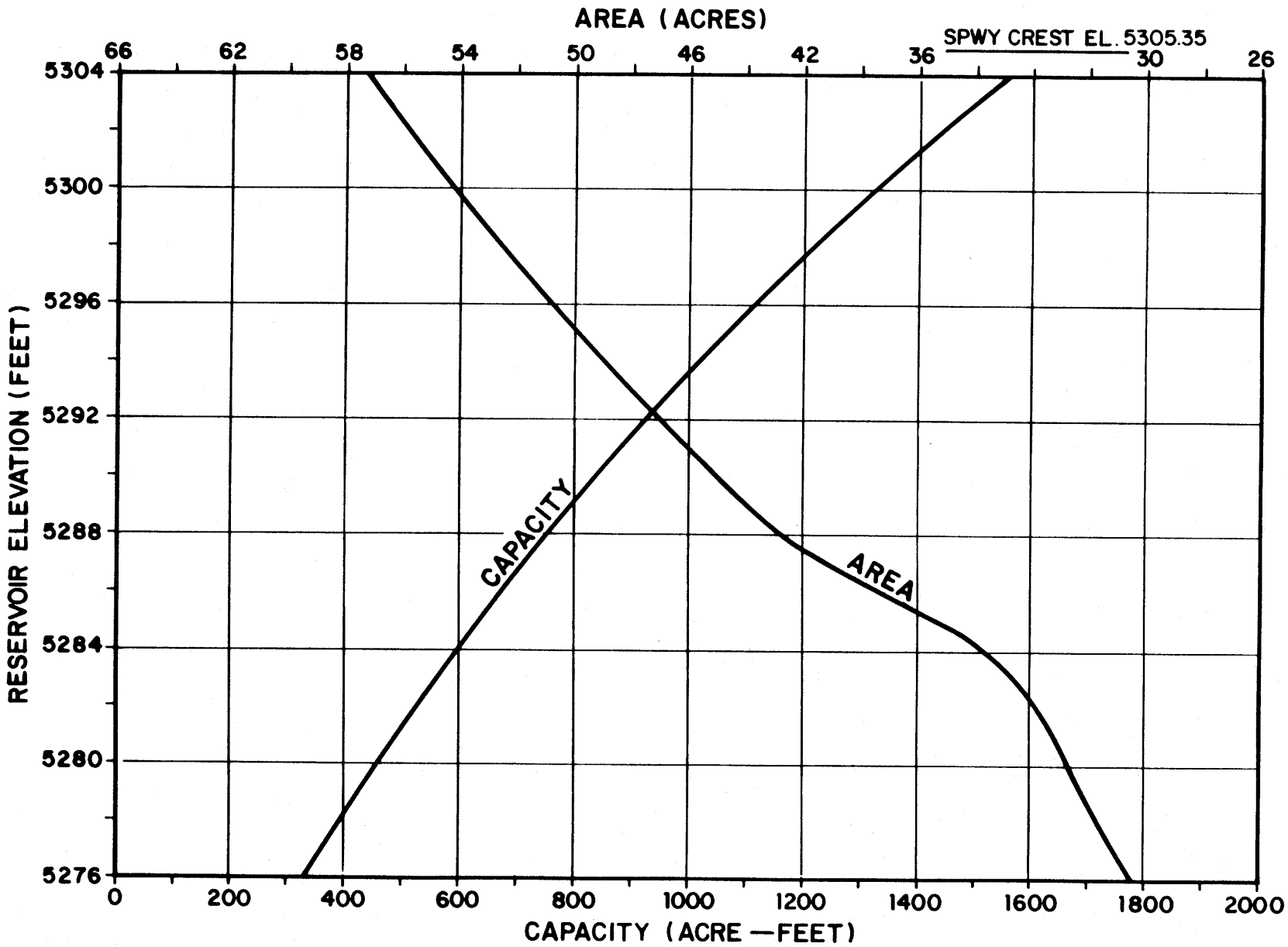
During MKE's Phase I project investigations, area-capacity data of the existing Bingham Canyon Reservoir was made available by Kennecott, herein designated as UCD June 1980 data. At the beginning of this study, the same reservoir area-capacity data were supplied by Kennecott's Environmental Engineering group. These data were also used in their recent study of the storm water management of 1984. The initial hydrological study was made using these reservoir data (Figure 3.4-4).

A new calculation of reservoir area-capacity was made available on July 19, 1985. These data were based on hydrographic surveys made in April 1985, supplemented by aerial photography. These area-capacity data reflect the most up-to-date information on the areas and storages available at respective elevations and, therefore, supersede the prior data. The final study (incorporating comments and revised data and/or assumptions after Kennecott's initial review) was based on this most recent area-capacity data. These reservoir area-capacity data are herein designated as UCD July 19, 1985, data (Figure 3.4-5).

At normal full pool elevation 5,305.35 feet (spillway crest elevation), Bingham Canyon Reservoir has a capacity of about 1,200 acre-feet based on the new 1985 data, versus a capacity of about 1,620 acre-feet for the old data. There is a loss of about 420 acre-feet of storage which can be attributed mainly to precipitates from the leach solution and sediments being accumulated at the bottom of the reservoir through the years.

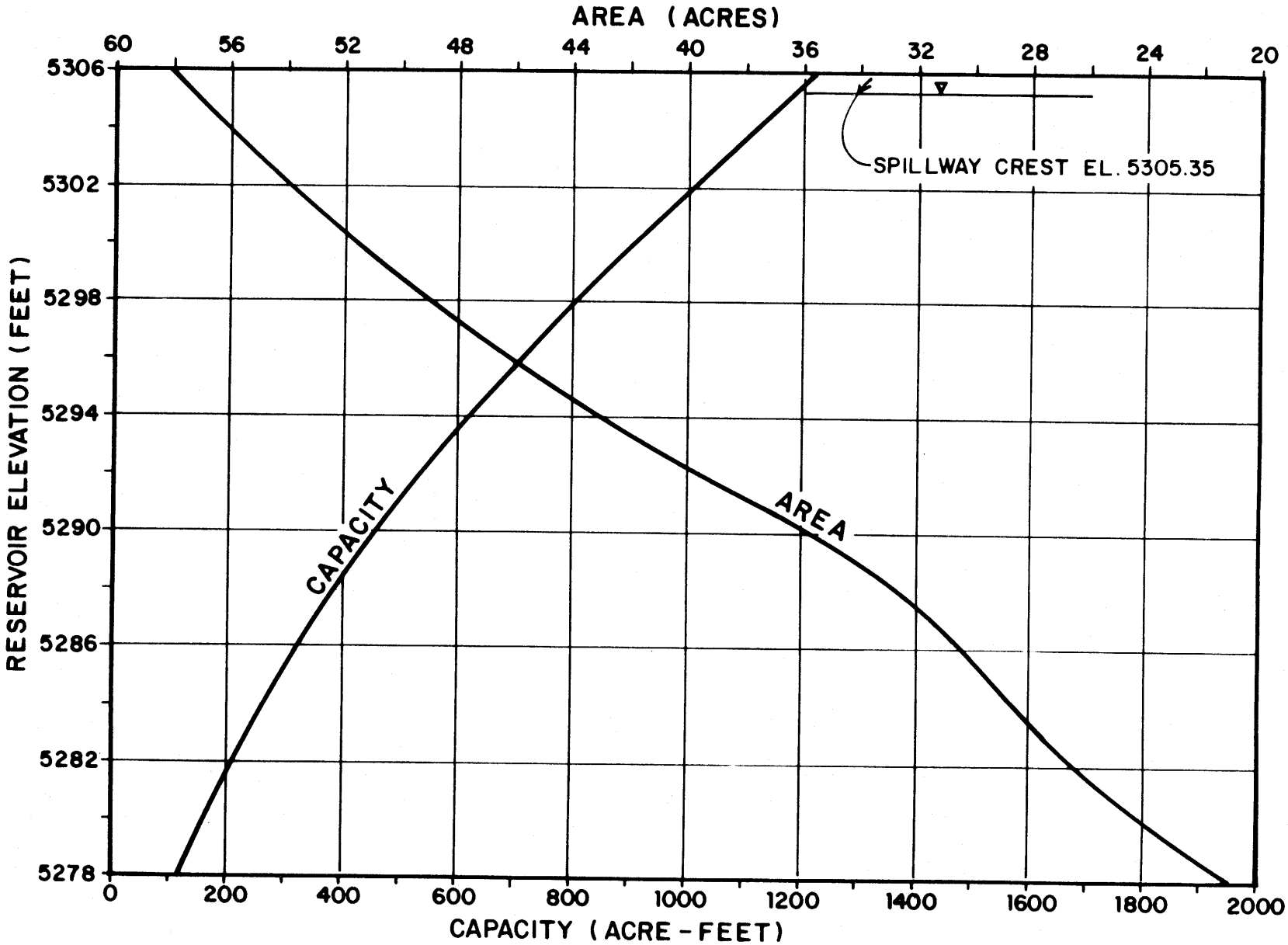
D. Net Lake Evaporation

There are no evaporation data available at Bingham Canyon. Therefore, evaporation estimates for the Bingham Canyon watershed were based on the estimates made by Kennecott Environmental Engineering Group for the Dike Station (Concentrator Tailings Pond) at Magna. These estimates were equation-derived based on evaporation data obtained from a salt



BINGHAM CANYON RESERVOIR
AREA-CAPACITY CURVE (UCD JUNE 1980 DATA)

FIGURE 3.4-4



BINGHAM CANYON RESERVOIR
AREA-CAPACITY CURVE (UCD JULY 1985 DATA)

FIGURE 3.4-5

company at the Great Salt Lake. Both the average daily gross pan evaporation and the average daily net evaporation from January 1980 through May 1985 (as estimated for the conditions at the Dike station) are available. Presumably, these equation-derived gross pan evaporation rates have already accounted for the major meteorological factors that influence evaporation, principally adjusted for wind, relative humidity and temperature conditions. The net (pan) evaporation rates were obtained after deducting the precipitation amounts for Salt Lake City from the gross precipitation. The gross and net evaporation for Dike station are shown in Table 3.4-4.

Bingham Canyon Reservoir net lake evaporation rates were derived from the Dike Station average daily gross pan evaporation data. First, the daily values were multiplied by the number of days in that particular month (28, 29, 30 or 31 days) to get the monthly gross pan evaporation rates. Then, monthly precipitation data at the Geology Building (which is the closest station to the existing reservoir and at elevation 5,550 feet) were subtracted from the gross amounts to obtain the net monthly pan evaporation. The pan evaporation amounts were then multiplied by an estimated pan coefficient of 0.80 to obtain the net lake (open water or reservoir) evaporation. Pan coefficient, depending upon the type of evaporation pan, usually ranges from 0.65 to 0.85. However, the type of pan used by the salt company from which the Dike station data were derived was not known. Theoretically, further adjustments for elevation and wind and other factors should also be made in transferring evaporation data from one location to another location. Wind and temperature conditions at Bingham Canyon Reservoir are not known. The elevation at Bingham Canyon Reservoir is about 1,000 feet higher than Magna. The adiabatic lapse rate is only about 1°C temperature correction. In absence of any valid wind and other meteorological data at Bingham Canyon, no further adjustments were made to the net lake evaporation rates, nor were they warranted.

TABLE 3.4-4

AVERAGE DAILY PAN EVAPORATION IN INCHES

AT DIKE STATION*

Month	Gross Pan Evaporation						Net Pan Evaporation					
	1980	1981	1982	1983	1984	1985	1980	1981	1982	1983	1984	1985
Jan.	0.141	0.048	0.202	0.073	0.016	0.020	0.048	0.027	0.167	0.035	0	-0.009
Feb.	0.129	0.159	0.086	0.156	0.064	0.103	0.051	0.130	0.067	0.107	0.031	0.073
Mar.	0.252	0.228	0.273	0.245	0.172	0.288	0.173	0.160	0.196	0.117	0.115	0.230
Apr.	0.387	0.370	0.432	0.293	0.376	0.436	0.357	0.355	0.378	0.239	0.228	0.415
May	0.235	0.292	0.416	0.340	0.411	0.508	0.148	0.173	0.356	0.257	0.373	0.413
Jun.	0.518	0.376	0.486	0.429	0.338	--	0.504	0.342	0.464	0.408	0.276	--
Jul.	0.445	0.562	0.426	0.677	0.408	--	0.402	0.551	0.343	0.644	0.353	--
Aug.	0.551	0.546	0.513	0.320	0.401	--	0.543	0.539	0.495	0.235	0.353	--
Sep.	0.386	0.431	0.282	0.400	0.363	--	0.362	0.415	0.047	0.366	0.306	--
Oct.	0.221	0.220	0.198	0.169	0.320	--	0.165	0.094	0.138	0.117	0.201	--
Nov.	0.112	0.137	0.137	0.195	0.219	--	0.073	0.103	0.112	0.121	0.171	--
Dec.	0.078	0.151	0.144	0.143	0.055	--	0.066	0.090	0.082	0.002	0.029	--

*Kennecott supplied data.

Similar derivations were made to obtain the net lake evaporation rates for the proposed Dry Fork Dam and Reservoir. The 6-station average monthly precipitation amounts (instead of those for the Geology Building) were deducted since the proposed Dry Fork Dam and Reservoir will be located at a higher elevation than the Bingham Canyon Reservoir. The net lake evaporation rates for Bingham Canyon and Dry Fork Reservoirs are shown in Table 3.4-5. Annual net lake evaporation for Bingham Canyon Reservoir ranges from about 4-1/2 feet to 6-1/2 feet a year. This is not unusual for a semi-arid region. As an indirect verification, the estimated amounts compare with the 30-year (1951-1980) long-term pan evaporation of 7 feet a year at Salt Lake City. Therefore, the estimated net lake monthly evaporation amounts were adopted for use in the water balance study. Monthly evaporation rates must be used to multiply the average reservoir surface area for the particular month in order to obtain the correct evaporation amount for the month. Annual totals cannot be used to multiply the average reservoir area for the year to obtain annual evaporation amounts. Both the evaporation rates and surface areas vary from month to month. And in a month where the net lake evaporation rate shows a minus, this indicates that there is more rainfall on the reservoir than the amount that is being evaporated, thus a gain in water content in the reservoir.

E. Selection of "Wet," Average," and "Dry" Years

Three water-years were selected for the water balance study, representing "wet," "average," and "dry" years, based on the frequency analysis and the developed annual precipitation frequency curve. As discussed briefly in Section 3.4-A, the selection is from the recent years where most of the data are available. The selected years are:

- Wet Year: Water-year 1984 was chosen. The average Bingham Canyon Basin annual precipitation is 37.62 inches. From the basin annual precipitation frequency curve (See Figure 3.4-3), this is equivalent to a return period (recurrence interval) of about 1 in 100 years. This water-year is also the wettest year on record.

TABLE 3.4-5

AVERAGE MONTHLY NET LAKE EVAPORATION IN FEET

AT BINGHAM CANYON RESERVOIR AND

DRY FORK RESERVOIR

Month	Bingham Canyon Reservoir Water-Year						Dry Fork Reservoir Water-Year					
	1980	1981	1982	1983	1984	1985	1980	1981	1982	1983	1984	1985
Oct.	0.230	0.428	0.185	0.287	0.211	0.452	0.201	0.383	0.147	0.249	0.219	0.385
Nov.	0.199	0.153	0.188	0.149	0.090	0.299	0.163	0.108	0.147	0.133	-0.014	0.193
Dec.	0.119	0.141	0.172	0.173	-0.008	0.056	0.101	0.117	0.084	0.047	-0.176	-0.009
Jan.	0.093	0.063	0.343	0.064	-0.017	0.029	0.049	0.012	0.257	0.044	-0.048	0.014
Feb.	0.119	0.251	0.099	0.185	0.097	0.154	0.065	0.221	0.066	0.132	-0.022	0.115
Mar.	0.367	0.386	0.426	0.234	0.266	0.442	0.295	0.297	0.320	0.129	0.160	0.365
Apr.	0.710	0.707	0.838	0.428	0.478	0.821	0.681	0.676	0.763	0.397	0.332	0.801
May	0.318	0.442	0.818	0.514	0.803	0.887	0.198	0.335	0.738	0.460	0.760	0.783
Jun.	1.005	0.717	0.927	0.757	0.568	--	1.007	0.697	0.927	0.743	0.512	--
Jul.	0.838	1.145	0.780	1.230	0.755	--	0.845	1.109	0.753	1.220	0.729	--
Aug.	1.121	1.078	0.983	0.334	0.700	--	1.112	1.046	0.974	0.393	0.666	--
Sep.	0.732	0.800	0.190	0.739	0.617	--	0.711	0.782	0.848	0.737	0.597	--
Total	5.851	6.311	5.949	5.094	4.560	--	5.428	5.783	6.024	4.684	3.715	--

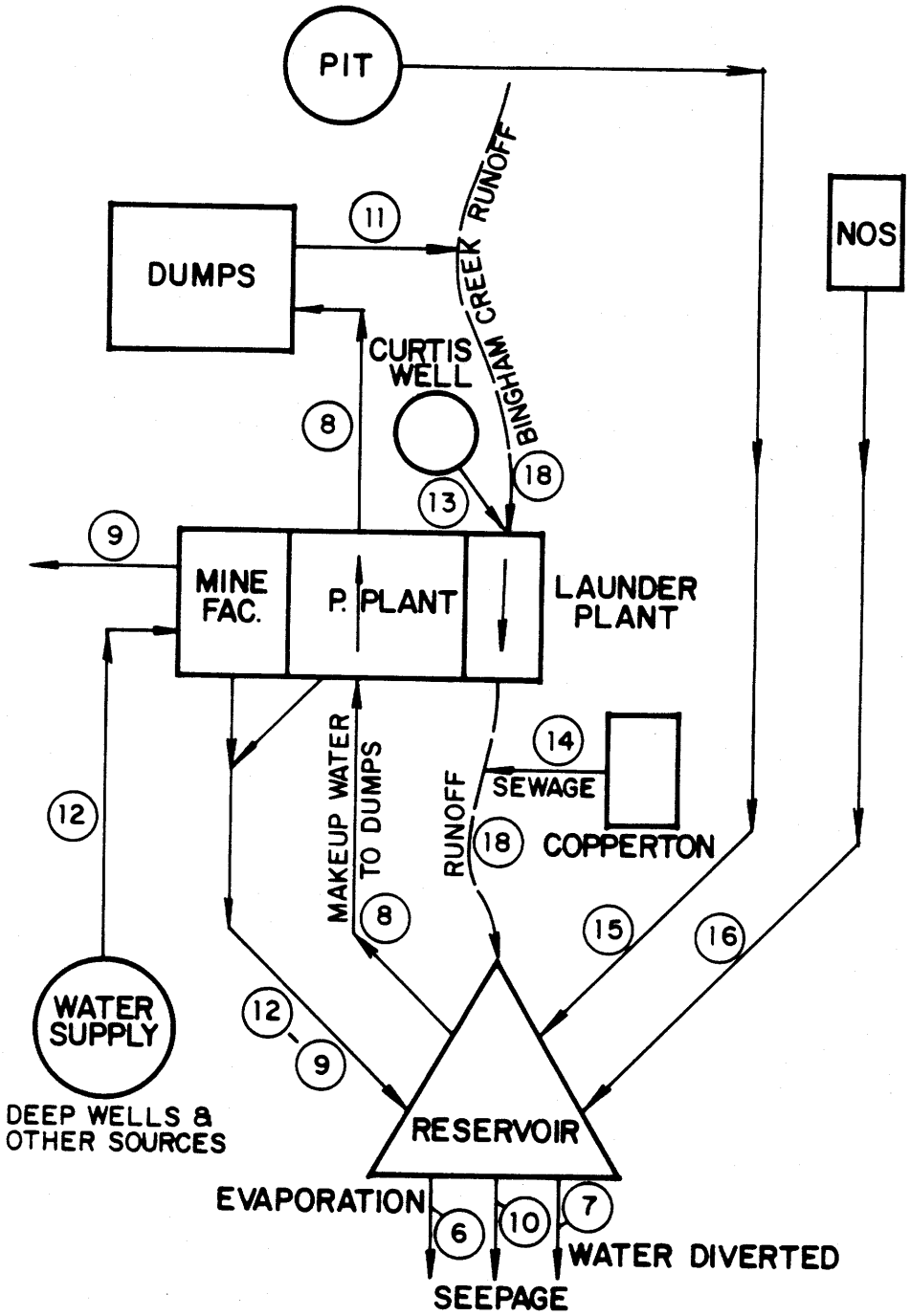
- Average Year: Water-year 1980, annual precipitation of 23.03 inches, was selected to represent conditions for an average year. The 1965 through 1985 average annual precipitation is 22.6 inches, and the long-term average (including estimated precipitation data from 1875) is about 22 inches. There are several years in the past 10 to 20 years with precipitation data that average 20 to 22 inches annually. However, 1980 was chosen because the year ranks 47th among 110 years of extended record. Although 1978 (annual precipitation of 22.3 inches, ranks 50th) is also an average year, most of the data on mine facilities operations are not readily available. Thus, 1980 was selected.

- Dry Year: Water-year 1981, which follows the average year 1980, was selected to represent typical dry year conditions. It is not the driest year of record, which occurred in 1934 with estimated annual precipitation of 11.3 inches. The 17.6-inch annual precipitation in 1981 ranks 87th out of 110 years, representing dry year conditions that may occur once in every 5 to 10 years.

F. Hydrological Study

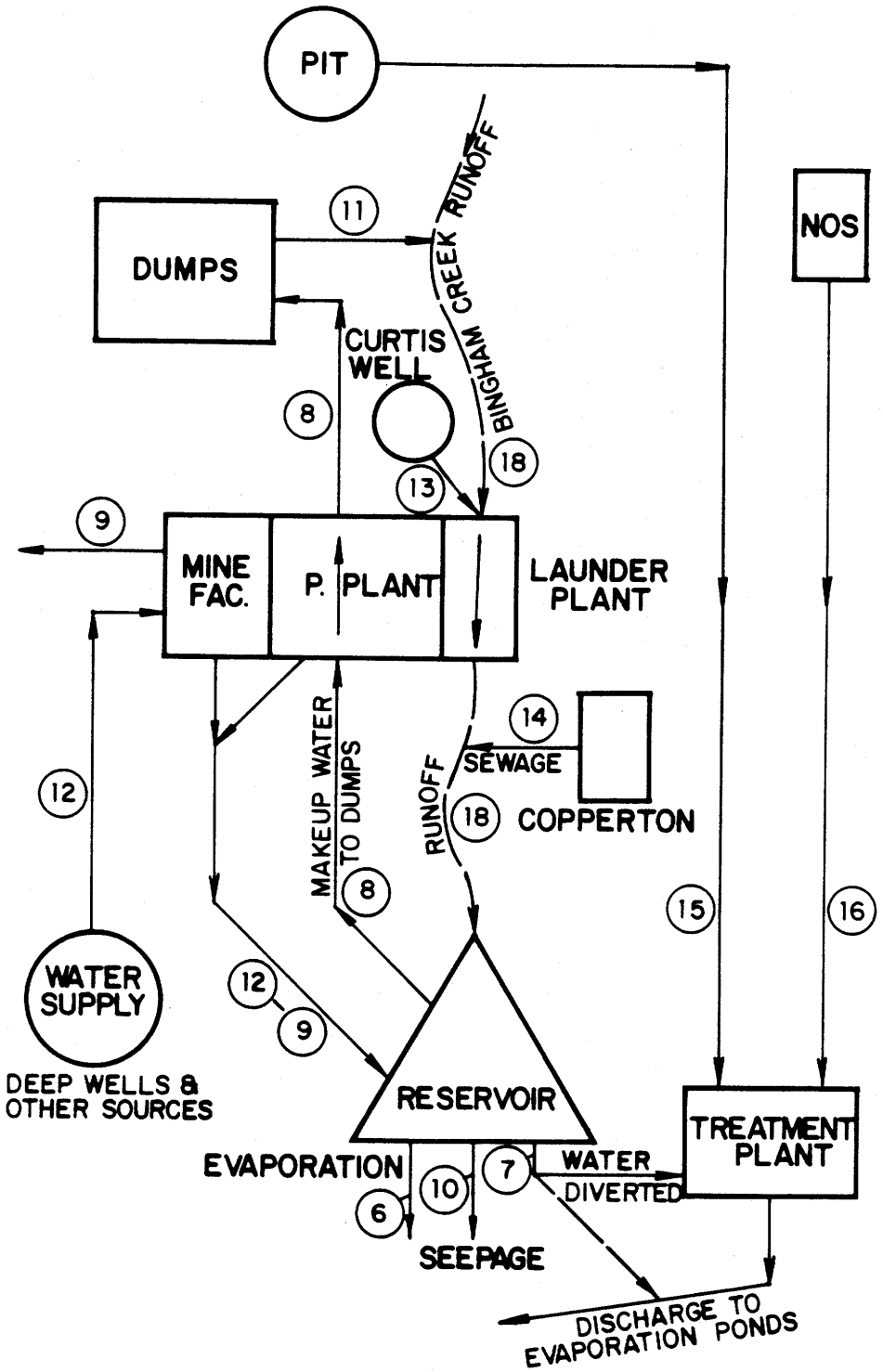
Heuristic water balance studies were made for the selected "wet," "average," and "dry" years, following the study approach and using the data as discussed in the prior sections. The Bingham Canyon mine water flow diagrams for 1979 through 1981 (average and dry years) and 1984 (wet year) are shown in Figures 3.4-6 and 3.4-7, respectively. Circled numbers shown on these figures refer to the line numbers used in the hydrological study spread sheets.

The results of the hydrological study are presented in Tables 3.4-6 through 3.4-9, and the explanations of the various line items are presented in Table 3.4-10.



BINGHAM CANYON MINE WATER FLOW DIAGRAM
WATER YEARS 1979-1981

FIGURE 3.4-6



BINGHAM CANYON MINE WATER FLOW DIAGRAM
WATER YEAR 1984

FIGURE 3.4-7

TABLE 3.4-6

SUMMARY

HEURISTIC HYDROLOGICAL STUDY
HISTORIC OPERATION,7/85 A/C CURVE
(UPDATED ON 7 NOV 85)

SUMMARY IN ANNUAL VOLUMES

ITEM	WATER-YEAR 1984 (WET)	WATER-YEAR 1980 (AVG)	WATER-YEAR 1981 (DRY)
RESERVOIR DATA			
1. EOM RESERVOIR ELEV (FT)	-	-	-
2. EOM RES STORAGE (AF)	-	-	-
3. EOM RES SURFACE AREA (AC)	-	-	-
4. AVG RES SURFACE AREA (AC)	51.7	45.0	36.4
5. NET LAKE EVAP RATES (FT)	4.560	5.851	6.311
OUTFLOWS			
6. RESERVOIR EVAP (AF)	235.8	263.4	229.6
7. BYPASS TO EVAP PONDS (AF)	6422.3	0.0	0.0
8. LEACH WATER DEFICIT (AF)	6830.7	9309.4	11630.0
9. MINE FAC USAGE/LOSS (AF)	1204.8	1100.6	1204.8
10.RESERVOIR SEEPAGE (AF)	4474.5	2193.7	1458.1
TOTAL OUTFLOWS (AF)	19168.1	12867.1	14522.5
INFLOWS			
11.LEACH SHORT CIRCUIT (AF)	819.7	1117.1	1395.6
12.MINE FAC:WELLS/OTHERS (AF)	2812.8	3203.6	3534.0
13.CURTIS WELL PUMPED (AF)	1282.8	1015.6	1282.8
14.COPPERTON SEWAGE (AF)	121.2	121.2	121.2
15.PIT WATER TO RES (AF)	0.0	1259.2	1465.0
16.NOS WATER TO RES (AF)	133.6	0.0	169.6
TOTAL INFLOWS (AF)	5170.1	6716.7	7968.2
BALANCE			
17.CHANGE IN RES STORAGE (AF)	-190.0	235.0	-165.0
18.INFLOW TO RESERVOIR (AF)	13808.0	6385.3	6389.3
ANALYSIS			
19.AVG BASIN GROSS PRECIP (IN)	37.62	23.03	17.60
20.AREA CONTRIB. TO R.O. (AC)	8707.2	8758.0	8758.0
21.GROSS PRECIP VOLUME (AF)	27331.4	16808.1	12845.1
22.RES NET INFLOW/GROSS PRECIP	0.51	0.38	0.50

SUMMARY IN AVERAGE FLOW RATES

ITEM	WATER-YEAR 1984 (WET)	WATER-YEAR 1980 (AVG)	WATER-YEAR 1981 (DRY)
RESERVOIR DATA			
1. EOM RESERVOIR ELEV (FT)	-	-	-
2. EOM RES STORAGE (AF)	-	-	-
3. EOM RES SURFACE AREA (AC)	-	-	-
4. AVG RES SURFACE AREA (AC)	51.7	45.0	36.4
5. NET LAKE EVAP RATES (FT)	4.560	5.851	6.311
OUTFLOWS			
6. RESERVOIR EVAP (GPM)	146.2	163.4	142.4
7. BYPASS TO EVAP PONDS (GPM)	3983.0	0.0	0.0
8. LEACH WATER DEFICIT (GPM)	4236.3	5773.6	7212.8
9. MINE FAC USAGE/LOSS (GPM)	747.2	682.6	747.2
10.RESERVOIR SEEPAGE (GPM)	2775.0	1360.5	904.3
TOTAL OUTFLOWS (GPM)	11887.8	7980.0	9006.6
INFLOWS			
11.LEACH SHORT CIRCUIT (GPM)	508.4	692.8	865.5
12.MINE FAC:WELLS/OTHERS (GPM)	1744.5	1986.8	2191.7
13.CURTIS WELL PUMPED (GPM)	795.6	629.9	795.6
14.COPPERTON SEWAGE (GPM)	75.2	75.2	75.2
15.PIT WATER TO RES (GPM)	0.0	780.9	908.6
16.NOS WATER TO RES (GPM)	82.9	0.0	105.2
TOTAL INFLOWS (GPM)	3206.4	4165.6	4941.8
BALANCE			
17.CHANGE IN RES STORAGE (AF)	-190.0	235.0	-165.0
18.INFLOW TO RESERVOIR (GPM)	8563.5	3960.1	3962.5
ANALYSIS			
19.AVG BASIN GROSS PRECIP (IN)	37.62	23.03	17.60
20.AREA CONTRIB. TO R.O. (AC)	8707.2	8758.0	8758.0
21.GROSS PRECIP VOLUME (GPM)	16950.5	10424.1	7966.3
22.RES NET INFLOW/GROSS PRECIP	0.51	0.38	0.50

NOTE: LINE 6 - LARGE VALUE OF EVAPORATION DURING 1980 WAS DUE TO THE HIGHER RESERVOIR LEVELS (AND CORRESPONDINGLY LARGER WATER SURFACE AREAS) DURING THE KENNECOTT EMPLOYEES STRIKE DURING JULY AND AUGUST OF THAT YEAR.

TABLE 3.4-7

WATER-YEAR 1984

HEURISTIC HYDROLOGICAL STUDY
HISTORIC OPERATION,7/85 A/C CURVE
WATER-YEAR 1984 (1:100 WET YEAR)
(UPDATED ON 7 NOV 85)

STARTING CONDITIONS:
EOM RES. ELEV. = 5301.30 FT
EOM RES. STORAGE = 980.00 AF
EOM RES. AREA = 52.90 AC

ITEM / WATER-YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
RESERVOIR DATA													
1. EOM RESERVOIR ELEV (FT)	5296.0	5294.2	5297.8	5297.3	5298.0	5299.1	5301.9	5303.0	5301.0	5300.7	5298.7	5297.7	-
2. EOM RES STORAGE (AF)	710.0	630.0	795.0	740.0	805.0	855.0	1000.0	1062.0	955.0	940.0	840.0	790.0	-
3. EOM RES SURFACE AREA (AC)	46.2	43.6	48.7	48.0	49.0	50.3	53.6	54.9	52.6	52.3	49.8	48.5	-
4. AVG RES SURFACE AREA (AC)	49.55	44.90	46.15	48.35	48.50	49.65	51.95	54.25	53.75	52.45	51.05	49.15	51.7
5. NET LAKE EVAP RATES (FT)	0.211	0.090	-0.008	-0.017	0.097	0.266	0.478	0.803	0.568	0.755	0.700	0.617	4.560
OUTFLOWS													
6. RESERVOIR EVAP (AF)	10.5	4.0	-0.4	-0.8	4.7	13.2	24.8	43.6	30.5	39.6	35.7	30.3	235.8
7. BYPASS TO EVAP PONDS (AF)	22.9	96.8	95.2	143.4	140.2	380.1	592.1	2349.9	1491.4	430.0	371.1	309.2	6422.3
8. LEACH WATER DEFICIT (AF)	875.6	546.5	435.7	507.7	505.8	394.1	374.6	653.2	663.2	614.6	577.8	681.9	6830.7
9. MINE FAC USAGE/LOSS (AF)	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	1204.8
10.RESERVOIR SEEPAGE (AF)	371.2	221.0	257.0	314.1	298.3	352.1	423.7	537.7	501.9	461.4	404.5	331.6	4474.5
TOTAL OUTFLOWS	1380.6	968.7	887.9	1064.8	1049.4	1239.9	1515.6	3684.8	2787.4	1646.0	1489.5	1453.4	19168.1
INFLOWS													
11.LEACH SHORT CIRCUIT (AF)	105.1	65.6	52.3	60.9	60.7	47.3	45.0	78.4	79.6	73.8	69.3	81.8	819.7
12.MINE FAC:WELLS/OTHERS (AF)	234.4	234.4	234.4	234.4	234.4	234.4	234.4	234.4	234.4	234.4	234.4	234.4	2812.8
13.CURTIS WELL PUMPED (AF)	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	1282.8
14.COPPERTON SEWAGE (AF)	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	121.2
15.PIT WATER TO RES (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.NOS WATER TO RES (AF)	0.0	0.0	0.0	0.0	0.0	0.0	133.6	0.0	0.0	0.0	0.0	0.0	133.6
TOTAL INFLOWS	456.5	417.0	403.7	412.3	412.1	398.7	530.0	429.8	431.0	425.2	420.7	433.2	5170.1
BALANCE													
17.CHANGE IN RES STORAGE (AF)	-270.0	-80.0	165.0	-55.0	65.0	50.0	145.0	62.0	-107.0	-15.0	-100.0	-50.0	-190.0
18.INFLOW TO RESERVOIR (AF)	654.1	471.8	649.2	597.5	702.3	891.2	1130.7	3317.0	2249.4	1205.8	968.8	970.2	13808.0
ANALYSIS													
19.AVG BASIN GROSS PRECIP (IN)	1.96	6.06	7.07	1.22	2.18	2.93	6.30	1.34	2.46	1.72	2.44	1.94	37.62
20.AREA CONTRIB. TO R.O. (AC)	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8148.5	8758.0	8758.0	8758.0	8707.2
21.GROSS PRECIP VOLUME (AF)	1430.5	4422.8	5159.9	890.4	1591.0	2138.4	4598.0	978.0	1670.4	1255.3	1780.8	1415.9	27331.4
22.RES NET INFLOW/GROSS PRECIP	0.46	0.11	0.13	0.67	0.44	0.42	0.25	3.39	1.35	0.96	0.54	0.69	0.51

NOTE: LINE 20 - REDUCED AREA DURING JUNE IS DUE TO TO DIVERSION OF THE CARR FORK SURFACE COLLECTION DITCH INTO THE MINE PIT FOR TWO WEEKS DURING THAT MONTH.

TABLE 3.4-8

WATER-YEAR 1980

HEURISTIC HYDROLOGICAL STUDY
HISTORIC OPERATION,7/85 A/C CURVE
WATER-YEAR 1980 (AVERAGE YEAR)
(UPDATED ON 7 NOV 85)

STARTING CONDITIONS:
EOM RES. ELEV. = 5290.20 FT
EOM RES. STORAGE = 465 AF
EOM RES. AREA = 36.00 AC

ITEM / WATER-YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
RESERVOIR DATA													
1. EOM RESERVOIR ELEV (FT)	5289.8	5287.5	5285.2	5287.5	5291.0	5292.5	5291.0	5299.1	5294.6	5300.0	5301.0	5295.8	-
2. EOM RES STORAGE (AF)	450.0	375.0	305.0	375.0	497.0	555.0	497.0	860.0	650.0	905.0	955.0	700.0	-
3. EOM RES SURFACE AREA (AC)	35.3	32.0	29.6	32.0	37.4	40.5	37.4	50.3	44.2	51.4	52.6	46.0	-
4. AVG RES SURFACE AREA (AC)	35.65	33.65	30.80	30.80	34.70	38.95	38.95	43.85	47.25	47.80	52.00	49.30	45.0
5. NET LAKE EVAP RATES (FT)	0.230	0.199	0.119	0.093	0.119	0.367	0.710	0.318	1.005	0.838	1.121	0.732	5.851
OUTFLOWS													
6. RESERVOIR EVAP (AF)	8.2	6.7	3.7	2.9	4.1	14.3	27.7	13.9	47.5	40.1	58.3	36.1	263.4
7. BYPASS TO EVAP PONDS (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8. LEACH WATER DEFICIT (AF)	981.5	925.2	927.1	931.0	822.3	683.9	815.7	677.6	941.6	534.5	534.5	534.5	9309.4
9. MINE FAC USAGE/LOSS (AF)	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	53.5	53.5	90.0	1100.6
10.RESERVOIR SEEPAGE (AF)	95.2	69.1	33.3	33.3	75.7	133.2	133.2	242.7	280.9	309.3	437.8	350.0	2193.7
TOTAL OUTFLOWS	1185.3	1101.4	1064.5	1067.6	1002.5	931.8	1077.0	1034.6	1370.4	937.4	1084.1	1010.6	12867.1
INFLOWS													
11.LEACH SHORT CIRCUIT (AF)	117.8	111.0	111.3	111.7	98.7	82.1	97.9	81.3	113.0	64.1	64.1	64.1	1117.1
12.MINE FAC:WELLS/OTHERS (AF)	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	160.4	160.4	232.3	3203.6
13.CURTIS WELL PUMPED (AF)	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	0.0	0.0	53.5	1015.6
14.COPPERTON SEWAGE (AF)	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	121.2
15.PIT WATER TO RES (AF)	82.9	80.2	82.9	82.9	77.5	82.9	200.5	248.6	200.5	40.1	40.1	40.1	1259.2
16.NOS WATER TO RES (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL INFLOWS	612.2	602.7	605.7	606.1	587.7	576.5	709.9	741.4	725.0	274.7	274.7	400.1	6716.7
BALANCE													
17.CHANGE IN RES STORAGE (AF)	-15.0	-75.0	-70.0	70.0	122.0	58.0	-58.0	363.0	-210.0	255.0	50.0	-255.0	235.0
18.INFLOW TO RESERVOIR (AF)	558.1	423.7	388.8	531.4	536.9	413.3	309.1	656.2	435.4	917.6	859.4	355.4	6385.3
ANALYSIS													
19.AVG BASIN GROSS PRECIP (IN)	2.08	1.39	0.59	3.64	2.76	3.39	1.39	4.32	0.44	1.71	0.40	0.92	23.03
20.AREA CONTRIB. TO R.O. (AC)	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0
21.GROSS PRECIP VOLUME (AF)	1518.1	1014.5	430.6	2656.6	2014.3	2474.1	1014.5	3152.9	321.1	1248.0	291.9	671.4	16808.1
22.RES NET INFLOW/GROSS PRECIP	0.37	0.42	0.90	0.20	0.27	0.17	0.30	0.21	1.36	0.74	2.94	0.53	0.38

NOTE: LINE 6 - LARGE VALUES FOR EVAPORATION BETWEEN JULY AND SEPTEMBER WERE DUE TO THE HIGHER RESERVOIR LEVELS (AND CORRESPONDINGLY LARGER WATER SURFACE AREAS) RESULTING FROM THE KENNECOTT EMPLOYEE STRIKE IN JULY AND AUGUST OF THAT YEAR.

TABLE 3.4-9

WATER-YEAR 1981

HEURISTIC HYDROLOGICAL STUDY
HISTORIC OPERATION,7/85 A/C CURVE
WATER-YEAR 1981 (1:5-10 DRY YEAR)
(UPDATED ON 7 NOV 85)

STARTING CONDITIONS:

EOM RES. ELEV. = 5295.80 FT
EOM RES. STORAGE = 700.00 AF
EOM RES. AREA = 46.00 AC

ITEM / WATER-YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
RESERVOIR DATA													
1. EOM RESERVOIR ELEV (FT)	5291.5	5291.8	5295.2	5292.2	5290.5	5295.5	5290.5	5293.6	5287.3	5287.6	5286.2	5292.0	-
2. EOM RES STORAGE (AF)	515.0	530.0	675.0	645.0	475.0	690.0	475.0	605.0	365.0	380.0	330.0	535.0	-
3. EOM RES SURFACE AREA (AC)	38.4	39.0	45.1	39.5	36.5	45.5	36.5	42.6	31.7	32.4	30.5	39.5	-
4. AVG RES SURFACE AREA (AC)	42.20	38.70	42.05	42.30	38.00	41.00	41.00	39.55	37.15	32.05	31.45	35.00	36.4
5. NET LAKE EVAP RATES (FT)	0.428	0.153	0.141	0.063	0.251	0.386	0.707	0.442	0.717	1.145	1.078	0.800	6.311
OUTFLOWS													
6. RESERVOIR EVAP (AF)	18.1	5.9	5.9	2.7	9.5	15.8	29.0	17.5	26.6	36.7	33.9	28.0	229.6
7. BYPASS TO EVAP PONDS (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8. LEACH WATER DEFICIT (AF)	968.0	936.7	854.7	893.4	839.4	802.3	777.7	1190.3	1240.1	1176.5	1197.2	753.7	11630.0
9. MINE FAC USAGE/LOSS (AF)	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	1204.8
10.RESERVOIR SEEPAGE (AF)	190.3	124.3	185.6	190.3	111.7	128.5	124.3	142.8	105.9	42.8	33.3	78.3	1458.1
TOTAL OUTFLOWS	1276.8	1167.3	1146.6	1186.8	1061.0	1047.0	1031.4	1451.0	1473.0	1356.4	1364.8	960.4	14522.5
INFLOWS													
11.LEACH SHORT CIRCUIT (AF)	116.2	112.4	102.6	107.2	100.7	96.3	93.3	142.8	148.8	141.2	143.7	90.4	1395.6
12.MINE FAC:WELLS/OTHERS (AF)	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	294.5	3534.0
13.CURTIS WELL PUMPED (AF)	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	1282.8
14.COPPERTON SEWAGE (AF)	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	121.2
15.PIT WATER TO RES (AF)	82.9	80.2	82.9	82.9	74.8	82.9	200.5	248.6	200.5	165.7	82.9	80.2	1465.0
16.NOS WATER TO RES (AF)	0.0	0.0	0.0	0.0	0.0	22.7	22.7	22.7	22.7	22.7	22.7	33.4	169.6
TOTAL INFLOWS	610.6	604.1	597.0	601.6	587.0	613.4	728.0	825.6	783.5	741.1	660.8	615.5	7968.2
BALANCE													
17.CHANGE IN RES STORAGE (AF)	-185.0	15.0	145.0	-30.0	-170.0	215.0	-215.0	130.0	-240.0	15.0	-50.0	205.0	-165.0
18.INFLOW TO RESERVOIR (AF)	481.2	578.2	694.7	555.2	304.0	648.7	88.4	755.3	449.5	630.3	654.0	549.9	6389.3
ANALYSIS													
19.AVG BASIN GROSS PRECIP (IN)	1.10	1.74	0.67	1.31	1.14	2.62	0.96	4.02	0.82	0.79	1.23	1.20	17.60
20.AREA CONTRIB. TO R.O. (AC)	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0	8758.0
21.GROSS PRECIP VOLUME (AF)	802.8	1269.9	489.0	956.1	832.0	1912.2	700.6	2933.9	598.5	576.6	897.7	875.8	12845.1
22.RES NET INFLOW/GROSS PRECIP	0.60	0.46	1.42	0.58	0.37	0.34	0.13	0.26	0.75	1.09	0.73	0.63	0.50

TABLE 3.4-10

EXPLANATION OF HYDROLOGICAL STUDY LINE ITEMS

Line No.

1. End of Month Reservoir Elevation (Feet) - From Kennecott Precipitation Plant operating records and from data obtained from Kennecott Environmental Engineering Department.

2. End of Month Reservoir Storage (Acre-Feet) - From July 1985 Kennecott Reservoir Area-Capacity Curve based on April 1985 survey data.

3. End of Month Reservoir Surface Area (Acres) - From July 1985 Kennecott Reservoir Area-Capacity Curve based on April 1985 survey data.

4. Average Reservoir Surface Area (Acres) - Average for beginning and end of month reservoir surface areas.

5. Net Lake Evaporation Rates (Feet) - Obtained from Kennecott Dike station gross pan evaporation rate minus the Geology Building station precipitation rate multiplied by 0.8 to obtain lake evaporation rate and to correct for elevation and wind condition to Bingham Canyon location.

6. Reservoir Evaporation (Acre-Feet) - Average reservoir surface area (line 4) multiplied by net lake evaporation rate (line 5).

7. Bypass to Evaporation Ponds (Acre-Feet) - The amount of water discharged to the evaporation ponds. Obtained from Kennecott Environmental Engineering Department records.

8. Leach Water Deficit (Acre-Feet) - The difference between the quantity of water processed in the Precipitation Plant and the

quantity of water pumped to the dumps. Obtained from Precipitation Plant operating records.

9. Mine Facilities Water Usage/Loss (Acre-Feet) - Water consumed for truck shops, dust control, sanitary system etc. Obtained from Kennecott records of weekly water measurements.

10. Reservoir Seepage (Acre-Feet) - Estimated water loss by seepage from the reservoir. Based on a modification of the curve for seepage vs. elevation developed in 1970 and 1971. The actual seepage values are not known, nor can they be accurately calculated from the data available. Due to lack of observed data on reservoir seepage losses, the assigned values are strictly based on judgement, considering the type of deposits at the bottom of the reservoir and the high reservoir operating levels in recent years. These conditions have caused sediments to settle on the reservoir floor and abutment area, effecting a reduction in seepage losses. The assigned values for seepage losses were used solely for the purpose of calculating inflow to the reservoir for a water balance based on available information.

11. Leach Short Circuit (Acre-Feet) - Estimated quantity of leach water that short circuits the leach system and returns to the reservoir. Arbitrarily assumed to be 12% of leach water deficit (line 8).

12. Mine Facility Water Supply: Wells/Other (Acre-Feet) - Water supplied from deep wells, Dry Fork, Barney's and Middle Canyon. Obtained from Kennecott records of weekly water measurements. In 1984, an estimated flow of 450 gpm overflowed from Yosemite Booster Pump Station and was not returning to the reservoir.

13. Curtis Well Pumps (Acre-Feet) - The estimated amount of water recovered from Bingham Canyon ground water. Assigned an

average rate of 800 gpm based on discussions with Kennecott personnel and size of pump.

14. Copperton Sewage (Acre-Feet) - The estimated amount of sewage flowing into the reservoir from the town sewer system. Estimated from water supply records obtained from Copperton Water Superintendent.

15. Pit Water to Reservoir (Acre-Feet) - The estimated amount of water pumped from the pit. Obtained from discussions with Kennecott personnel and pump sizes.

16. NOS Water to Reservoir (Acre-Feet) - The amount of water pumped from NOS to the reservoir based on operating records.

17. Change in Reservoir Storage (Acre-Feet) - Actual monthly change in reservoir storage from operating records of reservoir surface elevations and 1985 Area-Capacity Curve.

18. Inflow to Reservoir (Acre-Feet) - The computed amount of water inflow required to balance total inflows and outflows. Composed of inflows from precipitation and snowmelt runoff and excess leach short circuit water.

19. Average Basin Gross Precipitation (Inches) - The average precipitation reported by the six measuring stations in the basin, as shown on the following table:

Measuring Station	1980	1981	1984
Jackass Gulch	24.40	20.08	36.33
Bingham Canyon 2NE	19.89	14.63	30.07
Highland Boy	29.05	24.85	55.95
Keystone Notch	23.74	18.65	34.10
Geology Building	16.10	9.67	24.94
6190 Yard	24.98	17.71	44.45
Average	23.03	17.60	37.62

20. Area Contributing to Runoff (Acres) - The area tributary to Bingham Canyon that contributes precipitation runoff to Bingham Creek reservoir. Pit runoff is accounted for separately above (line 15).

21. Gross Precipitation Volume (Acre-Feet) - The gross precipitation volume falling on the area contributing to runoff. Average basin gross precipitation (line 19 divided by 12) multiplied by area contributing to runoff (line 20).

22. Reservoir Net Inflow/Gross Precipitation - The ratio of the volume of net inflow reaching the reservoir (line 18) to the gross precipitation volume (line 21). This value is calculated for the sole purpose of assessing the reasonableness of the overall balance. It serves as an independent check on the calculated estimate of the water inflow to the reservoir from precipitation and snowmelt runoff and excess leach short circuit.

3.5 SIMULATED OPERATIONS

In order to estimate quantities of water which must be managed under the operating conditions in effect during 1985 and subsequent years, the results of the hydrological study for water year 1984 was reformatted and restructured with different baseline assumptions. Examples of some of the adjustments would include the elimination of reservoir seepage by lining the reservoir, or increased flows from the NOS project.

Typical assumptions for simulated operations are presented in Table 3.5-1, and a typical hydrological balance for simulated operations is shown in Table 3.5-2. Similar balances were performed for other conditions and other water years for comparisons, and the relative impact of various water control measuers was assessed using these balances.

TABLE 3.5-1

TYPICAL ASSUMPTIONS FOR SIMULATED OPERATIONS

I. Design Basis: Simulated Operation - Water-Year 1984

(1:100 wet year annual precipitation)

II. Assumptions:

1. Basis: 1:100 wet year annual precipitation event (water-year 1984: 37.6 inches)

2. Reservoir areas: total surface area averaging 100 acres

3. Net Lake Evaporation rate as adjusted for water-year 1984 (Reservoir evaporation estimated from an assumed constant 100 acres of average surface area.)

4. Zero discharge of leach/reservoir solutions

5. Leach water flows as in water year 1985: to dumps = 24,000 gpm, return = 21,600 gpm, deficit = 2,400 gpm (Deficit is arbitrarily assumed to be 10% of flow to the dumps, of which 8.8% is assumed due to evaporative losses and 2.2% is assumed to short circuit back to the reservoir. Other losses are assumed to be negligible.)

6. Fresh water usage (deep wells, etc.): water usage as in water year 1984.

7. Reservoir seepage: zero (reservoirs are lined)

8. Leach water return through short circuiting: arbitrarily assumed at 12% of leach water deficit, which is analagous to a value of 2.2% of flow to dumps.

9. Fresh water supply (deep wells, etc.): For this calculation, the fresh water pumped is assumed to be reduced to 1,400 gpm (i.e., the head tank overflow to the Precipitation Plant is eliminated)

10. Curtis Well: Shut down

11. Copperton Sewage: Assumed to be no longer flowing into the reservoir system.

12. Pit water: Used same quantities as in water-year 1984.

13. NOS water: Assumed separate discharge to new concentrator or an irrigation canal for agricultural use, either without treatment other than use of a settling pond to reduce TSS, or with treatment in a new treatment plant.

14. Inflow to Reservoir: Since insufficient measurements are available to determine the inflow ratio, a ratio of 0.51 of gross precipitation has been assumed based on the hydrologic balance developed for historic conditions in the 1984 water year.

15. Change in Storage: On the basis of the above assumptions, this line represents the monthly rise or fall in the volume of water which must be stored in the leach water reservoir(s).

16. Cumulative Storage: It was assumed that the year started with 500 acre-feet of water in the reservoir. This quantity would be needed to assure uninterrupted operation in a dry year, and also represents an allowance for sedimentation.

TABLE 3.5-2

SIMULATED OPERATIONS

SIMULATED OPERATION: ASSUMED : NO RUNOFF DIVERTED
(UPDATED ON 7 NOV 85)
WATER-YEAR 1984 (1:100 WET YEAR)

ITEM / WATER-YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1. AVG RES SURFACE AREA (AC)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2. NET LAKE EVAP RATES (FT)	0.211	0.090	-0.008	-0.017	0.097	0.266	0.478	0.803	0.568	0.755	0.700	0.617	4.560
3. RESERVOIR EVAP (AF)	21.1	9.0	-0.8	-1.7	9.7	26.6	47.8	80.3	56.8	75.5	70.0	61.7	456.0
4. BYPASS TO EVAP PONDS (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5. LEACH WATER DEFICIT (AF)	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	320.7	3848.4
6. MINE FAC USAGE/LOSS (AF)	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	1204.8
7. RESERVOIR SEEPAGE (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8. LEACH SHORT CIRCUIT (AF)	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	462.0
9. MINE FAC:WELLS/OTHERS (AF)	187.1	187.1	187.1	187.1	187.1	187.1	187.1	187.1	187.1	187.1	187.1	187.1	2245.2
10.CURTIS WELL PUMPED (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.COPPERTON SEWAGE (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.PIT WATER TO RES (AF)	82.9	80.0	82.9	82.9	74.8	82.9	200.5	248.6	200.5	165.7	82.9	80.2	1464.8
13.NOS WATER TO RES (AF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.INFLOW TO RESERVOIR (AF)	654.1	471.8	649.1	597.5	702.3	891.1	1130.6	3317.0	2249.3	1205.8	968.8	970.1	13807.5
15.CHANGE IN STORAGE (AF)	520.4	347.3	537.3	486.6	571.9	751.9	1087.8	3289.8	2197.5	1100.5	786.2	793.1	12470.3
16.CUMULATIVE STORAGE (AF)	1020.4	1367.7	1905.0	2391.6	2963.5	3715.4	4803.2	8093.0	10290.5	11391.0	12177.2	12970.3	

CHAPTER 4
DETAILS OF STUDY

4.1 MATRIX OF CONDITIONS CONSIDERED

A. General

The purpose of these "trade-off" studies was to identify the most efficient combination of water control facilities that would allow the water volume of the 1984 water-year to be handled under the present operating conditions and within water discharge limitations. The criteria for evaluation of the combinations of variables are the technical requirements, capital cost, and operating and maintenance cost. The primary variables are:

- o Variable A — Quantity of moderately contaminated water treated and discharged
- o Variable B — Quantity of uncontaminated water diverted and discharged
- o Variable C — Quantity of contaminated water stored in reservoirs.

Variable A has high capital and operating cost associated with its implementation, whereas Variables B and C have high capital cost but low operating cost. The variables interact; for example, increasing either A or B results in a decrease in C. In addition, it is less expensive to treat moderately contaminated water than to treat leach water, while diverted water requires no treatment.

In order to isolate the effects of the interactions described above, the primary variables have been subdivided and the capital and operating costs are tabulated as follows:

- o Table 4.1-1 Capital costs
- o Table 4.1-2 Annual Operating and Maintenance Costs
- o Table 4.1-3 20-year Total Costs (total capital, operating, and maintenance cost for 20-year period)
- o Table 4.1-4 20-year Present Value Costs (assuming 8% interest, wet year = 20)

The three lowest capital and 20-year operating and maintenance costs are highlighted on tables 4.1-1, 4.1-3, and 4.1-4. Designations 1a and 3a are almost identical to designations 1 and 3 with minor differences in the water management systems.

The basis of the estimated costs shown in Tables 4.1-1 and 4.1-2 is presented in Chapter 5, Section 5.3. Generally, the costs are based on estimated quantities and unit prices for the various identified project features. In the case of dams and reservoirs, the estimated costs were interpolated or extrapolated from cost estimates for three to five different dam heights, and include the cost of reservoir lining, spillways, and outlet works. In the case of treatment plants, the estimated costs are factored from previous detailed estimates for similar facilities.

B. Explanation of Table 4.1-1 - Capital Costs

1. Column 1, Matrix Combination - In this column the primary variables are subdivided as shown below.

a. Group A - This is the base case for treatment, and requires treating the following waters for discharge:

- o NOS and Carr Fork Underground (one 6,250 gpm module)
- o NOS and Carr Fork Underground future flows plus Bingham Tunnel, Butterfield Tunnel and Bingham Canyon Cutoff (add a second 6,250 gpm module)

TABLE 4.1-1 - CAPITAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
A. BASE CASE FOR TREATMENT																
(1) NOS & CARR FORK UNDERGROUND																
(2) BINGHAM & BUTTERFIELD TUNNELS,																
AND BINGHAM CANYON CUTOFF																
1A. NO DIVERSION, NC, ND	13,058	$0	$0	$0	$0	$0	$0	$25,200	$0	$24,000	$49,200	$7,978	$57,178	$5,279	$62,457	
1B. NO DIVERSION, C7, ND	13,058	$0	$0	$0	$0	$0	$0	$25,200	$0	$24,000	$49,200	$12,499	$61,699	$9,113	$70,812	
1C. NO DIVERSION, NJ, ND	13,058	$0	$0	$0	$0	$0	$0	$25,200	$0	$24,000	$49,200	$8,665	$57,865	$8,177	$66,042	
1D. NO DIVERSION, NJ, ND, EP	13,058	$0	$0	$0	$0	$0	$0	$25,200	$0	$24,000	$49,200	$6,225	$55,425	$4,781	$60,206	
1E. NO DIVERSION, NC, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$50,160	$3,220	$53,380	$7,978	$61,358	$5,279	$66,637	
1F. NO DIVERSION, C7, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$50,160	$3,220	$53,380	$12,499	$65,879	$9,113	$74,992	
1G. NO DIVERSION, NJ, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$50,160	$3,220	$53,380	$8,665	$62,045	$8,177	$70,222	
1H. NO DIVERSION, NJ, AD, EP	13,058	$0	$0	$0	$0	$0	$0	$0	$50,160	$3,220	$53,380	$6,225	$59,605	$4,781	$64,386	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$27,700	$0	$3,220	$42,248	$7,978	$50,226	$5,279	$55,505	3a
2B. DIV COPPERTON & DRY FORK, P, C7, ND	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$27,700	$0	$3,220	$42,248	$12,499	$54,747	$9,113	$63,860	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$27,700	$0	$3,220	$42,248	$8,665	$50,913	$8,177	$59,090	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$27,700	$0	$3,220	$45,477	$7,978	$53,455	$5,279	$58,734	3
2E. DIV COPPERTON & DRY FORK, T, C7, ND	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$27,700	$0	$3,220	$45,477	$12,499	$57,976	$9,113	$67,089	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$27,700	$0	$3,220	$45,477	$8,665	$54,142	$8,177	$62,319	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$0	$38,460	$3,220	$53,008	$7,978	$60,986	$5,279	$66,265	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$0	$38,460	$3,220	$53,008	$12,499	$65,507	$9,113	$74,620	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	10,343	$1,494	$7,300	$2,534	$0	$0	$0	$0	$38,460	$3,220	$53,008	$8,665	$61,673	$8,177	$69,850	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$0	$38,460	$3,220	$56,237	$7,978	$64,215	$5,279	$69,494	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$0	$38,460	$3,220	$56,237	$12,499	$68,736	$9,113	$77,849	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	10,343	$1,494	$7,300	$0	$5,763	$0	$0	$0	$38,460	$3,220	$56,237	$8,665	$64,902	$8,177	$73,079	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$25,900	$0	$3,220	$46,225	$7,978	$54,203	$5,279	$59,482	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$25,900	$0	$3,220	$46,225	$12,499	$58,724	$9,113	$67,837	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$25,900	$0	$3,220	$46,225	$8,665	$54,890	$8,177	$63,067	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$25,900	$0	$3,220	$49,454	$7,978	$57,432	$5,279	$62,711	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$25,900	$0	$3,220	$49,454	$12,499	$61,953	$9,113	$71,066	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$25,900	$0	$3,220	$49,454	$8,665	$58,119	$8,177	$66,296	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$0	$33,660	$3,220	$53,985	$7,978	$61,963	$5,279	$67,242	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$0	$33,660	$3,220	$53,985	$12,499	$66,484	$9,113	$75,597	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	9,122	$6,171	$8,400	$2,534	$0	$0	$0	$0	$33,660	$3,220	$53,985	$8,665	$62,650	$8,177	$70,827	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$0	$33,660	$3,220	$57,214	$7,978	$65,192	$5,279	$70,471	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$0	$33,660	$3,220	$57,214	$12,499	$69,713	$9,113	$78,826	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	9,122	$6,171	$8,400	$0	$5,763	$0	$0	$0	$33,660	$3,220	$57,214	$8,665	$65,879	$8,177	$74,056	
4A. 3. + UPPER CARR FORK, P, NC, ND	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$25,000	$0	$3,220	$49,383	$7,978	$57,361	$5,279	$62,640	
4B. 3. + UPPER CARR FORK, P, C7, ND	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$25,000	$0	$3,220	$49,383	$12,499	$61,882	$9,113	$70,995	
4C. 3. + UPPER CARR FORK, P, NJ, ND	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$25,000	$0	$3,220	$49,383	$8,665	$58,048	$8,177	$66,225	
4D. 3. + UPPER CARR FORK, T, NC, ND	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$25,000	$0	$3,220	$52,612	$7,978	$60,590	$5,279	$65,869	
4E. 3. + UPPER CARR FORK, T, C7, ND	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$25,000	$0	$3,220	$52,612	$12,499	$65,111	$9,113	$74,224	
4F. 3. + UPPER CARR FORK, T, NJ, ND	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$25,000	$0	$3,220	$52,612	$8,665	$61,277	$8,177	$69,454	
4G. 3. + UPPER CARR FORK, P, NC, AD	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$0	$31,160	$3,220	$55,543	$7,978	$63,521	$5,279	$68,800	
4H. 3. + UPPER CARR FORK, P, C7, AD	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$0	$31,160	$3,220	$55,543	$12,499	$68,042	$9,113	$77,155	
4I. 3. + UPPER CARR FORK, P, NJ, AD	8,533	$9,829	$8,800	$2,534	$0	$0	$0	$0	$31,160	$3,220	$55,543	$8,665	$64,208	$8,177	$72,385	
4J. 3. + UPPER CARR FORK, T, NC, AD	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$0	$31,160	$3,220	$58,772	$7,978	$66,750	$5,279	$72,029	
4K. 3. + UPPER CARR FORK, T, C7, AD	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$0	$31,160	$3,220	$58,772	$12,499	$71,271	$9,113	$80,384	
4L. 3. + UPPER CARR FORK, T, NJ, AD	8,533	$9,829	$8,800	$0	$5,763	$0	$0	$0	$31,160	$3,220	$58,772	$8,665	$67,437	$8,177	$75,614	
5A. 4. + MUDDY & GALENA, P, NC, ND	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$24,600	$0	$3,220	$49,974	$7,978	$57,952	$5,279	$63,231	
5B. 4. + MUDDY & GALENA, P, C7, ND	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$24,600	$0	$3,220	$49,974	$12,499	$62,473	$9,113	$71,586	
5C. 4. + MUDDY & GALENA, P, NJ, ND	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$24,600	$0	$3,220	$49,974	$8,665	$58,639	$8,177	$66,816	
5D. 4. + MUDDY & GALENA, T, NC, ND	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$24,600	$0	$3,220	$53,203	$7,978	$61,181	$5,279	$66,460	

TABLE 4.1-1 - CAPITAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DIVERSION OF RUNOFF COST: DRY FORK DAM	DIVERSION OF RUNOFF COST: DRY FORK PUMPING	DIVERSION OF RUNOFF COST: DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	TREATMENT COST: LEACH WATER	STORAGE COST: NEW RESERVOIR	STORAGE COST: ALTERNATE RESERVOIR	STORAGE COST: EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 2.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
5E. 4. + MUDDY & GALENA, T, C7, ND	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$24,600	$0	$3,220	$53,203	$12,499	$65,702	$9,113	$74,815	
5F. 4. + MUDDY & GALENA, T, NJ, ND	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$24,600	$0	$3,220	$53,203	$8,665	$61,868	$8,177	$70,045	
5G. 4. + MUDDY & GALENA, P, NC, AD	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$0	$30,460	$3,220	$55,834	$7,978	$63,812	$5,279	$69,091	
5H. 4. + MUDDY & GALENA, P, C7, AD	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$0	$30,460	$3,220	$55,834	$12,499	$68,333	$9,113	$77,446	
5I. 4. + MUDDY & GALENA, P, NJ, AD	8,362	$10,620	$9,000	$2,534	$0	$0	$0	$0	$30,460	$3,220	$55,834	$8,665	$64,499	$8,177	$72,676	
5J. 4. + MUDDY & GALENA, T, NC, AD	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$0	$30,460	$3,220	$59,063	$7,978	$67,041	$5,279	$72,320	
5K. 4. + MUDDY & GALENA, T, C7, AD	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$0	$30,460	$3,220	$59,063	$12,499	$71,562	$9,113	$80,675	
5L. 4. + MUDDY & GALENA, T, NJ, AD	8,362	$10,620	$9,000	$0	$5,763	$0	$0	$0	$30,460	$3,220	$59,063	$8,665	$67,728	$8,177	$75,905	
B. TREAT A. + PIT & CARR FORK DITCH																
1A. NO DIVERSION, NC, ND	10,375	$0	$0	$0	$0	$7,212	$0	$28,000	$0	$3,220	$38,432	$7,978	$46,410	$5,279	$51,689	1a
1B. NO DIVERSION, C7, ND	10,375	$0	$0	$0	$0	$7,212	$0	$28,000	$0	$3,220	$38,432	$12,499	$50,931	$9,113	$60,044	
1C. NO DIVERSION, NJ, ND	10,375	$0	$0	$0	$0	$7,212	$0	$28,000	$0	$3,220	$38,432	$8,665	$47,097	$8,177	$55,274	
1D. NO DIVERSION, NJ, ND, EP	10,375	$0	$0	$0	$0	$7,212	$0	$28,000	$0	$3,220	$38,432	$6,225	$44,657	$4,781	$49,438	1
1E. NO DIVERSION, NC, AD	10,375	$0	$0	$0	$0	$7,212	$0	$0	$38,860	$3,220	$49,292	$7,978	$57,270	$5,279	$62,549	
1F. NO DIVERSION, C7, AD	10,375	$0	$0	$0	$0	$7,212	$0	$0	$38,860	$3,220	$49,292	$12,499	$61,791	$9,113	$70,904	
1G. NO DIVERSION, NJ, AD	10,375	$0	$0	$0	$0	$7,212	$0	$0	$38,860	$3,220	$49,292	$8,665	$57,957	$8,177	$66,134	
1H. NO DIVERSION, NJ, AD, EP	10,375	$0	$0	$0	$0	$7,212	$0	$0	$38,860	$3,220	$49,292	$6,225	$55,517	$4,781	$60,298	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$23,500	$0	$3,220	$45,260	$7,978	$53,238	$5,279	$58,517	
2B. DIV COPPERTON & DRY FORK, P, C7, ND	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$23,500	$0	$3,220	$45,260	$12,499	$57,759	$9,113	$66,872	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$23,500	$0	$3,220	$45,260	$8,665	$53,925	$8,177	$62,102	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$23,500	$0	$3,220	$48,489	$7,978	$56,467	$5,279	$61,746	
2E. DIV COPPERTON & DRY FORK, T, C7, ND	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$23,500	$0	$3,220	$48,489	$12,499	$60,988	$9,113	$70,101	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$23,500	$0	$3,220	$48,489	$8,665	$57,154	$8,177	$65,331	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$0	$27,660	$3,220	$49,420	$7,978	$57,398	$5,279	$62,677	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$0	$27,660	$3,220	$49,420	$12,499	$61,919	$9,113	$71,032	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	7,660	$1,494	$7,300	$2,534	$0	$7,212	$0	$0	$27,660	$3,220	$49,420	$8,665	$58,085	$8,177	$66,262	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$0	$27,660	$3,220	$52,649	$7,978	$60,627	$5,279	$65,906	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$0	$27,660	$3,220	$52,649	$12,499	$65,148	$9,113	$74,261	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	7,660	$1,494	$7,300	$0	$5,763	$7,212	$0	$0	$27,660	$3,220	$52,649	$8,665	$61,314	$8,177	$69,491	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$21,500	$0	$3,220	$49,037	$7,978	$57,015	$5,279	$62,294	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$21,500	$0	$3,220	$49,037	$12,499	$61,536	$9,113	$70,649	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$21,500	$0	$3,220	$49,037	$8,665	$57,702	$8,177	$65,879	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$21,500	$0	$3,220	$52,266	$7,978	$60,244	$5,279	$65,523	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$21,500	$0	$3,220	$52,266	$12,499	$64,765	$9,113	$73,878	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$21,500	$0	$3,220	$52,266	$8,665	$60,931	$8,177	$69,108	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$0	$23,060	$3,220	$50,597	$7,978	$58,575	$5,279	$63,854	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$0	$23,060	$3,220	$50,597	$12,499	$63,096	$9,113	$72,209	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	6,439	$6,171	$8,400	$2,534	$0	$7,212	$0	$0	$23,060	$3,220	$50,597	$8,665	$59,262	$8,177	$67,439	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$0	$23,060	$3,220	$53,826	$7,978	$61,804	$5,279	$67,083	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$0	$23,060	$3,220	$53,826	$12,499	$66,325	$9,113	$75,438	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	6,439	$6,171	$8,400	$0	$5,763	$7,212	$0	$0	$23,060	$3,220	$53,826	$8,665	$62,491	$8,177	$70,668	
C. TREAT B. + LEACH WATER																
1A. NO DIVERSION, NC, ND	8,749	$0	$0	$0	$0	$7,212	$5,293	$25,300	$0	$3,220	$41,025	$7,978	$49,003	$5,279	$54,282	
1B. NO DIVERSION, C7, ND	8,749	$0	$0	$0	$0	$7,212	$5,293	$25,300	$0	$3,220	$41,025	$12,499	$53,524	$9,113	$62,637	
1C. NO DIVERSION, NJ, ND	8,749	$0	$0	$0	$0	$7,212	$5,293	$25,300	$0	$3,220	$41,025	$8,665	$49,690	$8,177	$57,867	
1D. NO DIVERSION, NJ, ND, EP	8,749	$0	$0	$0	$0	$7,212	$5,293	$25,300	$0	$3,220	$41,025	$6,225	$47,250	$4,781	$52,031	2
1E. NO DIVERSION, NC, AD	8,749	$0	$0	$0	$0	$7,212	$5,293	$0	$32,060	$3,220	$47,785	$7,978	$55,763	$5,279	$61,042	
1F. NO DIVERSION, C7, AD	8,749	$0	$0	$0	$0	$7,212	$5,293	$0	$32,060	$3,220	$47,785	$12,499	$60,284	$9,113	$69,397	
1G. NO DIVERSION, NJ, AD	8,749	$0	$0	$0	$0	$7,212	$5,293	$0	$32,060	$3,220	$47,785	$8,665	$56,450	$8,177	$64,627	
1H. NO DIVERSION, NJ, AD, EP	8,749	$0	$0	$0	$0	$7,212	$5,293	$0	$32,060	$3,220	$47,785	$6,225	$54,010	$4,781	$58,791	

TABLE 4.1-1 - CAPITAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE EXISTING RESERVOIR	(1) SUBTOTAL (x $1,000)	6.25K GPM TREATMENT	(2) SUBTOTAL (x $1,000)	12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
2A. DIV COPPERTON & DRY FORK, P, NC, ND	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$20,900	$3,220	$47,953	$7,978	$55,931	$5,279	$61,210
2B. DIV COPPERTON & DRY FORK, P, C7, ND	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$20,900	$3,220	$47,953	$12,499	$60,452	$9,113	$69,565
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$20,900	$3,220	$47,953	$8,665	$56,618	$8,177	$64,795
2D. DIV COPPERTON & DRY FORK, T, NC, ND	6,034	$1,494	$7,300	$0	$7,212	$5,293	$20,900	$3,220	$51,182	$7,978	$59,160	$5,279	$64,439
2E. DIV COPPERTON & DRY FORK, T, C7, ND	6,034	$1,494	$7,300	$0	$7,212	$5,293	$20,900	$3,220	$51,182	$12,499	$63,681	$9,113	$72,794
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	6,034	$1,494	$7,300	$0	$7,212	$5,293	$20,900	$3,220	$51,182	$8,665	$59,847	$8,177	$68,024
2G. DIV COPPERTON & DRY FORK, P, NC, AD	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$21,660	$3,220	$48,713	$7,978	$56,691	$5,279	$61,970
2H. DIV COPPERTON & DRY FORK, P, C7, AD	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$21,660	$3,220	$48,713	$12,499	$61,212	$9,113	$70,325
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	6,034	$1,494	$7,300	$2,534	$7,212	$5,293	$21,660	$3,220	$48,713	$8,665	$57,378	$8,177	$65,555
2J. DIV COPPERTON & DRY FORK, T, NC, AD	6,034	$1,494	$7,300	$0	$7,212	$5,293	$21,660	$3,220	$51,942	$7,978	$59,920	$5,279	$65,199
2K. DIV COPPERTON & DRY FORK, T, C7, AD	6,034	$1,494	$7,300	$0	$7,212	$5,293	$21,660	$3,220	$51,942	$12,499	$64,441	$9,113	$73,554
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	6,034	$1,494	$7,300	$0	$7,212	$5,293	$21,660	$3,220	$51,942	$8,665	$60,607	$8,177	$68,784
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$22,620	$3,220	$55,450	$7,978	$63,428	$5,279	$68,707
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$22,620	$3,220	$55,450	$12,499	$67,949	$9,113	$77,062
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$22,620	$3,220	$55,450	$8,665	$64,115	$8,177	$72,292
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	4,813	$6,171	$8,400	$0	$7,212	$5,293	$22,620	$3,220	$58,679	$7,978	$66,657	$5,279	$71,936
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	4,813	$6,171	$8,400	$0	$7,212	$5,293	$22,620	$3,220	$58,679	$12,499	$71,178	$9,113	$80,291
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	4,813	$6,171	$8,400	$0	$7,212	$5,293	$22,620	$3,220	$58,679	$8,665	$67,344	$8,177	$75,521
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$18,660	$3,220	$51,490	$7,978	$59,468	$5,279	$64,747
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$18,660	$3,220	$51,490	$12,499	$63,989	$9,113	$73,102
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	4,813	$6,171	$8,400	$2,534	$7,212	$5,293	$18,660	$3,220	$51,490	$8,665	$60,155	$8,177	$68,332
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	4,813	$6,171	$8,400	$0	$7,212	$5,293	$18,660	$3,220	$54,719	$7,978	$62,697	$5,279	$67,976
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	4,813	$6,171	$8,400	$0	$7,212	$5,293	$18,660	$3,220	$54,719	$12,499	$67,218	$9,113	$76,331
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	4,813	$6,171	$8,400	$0	$7,212	$5,293	$18,660	$3,220	$54,719	$8,665	$63,384	$8,177	$71,561

NOTES: 1. P = PUMPING FROM DRY FORK RESERVOIR
2. T = CONVEYANCE FROM DRY FORK THROUGH A NEW TUNNEL
3. NC = TO THE NEW CONCENTRATOR FACILITY
4. C7 = TO THE C-7 CANAL INTO THE GREAT SALT LAKE
5. NJ = TO THE NORTH JORDAN IRRIGATION CANAL
(IN A NEW PIPELINE UNLESS INDICATED BY EP)
6. EP = EXISTING JORDAN RIVER PIPELINE
7. ND = NEW RESERVOIR IN BINGHAM CANYON DRAINAGE
8. AD = NEW RESERVOIR OUT OF THE CANYON

TABLE 4.1-2 - ANNUAL O&M COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
A. BASE CASE FOR TREATMENT															
(1) NOS & CARR FORK UNDERGROUND															
(2) BINGHAM & BUTTERFIELD TUNNELS, AND BINGHAM CANYON CUTOFF															
1A. NO DIVERSION, NC, ND	13,058	$0	$0	$0	$0	$0	$0	$115	$0	$115	$230	$745	$973	$1,211	$2,186
1B. NO DIVERSION, C7, ND	13,058	$0	$0	$0	$0	$0	$0	$115	$0	$115	$230	$1,022	$1,252	$1,404	$2,656
1C. NO DIVERSION, NJ, ND	13,058	$0	$0	$0	$0	$0	$0	$115	$0	$115	$230	$706	$936	$1,202	$2,138
1D. NO DIVERSION, NJ, ND, EP	13,058	$0	$0	$0	$0	$0	$0	$115	$0	$115	$230	$706	$936	$1,202	$2,138
1E. NO DIVERSION, NC, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$115	$0	$115	$745	$860	$1,211	$2,071
1F. NO DIVERSION, C7, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$115	$0	$115	$1,022	$1,137	$1,404	$2,541
1G. NO DIVERSION, NJ, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$115	$0	$115	$706	$821	$1,202	$2,023
1H. NO DIVERSION, NJ, AD, EP	13,058	$0	$0	$0	$0	$0	$0	$0	$115	$0	$115	$706	$821	$1,202	$2,023
2A. DIV COPPERTON & DRY FORK, P, NC, ND	10,343	$20	$50	$231	$0	$0	$0	$115	$0	$0	$416	$745	$1,161	$1,211	$2,372
2B. DIV COPPERTON & DRY FORK, P, C7, ND	10,343	$20	$50	$231	$0	$0	$0	$115	$0	$0	$416	$1,022	$1,438	$1,404	$2,842
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	10,343	$20	$50	$231	$0	$0	$0	$115	$0	$0	$416	$706	$1,122	$1,202	$2,324
2D. DIV COPPERTON & DRY FORK, T, NC, ND	10,343	$20	$50	$0	$58	$0	$0	$115	$0	$0	$243	$745	$988	$1,211	$2,199
2E. DIV COPPERTON & DRY FORK, T, C7, ND	10,343	$20	$50	$0	$58	$0	$0	$115	$0	$0	$243	$1,022	$1,265	$1,404	$2,669
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	10,343	$20	$50	$0	$58	$0	$0	$115	$0	$0	$243	$706	$949	$1,202	$2,151
2G. DIV COPPERTON & DRY FORK, P, NC, AD	10,343	$20	$50	$231	$0	$0	$0	$0	$115	$0	$416	$745	$1,161	$1,211	$2,372
2H. DIV COPPERTON & DRY FORK, P, C7, AD	10,343	$20	$50	$231	$0	$0	$0	$0	$115	$0	$416	$1,022	$1,438	$1,404	$2,842
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	10,343	$20	$50	$231	$0	$0	$0	$0	$115	$0	$416	$706	$1,122	$1,202	$2,324
2J. DIV COPPERTON & DRY FORK, T, NC, AD	10,343	$20	$50	$0	$58	$0	$0	$0	$115	$0	$243	$745	$988	$1,211	$2,199
2K. DIV COPPERTON & DRY FORK, T, C7, AD	10,343	$20	$50	$0	$58	$0	$0	$0	$115	$0	$243	$1,022	$1,265	$1,404	$2,669
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	10,343	$20	$50	$0	$58	$0	$0	$0	$115	$0	$243	$706	$949	$1,202	$2,151
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	9,122	$80	$50	$231	$0	$0	$0	$115	$0	$0	$476	$745	$1,221	$1,211	$2,432
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	9,122	$80	$50	$231	$0	$0	$0	$115	$0	$0	$476	$1,022	$1,498	$1,404	$2,902
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	9,122	$80	$50	$231	$0	$0	$0	$115	$0	$0	$476	$706	$1,182	$1,202	$2,384
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	9,122	$80	$50	$0	$58	$0	$0	$115	$0	$0	$303	$745	$1,048	$1,211	$2,259
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	9,122	$80	$50	$0	$58	$0	$0	$115	$0	$0	$303	$1,022	$1,325	$1,404	$2,729
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	9,122	$80	$50	$0	$58	$0	$0	$115	$0	$0	$303	$706	$1,009	$1,202	$2,211
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	9,122	$80	$50	$231	$0	$0	$0	$0	$115	$0	$476	$745	$1,221	$1,211	$2,432
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	9,122	$80	$50	$231	$0	$0	$0	$0	$115	$0	$476	$1,022	$1,498	$1,404	$2,902
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	9,122	$80	$50	$231	$0	$0	$0	$0	$115	$0	$476	$706	$1,182	$1,202	$2,384
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	9,122	$80	$50	$0	$58	$0	$0	$0	$115	$0	$303	$745	$1,048	$1,211	$2,259
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	9,122	$80	$50	$0	$58	$0	$0	$0	$115	$0	$303	$1,022	$1,325	$1,404	$2,729
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	9,122	$80	$50	$0	$58	$0	$0	$0	$115	$0	$303	$706	$1,009	$1,202	$2,211
4A. 3. + UPPER CARR FORK, P, NC, ND	8,533	$120	$50	$231	$0	$0	$0	$115	$0	$0	$516	$745	$1,261	$1,211	$2,472
4B. 3. + UPPER CARR FORK, P, C7, ND	8,533	$120	$50	$231	$0	$0	$0	$115	$0	$0	$516	$1,022	$1,538	$1,404	$2,942
4C. 3. + UPPER CARR FORK, P, NJ, ND	8,533	$120	$50	$231	$0	$0	$0	$115	$0	$0	$516	$706	$1,222	$1,202	$2,424
4D. 3. + UPPER CARR FORK, T, NC, ND	8,533	$120	$50	$0	$58	$0	$0	$115	$0	$0	$343	$745	$1,088	$1,211	$2,299
4E. 3. + UPPER CARR FORK, T, C7, ND	8,533	$120	$50	$0	$58	$0	$0	$115	$0	$0	$343	$1,022	$1,365	$1,404	$2,769
4F. 3. + UPPER CARR FORK, T, NJ, ND	8,533	$120	$50	$0	$58	$0	$0	$115	$0	$0	$343	$706	$1,049	$1,202	$2,251
4G. 3. + UPPER CARR FORK, P, NC, AD	8,533	$120	$50	$231	$0	$0	$0	$0	$115	$0	$516	$745	$1,261	$1,211	$2,472
4H. 3. + UPPER CARR FORK, P, C7, AD	8,533	$120	$50	$231	$0	$0	$0	$0	$115	$0	$516	$1,022	$1,538	$1,404	$2,942
4I. 3. + UPPER CARR FORK, P, NJ, AD	8,533	$120	$50	$231	$0	$0	$0	$0	$115	$0	$516	$706	$1,222	$1,202	$2,424
4J. 3. + UPPER CARR FORK, T, NC, AD	8,533	$120	$50	$0	$58	$0	$0	$0	$115	$0	$343	$745	$1,088	$1,211	$2,299
4K. 3. + UPPER CARR FORK, T, C7, AD	8,533	$120	$50	$0	$58	$0	$0	$0	$115	$0	$343	$1,022	$1,365	$1,404	$2,769
4L. 3. + UPPER CARR FORK, T, NJ, AD	8,533	$120	$50	$0	$58	$0	$0	$0	$115	$0	$343	$706	$1,049	$1,202	$2,251
5A. 4. + MUDDY & GALENA, P, NC, ND	8,362	$140	$50	$231	$0	$0	$0	$115	$0	$0	$536	$745	$1,281	$1,211	$2,492
5B. 4. + MUDDY & GALENA, P, C7, ND	8,362	$140	$50	$231	$0	$0	$0	$115	$0	$0	$536	$1,022	$1,558	$1,404	$2,962
5C. 4. + MUDDY & GALENA, P, NJ, ND	8,362	$140	$50	$231	$0	$0	$0	$115	$0	$0	$536	$706	$1,242	$1,202	$2,444
5D. 4. + MUDDY & GALENA, T, NC, ND	8,362	$140	$50	$0	$58	$0	$0	$115	$0	$0	$363	$745	$1,108	$1,211	$2,319

TABLE 4.1-2 - ANNUAL O&M COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
5E. 4. + MUDDY & GALENA, T, C7, ND	8,362	$140	$50	$0	$58	$0	$0	$115	$0	$0	$363	$1,022	$1,385	$1,404	$2,789
5F. 4. + MUDDY & GALENA, T, NJ, ND	8,362	$140	$50	$0	$58	$0	$0	$115	$0	$0	$363	$706	$1,069	$1,202	$2,271
5G. 4. + MUDDY & GALENA, P, NC, AD	8,362	$140	$50	$231	$0	$0	$0	$0	$115	$0	$536	$745	$1,281	$1,211	$2,492
5H. 4. + MUDDY & GALENA, P, C7, AD	8,362	$140	$50	$231	$0	$0	$0	$0	$115	$0	$536	$1,022	$1,558	$1,404	$2,962
5I. 4. + MUDDY & GALENA, P, NJ, AD	8,362	$140	$50	$231	$0	$0	$0	$0	$115	$0	$536	$706	$1,242	$1,202	$2,444
5J. 4. + MUDDY & GALENA, T, NC, AD	8,362	$140	$50	$0	$58	$0	$0	$0	$115	$0	$363	$745	$1,108	$1,211	$2,319
5K. 4. + MUDDY & GALENA, T, C7, AD	8,362	$140	$50	$0	$58	$0	$0	$0	$115	$0	$363	$1,022	$1,385	$1,404	$2,789
5L. 4. + MUDDY & GALENA, T, NJ, AD	8,362	$140	$50	$0	$58	$0	$0	$0	$115	$0	$363	$706	$1,069	$1,202	$2,271
B. TREAT A. + PIT & CARR FORK DITCH															
1A. NO DIVERSION, NC, ND	10,375	$0	$0	$0	$0	$736	$0	$115	$0	$0	$851	$745	$1,596	$1,211	$2,807
1B. NO DIVERSION, C7, ND	10,375	$0	$0	$0	$0	$736	$0	$115	$0	$0	$851	$1,022	$1,873	$1,404	$3,277
1C. NO DIVERSION, NJ, ND	10,375	$0	$0	$0	$0	$736	$0	$115	$0	$0	$851	$706	$1,557	$1,202	$2,759
1D. NO DIVERSION, NJ, ND, EP	10,375	$0	$0	$0	$0	$736	$0	$115	$0	$0	$851	$706	$1,557	$1,202	$2,759
1E. NO DIVERSION, NC, AD	10,375	$0	$0	$0	$0	$736	$0	$0	$115	$0	$851	$745	$1,596	$1,211	$2,807
1F. NO DIVERSION, C7, AD	10,375	$0	$0	$0	$0	$736	$0	$0	$115	$0	$851	$1,022	$1,873	$1,404	$3,277
1G. NO DIVERSION, NJ, AD	10,375	$0	$0	$0	$0	$736	$0	$0	$115	$0	$851	$706	$1,557	$1,202	$2,759
1H. NO DIVERSION, NJ, AD, EP	10,375	$0	$0	$0	$0	$736	$0	$0	$115	$0	$851	$706	$1,557	$1,202	$2,759
2A. DIV COPPERTON & DRY FORK, P, NC, ND	7,660	$20	$50	$231	$0	$736	$0	$115	$0	$0	$1,152	$745	$1,897	$1,211	$3,108
2B. DIV COPPERTON & DRY FORK, P, C7, ND	7,660	$20	$50	$231	$0	$736	$0	$115	$0	$0	$1,152	$1,022	$2,174	$1,404	$3,578
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	7,660	$20	$50	$231	$0	$736	$0	$115	$0	$0	$1,152	$706	$1,858	$1,202	$3,060
2D. DIV COPPERTON & DRY FORK, T, NC, ND	7,660	$20	$50	$0	$58	$736	$0	$115	$0	$0	$979	$745	$1,724	$1,211	$2,935
2E. DIV COPPERTON & DRY FORK, T, C7, ND	7,660	$20	$50	$0	$58	$736	$0	$115	$0	$0	$979	$1,022	$2,001	$1,404	$3,405
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	7,660	$20	$50	$0	$58	$736	$0	$115	$0	$0	$979	$706	$1,685	$1,202	$2,887
2G. DIV COPPERTON & DRY FORK, P, NC, AD	7,660	$20	$50	$231	$0	$736	$0	$0	$115	$0	$1,152	$745	$1,897	$1,211	$3,108
2H. DIV COPPERTON & DRY FORK, P, C7, AD	7,660	$20	$50	$231	$0	$736	$0	$0	$115	$0	$1,152	$1,022	$2,174	$1,404	$3,578
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	7,660	$20	$50	$231	$0	$736	$0	$0	$115	$0	$1,152	$706	$1,858	$1,202	$3,060
2J. DIV COPPERTON & DRY FORK, T, NC, AD	7,660	$20	$50	$0	$58	$736	$0	$0	$115	$0	$979	$745	$1,724	$1,211	$2,935
2K. DIV COPPERTON & DRY FORK, T, C7, AD	7,660	$20	$50	$0	$58	$736	$0	$0	$115	$0	$979	$1,022	$2,001	$1,404	$3,405
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	7,660	$20	$50	$0	$58	$736	$0	$0	$115	$0	$979	$706	$1,685	$1,202	$2,887
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	6,439	$80	$50	$231	$0	$736	$0	$115	$0	$0	$1,212	$745	$1,957	$1,211	$3,168
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	6,439	$80	$50	$231	$0	$736	$0	$115	$0	$0	$1,212	$1,022	$2,234	$1,404	$3,638
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	6,439	$80	$50	$231	$0	$736	$0	$115	$0	$0	$1,212	$706	$1,918	$1,202	$3,120
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	6,439	$80	$50	$0	$58	$736	$0	$115	$0	$0	$1,039	$745	$1,784	$1,211	$2,995
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	6,439	$80	$50	$0	$58	$736	$0	$115	$0	$0	$1,039	$1,022	$2,061	$1,404	$3,465
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	6,439	$80	$50	$0	$58	$736	$0	$115	$0	$0	$1,039	$706	$1,745	$1,202	$2,947
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	6,439	$80	$50	$231	$0	$736	$0	$0	$115	$0	$1,212	$745	$1,957	$1,211	$3,168
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	6,439	$80	$50	$231	$0	$736	$0	$0	$115	$0	$1,212	$1,022	$2,234	$1,404	$3,638
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	6,439	$80	$50	$231	$0	$736	$0	$0	$115	$0	$1,212	$706	$1,918	$1,202	$3,120
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	6,439	$80	$50	$0	$58	$736	$0	$0	$115	$0	$1,039	$745	$1,784	$1,211	$2,995
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	6,439	$80	$50	$0	$58	$736	$0	$0	$115	$0	$1,039	$1,022	$2,061	$1,404	$3,465
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	6,439	$80	$50	$0	$58	$736	$0	$0	$115	$0	$1,039	$706	$1,745	$1,202	$2,947
C. TREAT B. + LEACH WATER															
1A. NO DIVERSION, NC, ND	8,749	$0	$0	$0	$0	$736	$2,909	$115	$0	$0	$3,760	$745	$4,505	$1,211	$5,716
1B. NO DIVERSION, C7, ND	8,749	$0	$0	$0	$0	$736	$2,909	$115	$0	$0	$3,760	$1,022	$4,782	$1,404	$6,186
1C. NO DIVERSION, NJ, ND	8,749	$0	$0	$0	$0	$736	$2,909	$115	$0	$0	$3,760	$706	$4,466	$1,202	$5,668
1D. NO DIVERSION, NJ, ND, EP	8,749	$0	$0	$0	$0	$736	$2,909	$115	$0	$0	$3,760	$706	$4,466	$1,202	$5,668
1E. NO DIVERSION, NC, AD	8,749	$0	$0	$0	$0	$736	$2,909	$0	$115	$0	$3,760	$745	$4,505	$1,211	$5,716
1F. NO DIVERSION, C7, AD	8,749	$0	$0	$0	$0	$736	$2,909	$0	$115	$0	$3,760	$1,022	$4,782	$1,404	$6,186
1G. NO DIVERSION, NJ, AD	8,749	$0	$0	$0	$0	$736	$2,909	$0	$115	$0	$3,760	$706	$4,466	$1,202	$5,668
1H. NO DIVERSION, NJ, AD, EP	8,749	$0	$0	$0	$0	$736	$2,909	$0	$115	$0	$3,760	$706	$4,466	$1,202	$5,668

TABLE 4.1-2 - ANNUAL O&M COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DIVERSION OF RUNOFF COST: DRY FORK DAM	DIVERSION OF RUNOFF COST: DRY FORK PUMPING	DIVERSION OF RUNOFF COST: DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	TREATMENT COST: LEACH WATER	STORAGE COST: NEW RESERVOIR	STORAGE COST: ALTERNATE RESERVOIR	STORAGE COST: EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
2A. DIV COPPERTON & DRY FORK, P, NC, ND	6,034	$20	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,061	$745	$4,806	$1,211	$6,017
2B. DIV COPPERTON & DRY FORK, P, C7, ND	6,034	$20	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,061	$1,022	$5,083	$1,404	$6,487
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	6,034	$20	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,061	$706	$4,767	$1,202	$5,969
2D. DIV COPPERTON & DRY FORK, T, NC, ND	6,034	$20	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,888	$745	$4,633	$1,211	$5,844
2E. DIV COPPERTON & DRY FORK, T, C7, ND	6,034	$20	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,888	$1,022	$4,910	$1,404	$6,314
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	6,034	$20	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,888	$706	$4,594	$1,202	$5,796
2G. DIV COPPERTON & DRY FORK, P, NC, AD	6,034	$20	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,061	$745	$4,806	$1,211	$6,017
2H. DIV COPPERTON & DRY FORK, P, C7, AD	6,034	$20	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,061	$1,022	$5,083	$1,404	$6,487
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	6,034	$20	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,061	$706	$4,767	$1,202	$5,969
2J. DIV COPPERTON & DRY FORK, T, NC, AD	6,034	$20	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,888	$745	$4,633	$1,211	$5,844
2K. DIV COPPERTON & DRY FORK, T, C7, AD	6,034	$20	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,888	$1,022	$4,910	$1,404	$6,314
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	6,034	$20	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,888	$706	$4,594	$1,202	$5,796
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	4,813	$80	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,121	$745	$4,866	$1,211	$6,077
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	4,813	$80	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,121	$1,022	$5,143	$1,404	$6,547
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	4,813	$80	$50	$231	$0	$736	$2,909	$115	$0	$0	$4,121	$706	$4,827	$1,202	$6,029
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	4,813	$80	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,948	$745	$4,693	$1,211	$5,904
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	4,813	$80	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,948	$1,022	$4,970	$1,404	$6,374
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	4,813	$80	$50	$0	$58	$736	$2,909	$115	$0	$0	$3,948	$706	$4,654	$1,202	$5,856
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	4,813	$80	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,121	$745	$4,866	$1,211	$6,077
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	4,813	$80	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,121	$1,022	$5,143	$1,404	$6,547
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	4,813	$80	$50	$231	$0	$736	$2,909	$0	$115	$0	$4,121	$706	$4,827	$1,202	$6,029
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	4,813	$80	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,948	$745	$4,693	$1,211	$5,904
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	4,813	$80	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,948	$1,022	$4,970	$1,404	$6,374
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	4,813	$80	$50	$0	$58	$736	$2,909	$0	$115	$0	$3,948	$706	$4,654	$1,202	$5,856

NOTES:
1. P = PUMPING FROM DRY FORK RESERVOIR
2. T = CONVEYANCE FROM DRY FORK THROUGH A NEW TUNNEL
3. NC = TO THE NEW CONCENTRATOR FACILITY
4. C7 = TO THE C-7 CANAL INTO THE GREAT SALT LAKE
5. NJ = TO THE NORTH JORDAN IRRIGATION CANAL (IN A NEW PIPELINE UNLESS INDICATED BY EP)
6. EP = EXISTING JORDAN RIVER PIPELINE
7. ND = NEW RESERVOIR IN BINGHAM CANYON DRAINAGE
8. AD = NEW RESERVOIR OUT OF THE CANYON

TABLE 4.1-3 - 20 YEAR TOTAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DIVERSION OF RUNOFF COST: DRY FORK DAM	DIVERSION OF RUNOFF COST: DRY FORK PUMPING	DIVERSION OF RUNOFF COST: DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	TREATMENT COST: LEACH WATER	STORAGE COST: NEW RESERVOIR	STORAGE COST: ALTERNATE RESERVOIR	STORAGE COST: EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
A. BASE CASE FOR TREATMENT																
(1) NOS & CARR FORK UNDERGROUND																
(2) BINGHAM & BUTTERFIELD TUNNELS, AND BINGHAM CANYON CUTOFF																
1A. NO DIVERSION, NC, ND	13,058	$0	$0	$0	$0	$0	$0	$27,500	$0	$26,300	$53,800	$22,878	$76,678	$29,499	$106,177	
1B. NO DIVERSION, C7, ND	13,058	$0	$0	$0	$0	$0	$0	$27,500	$0	$26,300	$53,800	$32,939	$86,739	$37,193	$123,932	
1C. NO DIVERSION, NJ, ND	13,058	$0	$0	$0	$0	$0	$0	$27,500	$0	$26,300	$53,800	$22,785	$76,585	$32,217	$108,802	
1D. NO DIVERSION, NJ, ND, EP	13,058	$0	$0	$0	$0	$0	$0	$27,500	$0	$26,300	$53,800	$20,345	$74,145	$28,821	$102,966	
1E. NO DIVERSION, NC, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$52,460	$3,220	$55,680	$22,878	$78,558	$29,499	$108,057	
1F. NO DIVERSION, C7, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$52,460	$3,220	$55,680	$32,939	$88,619	$37,193	$125,812	
1G. NO DIVERSION, NJ, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$52,460	$3,220	$55,680	$22,785	$78,465	$32,217	$110,682	
1H. NO DIVERSION, NJ, AD, EP	13,058	$0	$0	$0	$0	$0	$0	$0	$52,460	$3,220	$55,680	$20,345	$76,025	$28,821	$104,846	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$30,000	$0	$3,220	$50,568	$22,878	$73,446	$29,499	$102,945	3a
2B. DIV COPPERTON & DRY FORK, P, C7, ND	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$30,000	$0	$3,220	$50,568	$32,939	$83,507	$37,193	$120,700	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$30,000	$0	$3,220	$50,568	$22,785	$73,353	$32,217	$105,570	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$30,000	$0	$3,220	$50,337	$22,878	$73,215	$29,499	$102,714	3
2E. DIV COPPERTON & DRY FORK, T, C7, ND	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$30,000	$0	$3,220	$50,337	$32,939	$83,276	$37,193	$120,469	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$30,000	$0	$3,220	$50,337	$22,785	$73,122	$32,217	$105,339	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$0	$40,760	$3,220	$61,328	$22,878	$84,206	$29,499	$113,705	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$0	$40,760	$3,220	$61,328	$32,939	$94,267	$37,193	$131,460	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	10,343	$1,894	$8,300	$7,154	$0	$0	$0	$0	$40,760	$3,220	$61,328	$22,785	$84,113	$32,217	$116,330	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$0	$40,760	$3,220	$61,097	$22,878	$83,975	$29,499	$113,474	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$0	$40,760	$3,220	$61,097	$32,939	$94,036	$37,193	$131,229	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	10,343	$1,894	$8,300	$0	$6,923	$0	$0	$0	$40,760	$3,220	$61,097	$22,785	$83,882	$32,217	$116,099	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$28,200	$0	$3,220	$55,745	$22,878	$78,623	$29,499	$108,122	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$28,200	$0	$3,220	$55,745	$32,939	$88,684	$37,193	$125,877	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$28,200	$0	$3,220	$55,745	$22,785	$78,530	$32,217	$110,747	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$28,200	$0	$3,220	$55,514	$22,878	$78,392	$29,499	$107,891	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$28,200	$0	$3,220	$55,514	$32,939	$88,453	$37,193	$125,646	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$28,200	$0	$3,220	$55,514	$22,785	$78,299	$32,217	$110,516	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$0	$35,960	$3,220	$63,505	$22,878	$86,383	$29,499	$115,882	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$0	$35,960	$3,220	$63,505	$32,939	$96,444	$37,193	$133,637	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	9,122	$7,771	$9,400	$7,154	$0	$0	$0	$0	$35,960	$3,220	$63,505	$22,785	$86,290	$32,217	$118,507	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$0	$35,960	$3,220	$63,274	$22,878	$86,152	$29,499	$115,651	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$0	$35,960	$3,220	$63,274	$32,939	$96,213	$37,193	$133,406	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	9,122	$7,771	$9,400	$0	$6,923	$0	$0	$0	$35,960	$3,220	$63,274	$22,785	$86,059	$32,217	$118,276	
4A. 3. + UPPER CARR FORK, P, NC, ND	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$27,300	$0	$3,220	$59,703	$22,878	$82,581	$29,499	$112,080	
4B. 3. + UPPER CARR FORK, P, C7, ND	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$27,300	$0	$3,220	$59,703	$32,939	$92,642	$37,193	$129,835	
4C. 3. + UPPER CARR FORK, P, NJ, ND	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$27,300	$0	$3,220	$59,703	$22,785	$82,488	$32,217	$114,705	
4D. 3. + UPPER CARR FORK, T, NC, ND	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$27,300	$0	$3,220	$59,472	$22,878	$82,350	$29,499	$111,849	
4E. 3. + UPPER CARR FORK, T, C7, ND	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$27,300	$0	$3,220	$59,472	$32,939	$92,411	$37,193	$129,604	
4F. 3. + UPPER CARR FORK, T, NJ, ND	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$27,300	$0	$3,220	$59,472	$22,785	$82,257	$32,217	$114,474	
4G. 3. + UPPER CARR FORK, P, NC, AD	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$0	$33,460	$3,220	$65,863	$22,878	$88,741	$29,499	$118,240	
4H. 3. + UPPER CARR FORK, P, C7, AD	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$0	$33,460	$3,220	$65,863	$32,939	$98,802	$37,193	$135,995	
4I. 3. + UPPER CARR FORK, P, NJ, AD	8,533	$12,229	$9,800	$7,154	$0	$0	$0	$0	$33,460	$3,220	$65,863	$22,785	$88,648	$32,217	$120,865	
4J. 3. + UPPER CARR FORK, T, NC, AD	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$0	$33,460	$3,220	$65,632	$22,878	$88,510	$29,499	$118,009	
4K. 3. + UPPER CARR FORK, T, C7, AD	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$0	$33,460	$3,220	$65,632	$32,939	$98,571	$37,193	$135,764	
4L. 3. + UPPER CARR FORK, T, NJ, AD	8,533	$12,229	$9,800	$0	$6,923	$0	$0	$0	$33,460	$3,220	$65,632	$22,785	$88,417	$32,217	$120,634	
5A. 4. + MUDDY & GALENA, P, NC, ND	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$26,900	$0	$3,220	$60,694	$22,878	$83,572	$29,499	$113,071	
5B. 4. + MUDDY & GALENA, P, C7, ND	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$26,900	$0	$3,220	$60,694	$32,939	$93,633	$37,193	$130,826	
5C. 4. + MUDDY & GALENA, P, NJ, ND	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$26,900	$0	$3,220	$60,694	$22,785	$83,479	$32,217	$115,696	
5D. 4. + MUDDY & GALENA, T, NC, ND	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$26,900	$0	$3,220	$60,463	$22,878	$83,341	$29,499	$112,840	

TABLE 4.1-3 - 20 YEAR TOTAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
5E. 4. + MUDDY & GALENA, T, C7, ND	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$26,900	$0	$3,220	$60,463	$32,939	$93,402	$37,193	$130,595	
5F. 4. + MUDDY & GALENA, T, NJ, ND	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$26,900	$0	$3,220	$60,463	$22,785	$83,248	$32,217	$115,465	
5G. 4. + MUDDY & GALENA, P, NC, AD	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$0	$32,760	$3,220	$66,554	$22,878	$89,432	$29,499	$118,931	
5H. 4. + MUDDY & GALENA, P, C7, AD	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$0	$32,760	$3,220	$66,554	$32,939	$99,493	$37,193	$136,686	
5I. 4. + MUDDY & GALENA, P, NJ, AD	8,362	$13,420	$10,000	$7,154	$0	$0	$0	$0	$32,760	$3,220	$66,554	$22,785	$89,339	$32,217	$121,556	
5J. 4. + MUDDY & GALENA, T, NC, AD	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$0	$32,760	$3,220	$66,323	$22,878	$89,201	$29,499	$118,700	
5K. 4. + MUDDY & GALENA, T, C7, AD	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$0	$32,760	$3,220	$66,323	$32,939	$99,262	$37,193	$136,455	
5L. 4. + MUDDY & GALENA, T, NJ, AD	8,362	$13,420	$10,000	$0	$6,923	$0	$0	$0	$32,760	$3,220	$66,323	$22,785	$89,108	$32,217	$121,325	
B. TREAT A. + PIT & CARR FORK DITCH																
1A. NO DIVERSION, NC, ND	10,375	$0	$0	$0	$0	$7,948	$0	$30,300	$0	$3,220	$41,468	$22,878	$64,346	$29,499	$93,845	1a
1B. NO DIVERSION, C7, ND	10,375	$0	$0	$0	$0	$7,948	$0	$30,300	$0	$3,220	$41,468	$32,939	$74,407	$37,193	$111,600	
1C. NO DIVERSION, NJ, ND	10,375	$0	$0	$0	$0	$7,948	$0	$30,300	$0	$3,220	$41,468	$22,785	$64,253	$32,217	$96,470	
1D. NO DIVERSION, NJ, ND, EP	10,375	$0	$0	$0	$0	$7,948	$0	$30,300	$0	$3,220	$41,468	$20,345	$61,813	$28,821	$90,634	1
1E. NO DIVERSION, NC, AD	10,375	$0	$0	$0	$0	$7,948	$0	$0	$41,160	$3,220	$52,328	$22,878	$75,206	$29,499	$104,705	
1F. NO DIVERSION, C7, AD	10,375	$0	$0	$0	$0	$7,948	$0	$0	$41,160	$3,220	$52,328	$32,939	$85,267	$37,193	$122,460	
1G. NO DIVERSION, NJ, AD	10,375	$0	$0	$0	$0	$7,948	$0	$0	$41,160	$3,220	$52,328	$22,785	$75,113	$32,217	$107,330	
1H. NO DIVERSION, NJ, AD, EP	10,375	$0	$0	$0	$0	$7,948	$0	$0	$41,160	$3,220	$52,328	$20,345	$72,673	$28,821	$101,494	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$25,800	$0	$3,220	$54,316	$22,878	$77,194	$29,499	$106,693	
2B. DIV COPPERTON & DRY FORK, P, C7, ND	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$25,800	$0	$3,220	$54,316	$32,939	$87,255	$37,193	$124,448	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$25,800	$0	$3,220	$54,316	$22,785	$77,101	$32,217	$109,318	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$25,800	$0	$3,220	$54,085	$22,878	$76,963	$29,499	$106,462	
2E. DIV COPPERTON & DRY FORK, T, C7, ND	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$25,800	$0	$3,220	$54,085	$32,939	$87,024	$37,193	$124,217	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$25,800	$0	$3,220	$54,085	$22,785	$76,870	$32,217	$109,087	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$0	$29,960	$3,220	$58,476	$22,878	$81,354	$29,499	$110,853	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$0	$29,960	$3,220	$58,476	$32,939	$91,415	$37,193	$128,608	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	7,660	$1,894	$8,300	$7,154	$0	$7,948	$0	$0	$29,960	$3,220	$58,476	$22,785	$81,261	$32,217	$113,478	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$0	$29,960	$3,220	$58,245	$22,878	$81,123	$29,499	$110,622	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$0	$29,960	$3,220	$58,245	$32,939	$91,184	$37,193	$128,377	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	7,660	$1,894	$8,300	$0	$6,923	$7,948	$0	$0	$29,960	$3,220	$58,245	$22,785	$81,030	$32,217	$113,247	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$23,800	$0	$3,220	$59,293	$22,878	$82,171	$29,499	$111,670	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$23,800	$0	$3,220	$59,293	$32,939	$92,232	$37,193	$129,425	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$23,800	$0	$3,220	$59,293	$22,785	$82,078	$32,217	$114,295	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$23,800	$0	$3,220	$59,062	$22,878	$81,940	$29,499	$111,439	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$23,800	$0	$3,220	$59,062	$32,939	$92,001	$37,193	$129,194	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$23,800	$0	$3,220	$59,062	$22,785	$81,847	$32,217	$114,064	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$0	$25,360	$3,220	$60,853	$22,878	$83,731	$29,499	$113,230	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$0	$25,360	$3,220	$60,853	$32,939	$93,792	$37,193	$130,985	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	6,439	$7,771	$9,400	$7,154	$0	$7,948	$0	$0	$25,360	$3,220	$60,853	$22,785	$83,638	$32,217	$115,855	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$0	$25,360	$3,220	$60,622	$22,878	$83,500	$29,499	$112,999	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$0	$25,360	$3,220	$60,622	$32,939	$93,561	$37,193	$130,754	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	6,439	$7,771	$9,400	$0	$6,923	$7,948	$0	$0	$25,360	$3,220	$60,622	$22,785	$83,407	$32,217	$115,624	
C. TREAT B. + LEACH WATER																
1A. NO DIVERSION, NC, ND	8,749	$0	$0	$0	$0	$7,948	$8,202	$27,600	$0	$3,220	$46,970	$22,878	$69,848	$29,499	$99,347	
1B. NO DIVERSION, C7, ND	8,749	$0	$0	$0	$0	$7,948	$8,202	$27,600	$0	$3,220	$46,970	$32,939	$79,909	$37,193	$117,102	
1C. NO DIVERSION, NJ, ND	8,749	$0	$0	$0	$0	$7,948	$8,202	$27,600	$0	$3,220	$46,970	$22,785	$69,755	$32,217	$101,972	
1D. NO DIVERSION, NJ, ND, EP	8,749	$0	$0	$0	$0	$7,948	$8,202	$27,600	$0	$3,220	$46,970	$20,345	$67,315	$28,821	$96,136	2
1E. NO DIVERSION, NC, AD	8,749	$0	$0	$0	$0	$7,948	$8,202	$0	$34,360	$3,220	$53,730	$22,878	$76,608	$29,499	$106,107	
1F. NO DIVERSION, C7, AD	8,749	$0	$0	$0	$0	$7,948	$8,202	$0	$34,360	$3,220	$53,730	$32,939	$86,669	$37,193	$123,862	
1G. NO DIVERSION, NJ, AD	8,749	$0	$0	$0	$0	$7,948	$8,202	$0	$34,360	$3,220	$53,730	$22,785	$76,515	$32,217	$108,732	
1H. NO DIVERSION, NJ, AD, EP	8,749	$0	$0	$0	$0	$7,948	$8,202	$0	$34,360	$3,220	$53,730	$20,345	$74,075	$28,821	$102,896	

TABLE 4.1-3 - 20 YEAR TOTAL COSTS
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DIVERSION OF RUNOFF COST: DRY FORK DAM	DIVERSION OF RUNOFF COST: DRY FORK PUMPING	DIVERSION OF RUNOFF COST: DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	TREATMENT COST: LEACH WATER	STORAGE COST: NEW RESERVOIR	STORAGE COST: ALTERNATE RESERVOIR	STORAGE COST: EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
2A. DIV COPPERTON & DRY FORK, P, NC, ND	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$23,200	$0	$3,220	$59,918	$22,878	$82,796	$29,499	$112,295
2B. DIV COPPERTON & DRY FORK, P, C7, ND	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$23,200	$0	$3,220	$59,918	$32,939	$92,857	$37,193	$130,050
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$23,200	$0	$3,220	$59,918	$22,785	$82,703	$32,217	$114,920
2D. DIV COPPERTON & DRY FORK, T, NC, ND	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$23,200	$0	$3,220	$59,687	$22,878	$82,565	$29,499	$112,064
2E. DIV COPPERTON & DRY FORK, T, C7, ND	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$23,200	$0	$3,220	$59,687	$32,939	$92,626	$37,193	$129,819
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$23,200	$0	$3,220	$59,687	$22,785	$82,472	$32,217	$114,689
2G. DIV COPPERTON & DRY FORK, P, NC, AD	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$0	$23,960	$3,220	$60,678	$22,878	$83,556	$29,499	$113,055
2H. DIV COPPERTON & DRY FORK, P, C7, AD	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$0	$23,960	$3,220	$60,678	$32,939	$93,617	$37,193	$130,810
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	6,034	$1,894	$8,300	$7,154	$0	$7,948	$8,202	$0	$23,960	$3,220	$60,678	$22,785	$83,463	$32,217	$115,680
2J. DIV COPPERTON & DRY FORK, T, NC, AD	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$0	$23,960	$3,220	$60,447	$22,878	$83,325	$29,499	$112,824
2K. DIV COPPERTON & DRY FORK, T, C7, AD	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$0	$23,960	$3,220	$60,447	$32,939	$93,386	$37,193	$130,579
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	6,034	$1,894	$8,300	$0	$6,923	$7,948	$8,202	$0	$23,960	$3,220	$60,447	$22,785	$83,232	$32,217	$115,449
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$24,920	$0	$3,220	$68,615	$22,878	$91,493	$29,499	$120,992
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$24,920	$0	$3,220	$68,615	$32,939	$101,554	$37,193	$138,747
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$24,920	$0	$3,220	$68,615	$22,785	$91,400	$32,217	$123,617
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$24,920	$0	$3,220	$68,384	$22,878	$91,262	$29,499	$120,761
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$24,920	$0	$3,220	$68,384	$32,939	$101,323	$37,193	$138,516
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$24,920	$0	$3,220	$68,384	$22,785	$91,169	$32,217	$123,386
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$0	$20,960	$3,220	$64,655	$22,878	$87,533	$29,499	$117,032
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$0	$20,960	$3,220	$64,655	$32,939	$97,594	$37,193	$134,787
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	4,813	$7,771	$9,400	$7,154	$0	$7,948	$8,202	$0	$20,960	$3,220	$64,655	$22,785	$87,440	$32,217	$119,657
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$0	$20,960	$3,220	$64,424	$22,878	$87,302	$29,499	$116,801
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$0	$20,960	$3,220	$64,424	$32,939	$97,363	$37,193	$134,556
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	4,813	$7,771	$9,400	$0	$6,923	$7,948	$8,202	$0	$20,960	$3,220	$64,424	$22,785	$87,209	$32,217	$119,426

NOTES:
1. P = PUMPING FROM DRY FORK RESERVOIR
2. T = CONVEYANCE FROM DRY FORK THROUGH A NEW TUNNEL
3. NC = TO THE NEW CONCENTRATOR FACILITY
4. C7 = TO THE C-7 CANAL INTO THE GREAT SALT LAKE
5. NJ = TO THE NORTH JORDAN IRRIGATION CANAL (IN A NEW PIPELINE UNLESS INDICATED BY EP)
6. EP = EXISTING JORDAN RIVER PIPELINE
7. ND = NEW RESERVOIR IN BINGHAM CANYON DRAINAGE
8. AD = NEW RESERVOIR OUT OF THE CANYON

TABLE 4.1-4 - 20 YEAR PRESENT VALUE, WET YEAR = 20, I = 8%
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
A. BASE CASE FOR TREATMENT																
(1) NOS & CARR FORK UNDERGROUND																
(2) BINGHAM & BUTTERFIELD TUNNELS, AND BINGHAM CANYON CUTOFF																
1A. NO DIVERSION, NC, ND	13,058	$0	$0	$0	$0	$0	$0	$26,329	$0	$25,129	$51,458	$15,292	$66,751	$17,169	$83,919	
1B. NO DIVERSION, C7, ND	13,058	$0	$0	$0	$0	$0	$0	$26,329	$0	$25,129	$51,458	$22,533	$73,991	$22,897	$96,889	
1C. NO DIVERSION, NJ, ND	13,058	$0	$0	$0	$0	$0	$0	$26,329	$0	$25,129	$51,458	$15,597	$67,055	$19,978	$87,033	
1D. NO DIVERSION, NJ, ND, EP	13,058	$0	$0	$0	$0	$0	$0	$26,329	$0	$25,129	$51,458	$13,157	$64,615	$16,582	$81,197	
1E. NO DIVERSION, NC, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$51,289	$3,220	$54,509	$15,292	$69,801	$17,169	$86,970	
1F. NO DIVERSION, C7, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$51,289	$3,220	$54,509	$22,533	$77,042	$22,897	$99,940	
1G. NO DIVERSION, NJ, AD	13,058	$0	$0	$0	$0	$0	$0	$0	$51,289	$3,220	$54,509	$15,597	$70,106	$19,978	$90,084	
1H. NO DIVERSION, NJ, AD, EP	13,058	$0	$0	$0	$0	$0	$0	$0	$51,289	$3,220	$54,509	$13,157	$67,666	$16,582	$84,248	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$28,829	$0	$3,220	$46,332	$15,292	$61,625	$17,169	$78,793	3a
2B. DIV COPPERTON & DRY FORK, P, C7, ND	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$28,829	$0	$3,220	$46,332	$22,533	$68,865	$22,897	$91,763	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$28,829	$0	$3,220	$46,332	$15,597	$61,929	$19,978	$81,907	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$28,829	$0	$3,220	$47,863	$15,292	$63,155	$17,169	$80,324	3
2E. DIV COPPERTON & DRY FORK, T, C7, ND	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$28,829	$0	$3,220	$47,863	$22,533	$70,396	$22,897	$93,293	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$28,829	$0	$3,220	$47,863	$15,597	$63,459	$19,978	$83,438	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$0	$39,589	$3,220	$57,092	$15,292	$72,385	$17,169	$89,553	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$0	$39,589	$3,220	$57,092	$22,533	$79,625	$22,897	$102,523	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	10,343	$1,690	$7,791	$4,802	$0	$0	$0	$0	$39,589	$3,220	$57,092	$15,597	$72,689	$19,978	$92,667	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$0	$39,589	$3,220	$58,623	$15,292	$73,915	$17,169	$91,084	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$0	$39,589	$3,220	$58,623	$22,533	$81,156	$22,897	$104,053	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	10,343	$1,690	$7,791	$0	$6,332	$0	$0	$0	$39,589	$3,220	$58,623	$15,597	$74,219	$19,978	$94,198	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$27,029	$0	$3,220	$50,898	$15,292	$66,191	$17,169	$83,359	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$27,029	$0	$3,220	$50,898	$22,533	$73,431	$22,897	$96,329	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$27,029	$0	$3,220	$50,898	$15,597	$66,495	$19,978	$86,473	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$27,029	$0	$3,220	$52,429	$15,292	$67,721	$17,169	$84,890	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$27,029	$0	$3,220	$52,429	$22,533	$74,962	$22,897	$97,859	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$27,029	$0	$3,220	$52,429	$15,597	$68,025	$19,978	$88,004	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$0	$34,789	$3,220	$58,658	$15,292	$73,951	$17,169	$91,119	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$0	$34,789	$3,220	$58,658	$22,533	$81,191	$22,897	$104,089	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	9,122	$6,956	$8,891	$4,802	$0	$0	$0	$0	$34,789	$3,220	$58,658	$15,597	$74,255	$19,978	$94,233	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$0	$34,789	$3,220	$60,189	$15,292	$75,481	$17,169	$92,650	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$0	$34,789	$3,220	$60,189	$22,533	$82,722	$22,897	$105,619	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	9,122	$6,956	$8,891	$0	$6,332	$0	$0	$0	$34,789	$3,220	$60,189	$15,597	$75,785	$19,978	$95,764	
4A. 3. + UPPER CARR FORK, P, NC, ND	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$26,129	$0	$3,220	$54,449	$15,292	$69,741	$17,169	$86,910	
4B. 3. + UPPER CARR FORK, P, C7, ND	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$26,129	$0	$3,220	$54,449	$22,533	$76,982	$22,897	$99,280	
4C. 3. + UPPER CARR FORK, P, NJ, ND	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$26,129	$0	$3,220	$54,449	$15,597	$70,046	$19,978	$90,024	
4D. 3. + UPPER CARR FORK, T, NC, ND	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$26,129	$0	$3,220	$55,980	$15,292	$71,272	$17,169	$88,441	
4E. 3. + UPPER CARR FORK, T, C7, ND	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$26,129	$0	$3,220	$55,980	$22,533	$78,513	$22,897	$101,410	
4F. 3. + UPPER CARR FORK, T, NJ, ND	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$26,129	$0	$3,220	$55,980	$15,597	$71,576	$19,978	$91,554	
4G. 3. + UPPER CARR FORK, P, NC, AD	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$0	$32,289	$3,220	$60,609	$15,292	$75,901	$17,169	$93,070	
4H. 3. + UPPER CARR FORK, P, C7, AD	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$0	$32,289	$3,220	$60,609	$22,533	$83,142	$22,897	$106,040	
4I. 3. + UPPER CARR FORK, P, NJ, AD	8,533	$11,007	$9,291	$4,802	$0	$0	$0	$0	$32,289	$3,220	$60,609	$15,597	$76,206	$19,978	$96,184	
4J. 3. + UPPER CARR FORK, T, NC, AD	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$0	$32,289	$3,220	$62,140	$15,292	$77,432	$17,169	$94,601	
4K. 3. + UPPER CARR FORK, T, C7, AD	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$0	$32,289	$3,220	$62,140	$22,533	$84,673	$22,897	$107,570	
4L. 3. + UPPER CARR FORK, T, NJ, AD	8,533	$11,007	$9,291	$0	$6,332	$0	$0	$0	$32,289	$3,220	$62,140	$15,597	$77,736	$19,978	$97,714	
5A. 4. + MUDDY & GALENA, P, NC, ND	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$25,729	$0	$3,220	$55,236	$15,292	$70,529	$17,169	$87,697	
5B. 4. + MUDDY & GALENA, P, C7, ND	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$25,729	$0	$3,220	$55,236	$22,533	$77,769	$22,897	$100,667	
5C. 4. + MUDDY & GALENA, P, NJ, ND	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$25,729	$0	$3,220	$55,236	$15,597	$70,833	$19,978	$90,811	
5D. 4. + MUDDY & GALENA, T, NC, ND	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$25,729	$0	$3,220	$56,767	$15,292	$72,059	$17,169	$89,228	

TABLE 4.1-4 - 20 YEAR PRESENT VALUE, WET YEAR = 20, I = 8%
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST: DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	TREATMENT COST: CARR FORK & PIT	LEACH WATER	STORAGE COST: NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR	SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATMENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)	
5E. 4. + MUDDY & GALENA, T, C7, ND	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$25,729	$0	$3,220	$56,767	$22,533	$79,300	$22,897	$102,197	
5F. 4. + MUDDY & GALENA, T, NJ, ND	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$25,729	$0	$3,220	$56,767	$15,597	$72,363	$19,978	$92,342	
5G. 4. + MUDDY & GALENA, P, NC, AD	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$0	$31,589	$3,220	$61,096	$15,292	$76,389	$17,169	$93,557	
5H. 4. + MUDDY & GALENA, P, C7, AD	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$0	$31,589	$3,220	$61,096	$22,533	$83,629	$22,897	$106,527	
5I. 4. + MUDDY & GALENA, P, NJ, AD	8,362	$11,995	$9,491	$4,802	$0	$0	$0	$0	$31,589	$3,220	$61,096	$15,597	$76,693	$19,978	$96,671	
5J. 4. + MUDDY & GALENA, T, NC, AD	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$0	$31,589	$3,220	$62,627	$15,292	$77,919	$17,169	$95,088	
5K. 4. + MUDDY & GALENA, T, C7, AD	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$0	$31,589	$3,220	$62,627	$22,533	$85,160	$22,897	$108,057	
5L. 4. + MUDDY & GALENA, T, NJ, AD	8,362	$11,995	$9,491	$0	$6,332	$0	$0	$0	$31,589	$3,220	$62,627	$15,597	$78,223	$19,978	$98,202	
B. TREAT A. + PIT & CARR FORK DITCH																
1A. NO DIVERSION, NC, ND	10,375	$0	$0	$0	$0	$7,370	$0	$29,129	$0	$3,220	$39,719	$15,292	$55,012	$17,169	$72,180	1a
1B. NO DIVERSION, C7, ND	10,375	$0	$0	$0	$0	$7,370	$0	$29,129	$0	$3,220	$39,719	$22,533	$62,252	$22,897	$85,150	
1C. NO DIVERSION, NJ, ND	10,375	$0	$0	$0	$0	$7,370	$0	$29,129	$0	$3,220	$39,719	$15,597	$55,316	$19,978	$75,294	
1D. NO DIVERSION, NJ, ND, EP	10,375	$0	$0	$0	$0	$7,370	$0	$29,129	$0	$3,220	$39,719	$13,157	$52,876	$16,582	$69,458	1
1E. NO DIVERSION, NC, AD	10,375	$0	$0	$0	$0	$7,370	$0	$0	$39,989	$3,220	$50,579	$15,292	$65,872	$17,169	$83,040	
1F. NO DIVERSION, C7, AD	10,375	$0	$0	$0	$0	$7,370	$0	$0	$39,989	$3,220	$50,579	$22,533	$73,112	$22,897	$96,010	
1G. NO DIVERSION, NJ, AD	10,375	$0	$0	$0	$0	$7,370	$0	$0	$39,989	$3,220	$50,579	$15,597	$66,176	$19,978	$86,154	
1H. NO DIVERSION, NJ, AD, EP	10,375	$0	$0	$0	$0	$7,370	$0	$0	$39,989	$3,220	$50,579	$13,157	$63,736	$16,582	$80,318	
2A. DIV COPPERTON & DRY FORK, P, NC, ND	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$24,629	$0	$3,220	$49,503	$15,292	$64,795	$17,169	$81,964	
2B. DIV COPPERTON & DRY FORK, P, C7, ND	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$24,629	$0	$3,220	$49,503	$22,533	$72,036	$22,897	$94,933	
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$24,629	$0	$3,220	$49,503	$15,597	$65,099	$19,978	$85,077	
2D. DIV COPPERTON & DRY FORK, T, NC, ND	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$24,629	$0	$3,220	$51,033	$15,292	$66,325	$17,169	$83,494	
2E. DIV COPPERTON & DRY FORK, T, C7, ND	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$24,629	$0	$3,220	$51,033	$22,533	$73,566	$22,897	$96,463	
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$24,629	$0	$3,220	$51,033	$15,597	$66,630	$19,978	$86,608	
2G. DIV COPPERTON & DRY FORK, P, NC, AD	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$0	$28,789	$3,220	$53,663	$15,292	$68,955	$17,169	$86,124	
2H. DIV COPPERTON & DRY FORK, P, C7, AD	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$0	$28,789	$3,220	$53,663	$22,533	$76,196	$22,897	$99,093	
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	7,660	$1,690	$7,791	$4,802	$0	$7,370	$0	$0	$28,789	$3,220	$53,663	$15,597	$69,259	$19,978	$89,237	
2J. DIV COPPERTON & DRY FORK, T, NC, AD	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$0	$28,789	$3,220	$55,193	$15,292	$70,485	$17,169	$87,654	
2K. DIV COPPERTON & DRY FORK, T, C7, AD	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$0	$28,789	$3,220	$55,193	$22,533	$77,726	$22,897	$100,623	
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	7,660	$1,690	$7,791	$0	$6,332	$7,370	$0	$0	$28,789	$3,220	$55,193	$15,597	$70,790	$19,978	$90,768	
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$22,629	$0	$3,220	$53,869	$15,292	$69,161	$17,169	$86,330	
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$22,629	$0	$3,220	$53,869	$22,533	$76,402	$22,897	$99,299	
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$22,629	$0	$3,220	$53,869	$15,597	$69,465	$19,978	$89,443	
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$22,629	$0	$3,220	$55,399	$15,292	$70,692	$17,169	$87,860	
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$22,629	$0	$3,220	$55,399	$22,533	$77,932	$22,897	$100,830	
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$22,629	$0	$3,220	$55,399	$15,597	$70,996	$19,978	$90,974	
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$0	$24,189	$3,220	$55,429	$15,292	$70,721	$17,169	$87,890	
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$0	$24,189	$3,220	$55,429	$22,533	$77,962	$22,897	$100,859	
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	6,439	$6,956	$8,891	$4,802	$0	$7,370	$0	$0	$24,189	$3,220	$55,429	$15,597	$71,025	$19,978	$91,003	
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$0	$24,189	$3,220	$56,959	$15,292	$72,252	$17,169	$89,420	
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$0	$24,189	$3,220	$56,959	$22,533	$79,492	$22,897	$102,390	
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	6,439	$6,956	$8,891	$0	$6,332	$7,370	$0	$0	$24,189	$3,220	$56,959	$15,597	$72,556	$19,978	$92,534	
C. TREAT B. + LEACH WATER																
1A. NO DIVERSION, NC, ND	8,749	$0	$0	$0	$0	$7,370	$5,918	$26,429	$0	$3,220	$42,938	$15,292	$58,230	$17,169	$75,399	
1B. NO DIVERSION, C7, ND	8,749	$0	$0	$0	$0	$7,370	$5,918	$26,429	$0	$3,220	$42,938	$22,533	$65,471	$22,897	$88,368	
1C. NO DIVERSION, NJ, ND	8,749	$0	$0	$0	$0	$7,370	$5,918	$26,429	$0	$3,220	$42,938	$15,597	$58,534	$19,978	$78,512	
1D. NO DIVERSION, NJ, ND, EP	8,749	$0	$0	$0	$0	$7,370	$5,918	$26,429	$0	$3,220	$42,938	$13,157	$56,094	$16,582	$72,676	2
1E. NO DIVERSION, NC, AD	8,749	$0	$0	$0	$0	$7,370	$5,918	$0	$33,189	$3,220	$49,698	$15,292	$64,990	$17,169	$82,159	
1F. NO DIVERSION, C7, AD	8,749	$0	$0	$0	$0	$7,370	$5,918	$0	$33,189	$3,220	$49,698	$22,533	$72,231	$22,897	$95,128	
1G. NO DIVERSION, NJ, AD	8,749	$0	$0	$0	$0	$7,370	$5,918	$0	$33,189	$3,220	$49,698	$15,597	$65,294	$19,978	$85,272	
1H. NO DIVERSION, NJ, AD, EP	8,749	$0	$0	$0	$0	$7,370	$5,918	$0	$33,189	$3,220	$49,698	$13,157	$62,854	$16,582	$79,436	

TABLE 4.1-4 - 20 YEAR PRESENT VALUE, WET YEAR = 20, I = 8%
(ALL COSTS x $1,000)

MATRIX COMBINATION (ITEMS CONSIDERED)	RESERVOIR REQUIREMENTS (ACRE-FEET)	DIVERSION OF RUNOFF COST				TREATMENT COST		STORAGE COST			SUBTOTAL (x $1,000)	(1) 6.25K GPM TREATKENT	SUBTOTAL (x $1,000)	(2) 12.5K GPM TREATMENT	TOTAL COSTS (x $1,000)
		DIVERSION	DRY FORK DAM	DRY FORK PUMPING	DRY FORK TUNNEL	CARR FORK & PIT	LEACH WATER	NEW RESERVOIR	ALTERNATE RESERVOIR	EXISTING RESERVOIR					
2A. DIV COPPERTON & DRY FORK, P, NC, ND	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$22,029	$0	$3,220	$52,821	$15,292	$68,113	$17,169	$85,282
2B. DIV COPPERTON & DRY FORK, P, C7, ND	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$22,029	$0	$3,220	$52,821	$22,533	$75,354	$22,897	$98,251
2C. DIV COPPERTON & DRY FORK, P, NJ, ND	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$22,029	$0	$3,220	$52,821	$15,597	$68,417	$19,978	$88,396
2D. DIV COPPERTON & DRY FORK, T, NC, ND	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$22,029	$0	$3,220	$54,351	$15,292	$69,644	$17,169	$86,812
2E. DIV COPPERTON & DRY FORK, T, C7, ND	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$22,029	$0	$3,220	$54,351	$22,533	$76,884	$22,897	$99,782
2F. DIV COPPERTON & DRY FORK, T, NJ, ND	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$22,029	$0	$3,220	$54,351	$15,597	$69,948	$19,978	$89,926
2G. DIV COPPERTON & DRY FORK, P, NC, AD	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$0	$22,789	$3,220	$53,581	$15,292	$68,873	$17,169	$86,042
2H. DIV COPPERTON & DRY FORK, P, C7, AD	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$0	$22,789	$3,220	$53,581	$22,533	$76,114	$22,897	$99,011
2I. DIV COPPERTON & DRY FORK, P, NJ, AD	6,034	$1,690	$7,791	$4,802	$0	$7,370	$5,918	$0	$22,789	$3,220	$53,581	$15,597	$69,177	$19,978	$89,156
2J. DIV COPPERTON & DRY FORK, T, NC, AD	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$0	$22,789	$3,220	$55,111	$15,292	$70,404	$17,169	$87,572
2K. DIV COPPERTON & DRY FORK, T, C7, AD	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$0	$22,789	$3,220	$55,111	$22,533	$77,644	$22,897	$100,542
2L. DIV COPPERTON & DRY FORK, T, NJ, AD	6,034	$1,690	$7,791	$0	$6,332	$7,370	$5,918	$0	$22,789	$3,220	$55,111	$15,597	$70,708	$19,978	$90,686
3A. 2. + FREEMAN & MARKHAM, P, NC, ND	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$23,749	$0	$3,220	$60,907	$15,292	$76,199	$17,169	$93,368
3B. 2. + FREEMAN & MARKHAM, P, C7, ND	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$23,749	$0	$3,220	$60,907	$22,533	$83,440	$22,897	$106,338
3C. 2. + FREEMAN & MARKHAM, P, NJ, ND	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$23,749	$0	$3,220	$60,907	$15,597	$76,504	$19,978	$96,482
3D. 2. + FREEMAN & MARKHAM, T, NC, ND	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$23,749	$0	$3,220	$62,438	$15,292	$77,730	$17,169	$94,899
3E. 2. + FREEMAN & MARKHAM, T, C7, ND	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$23,749	$0	$3,220	$62,438	$22,533	$84,971	$22,897	$107,868
3F. 2. + FREEMAN & MARKHAM, T, NJ, ND	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$23,749	$0	$3,220	$62,438	$15,597	$78,034	$19,978	$98,012
3G. 2. + FREEMAN & MARKHAM, P, NC, AD	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$0	$19,789	$3,220	$56,947	$15,292	$72,239	$17,169	$89,408
3H. 2. + FREEMAN & MARKHAM, P, C7, AD	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$0	$19,789	$3,220	$56,947	$22,533	$79,480	$22,897	$102,378
3I. 2. + FREEMAN & MARKHAM, P, NJ, AD	4,813	$6,956	$8,891	$4,802	$0	$7,370	$5,918	$0	$19,789	$3,220	$56,947	$15,597	$72,544	$19,978	$92,522
3J. 2. + FREEMAN & MARKHAM, T, NC, AD	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$0	$19,789	$3,220	$58,478	$15,292	$73,770	$17,169	$90,939
3K. 2. + FREEMAN & MARKHAM, T, C7, AD	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$0	$19,789	$3,220	$58,478	$22,533	$81,011	$22,897	$103,908
3L. 2. + FREEMAN & MARKHAM, T, NJ, AD	4,813	$6,956	$8,891	$0	$6,332	$7,370	$5,918	$0	$19,789	$3,220	$58,478	$15,597	$74,074	$19,978	$94,052

NOTES:
1. P = PUMPING FROM DRY FORK RESERVOIR
2. T = CONVEYANCE FROM DRY FORK THROUGH A NEW TUNNEL
3. NC = TO THE NEW CONCENTRATOR FACILITY
4. C7 = TO THE C-7 CANAL INTO THE GREAT SALT LAKE
5. NJ = TO THE NORTH JORDAN IRRIGATION CANAL (IN A NEW PIPELINE UNLESS INDICATED BY EP)
6. EP = EXISTING JORDAN RIVER PIPELINE
7. ND = NEW RESERVOIR IN BINGHAM CANYON DRAINAGE
8. AD = NEW RESERVOIR OUT OF THE CANYON

b. Group B - In addition to the water treated in Group A, treat Pit and Carr Fork Ditch Water.

c. Group C - In addition to the water treated in Group B, treat Leach Water.

d. Diversion - Within each of the groups above, the diversion of uncontaminated water was examined in increments starting from Copperton and Dry Fork and adding each of the subsequent undisturbed drainage areas on the west and south sides of Bingham Canyon. The sequence used is as follows:

1. No Diversion
2. Diversion of the Copperton and Dry Fork drainages
3. Diversion of 2 plus the Freeman and Markham drainages
4. Diversion of 3 plus the Upper Carr Fork drainage
5. Diversion of 4 plus the Muddy and Galena drainages

e. Other Variables - In addition to the treatment and diversion designation, each line in Column 1 is coded to indicate which combination of variables is covered in that line. These codes and corresponding variables are:

P = Diverted uncontaminated water pumped from Dry Fork Reservoir to the existing pipeline and then gravity discharged to the Jordan River or the North Jordan Irrigation Canal.

T = Diverted uncontaminated water discharged by gravity through a new tunnel from Dry Fork Reservoir to the existing pipeline and then gravity discharged to the Jordan River or the North Jordan Irrigation Canal.

NC = Treated mine discharge water pumped to a New Concentrator.

C7 = Treated mine discharge water gravity flow to the C-7 Canal.

NJ = Treated mine discharge water gravity flow to the Jordan River or the North Jordan Irrigation Canal using a new pipeline.

EP = Treated mine discharge water gravity flow to the Jordan River or the North Jordan Irrigation Canal using the existing pipeline.

ND = New reservoir in Bingham Canyon drainage.

AD = Alternate new reservoir out of Bingham Canyon drainage and located south of Bingham Creek in the wheat fields.

2. Column 2, Reservoir Requirements (Acre-Feet) - This is the amount of contaminated water to be stored based on the simulated hydrological study after allowance for diversion and/or treatment.

3. Column 3, Diversion of Runoff Cost - All costs are shown in $1000's.

a. Diversion - This is the cost of channels required to collect the runoff and deliver it to the Dry Fork Dam or, in the case of Copperton, to Bingham Creek drainage.

b. Dry Fork Dam - This is the cost of the dam sized for storage of the collected runoff.

c. Dry Fork Pumping - This is the cost of the pump station and pipeline required to pump collected runoff water over the Barney Creek divide and to the existing Jordan River pipeline for discharge to the Jordan River or the North Jordan Irrigation Canal.

d. Dry Fork Tunnel - This is the cost of a tunnel to carry water from the Dry Fork Dam to the existing pipeline by gravity.

4. Column 4, Treatment Cost

a. Carr Fork and Pit - This is the cost of the pipeline to the C-7 canal area and the treatment plant to treat 1,800 gpm (3,000 gpm design) of Carr Fork Ditch and Pit mine drainage water.

b. Leach Water - This is the cost of the pipeline to the C-7 canal area and the treatment plant required to treat 1,000 gpm (1,500 gpm design) of leach water.

5. Column 5, Storage Cost

a. New Reservoir - This is the cost for construction of a new reservoir in the Bingham Canyon drainage east (downstream) of the existing reservoir.

b. Alternate Reservoir - This is the cost for construction of a new reservoir in the wheat fields to the south of, and outside, the Bingham Creek drainage area.

c. Existing Reservoir - This is the cost for:

(1) Enlarging the existing reservoir, or
(2) Cleaning up the sediment and precipitate in the existing reservoir and breaching the dam in cases where the existing dam will be abandoned. (Tailings underlying the sediment and precipitate will not be removed.)

6. Column 6, Subtotal - This is the sum (in $1,000's) of the costs for all applicable items from the previous columns.

7. Column 7, 6.25K gpm Treatment - This is the cost for the 6,250 gpm modular treatment plant to treat present flows of NOS and Carr Fork underground mine drainage.

8. Column 8, Subtotal - This is the sum (in $1,000's) of the costs for all applicable items from the previous columns.

9. Column 9, 12.5K gpm Treatment - This is the incremental cost for the second 6,250 gpm modular treatment plant to treat the increased

NOS discharge water and the Bingham and Butterfield Tunnel discharge and Bingham Canyon Cutoff water.

10. Column 10, Total Costs - This is the total cost for all applicable items from the previous columns.

C. Explanation of Table 4.1-2 - Annual Operation and Maintenance Costs

This table is structured in an identical manner to Table 4.1-1. However, the costs reported are the annual operating and maintenance costs for each item described above.

D. Explanation of Table 4.1-3 - 20-Year Total Costs

This table is structured in an identical manner to Tables 4.1-1 and 4.1-2, but the capital costs have been added to 20 years of operating costs and the results are shown in this table. Treatment costs for Pit, Carr Fork Ditch and leach water will not occur every year; it is estimated that they will occur with a 1 in 20 probability. Since it is not known in which of the 20 years this treatment cost will occur, this method of tabulation provides a means of examining the total cost over the period. It is analagous to performing a present value analysis at 0% interest.

E. Explanation of Table 4.1-4 - 20-Year Present Value Cost

This table is structured in an identical manner to Table 4.1-3, except that the 20 years of annual operating costs are present-valued based on an 8% interest rate, compounded annually. In this table, the treatment costs for Pit, Carr Fork Ditch, and leach water are assumed to be incurred in year 20, providing the smallest present value contribution. In this manner, the sensitivity of the relative cost rankings with interest rate can be assessed.

4.2 HYDROLOGICAL DATA

The trade-off studies for the uncontaminated water collection system, contaminated water storage requirements, treatment plant capacities, and discharge facilities require hydrological data for the project area. This data is needed to determine the design volumes of runoff from rainfall and snowmelt, the design flows for the water collection and discharge facilities, and the design flood for the reservoir spillways. The hydrological data concerning the drainage area of the Bingham Canyon basin, the design annual precipitation with a recurrence interval of 100 years, and the corresponding volume of runoff were established during the hydrological and meteorological study. The data are presented and discussed in Chapter 3 and are given as follows:

- Bingham Creek Drainage Area: 8,758 acres (13.7 mi^2)
- 100-Year Annual Precipitation: 37.6 inches
- 100-Year Inflow Volume: 13,808 acre-feet

The values of the all season design storms for the project area were determined during the Phase I Study and were presented in Section 4 of the Phase I report (Ref. 1). The preliminary design of the discharge facilities and reservoir spillways for the trade-off study will be based on these data, which are as follows:

- 10-year, 24-hour rainfall: 2.4 inches
  (With areal reduction factor: 2.3 inches)
- 100-year, 24-hour rainfall: 3.6 inches
  (With areal reduction factor: 3.5 inches)
- Local PMF storm, 6-hour: 11.0 inches
  (With areal reduction factor: 10.7 inches)

The areal reduction factor is a reduction permitted for larger area basins to reflect the reduced probability of the calculated intensity of rainfall effecting the entire basin simultaneously. Since this factor had little effect for the Bingham Canyon drainage basin, it was conservatively decided to use the full unfactored precipitation quantities in the trade-off studies.

The Probable Maximum Flood (PMF) inflow hydrograph and the results of the flood routing calculations obtained in the Phase I Study will be used in the Phase II Study for the preliminary design of the reservoir spillways for the different reservoir storage alternatives. The peak inflow for the PMF is 37,600 cubic feet per second (cfs), with a total inflow volume of about 4,000 acre-feet and the peak outflow is 33,800 cfs for the selected spillway crest length of 800 feet.

The precipitation intensity-duration-frequency curves derived during the Phase I Study and presented in Section 4 of the Phase I report (Ref. 1) will be used for the preliminary design of the uncontaminated water collection channels for the trade-off study.

4.3 UNCONTAMINATED WATER COLLECTION

A. Introduction

The purpose of the uncontaminated water collection system for the Bingham Canyon watershed is to reduce the storage and treatment requirements for contaminated water caused by rainfall and snowmelt runoff intermingling with mine leach water. The water collection system was designed to intercept uncontaminated surface runoff entering the waste dumps; to reduce runoff inflow into the leach water reservoir(s); and to reduce the recharge to the ground-water system around the mine pit.

The scope of work involved in the conceptual design of the uncontaminated water collection system consisted of the following:

- Prepare preliminary layouts and determine the requirements for the facilities to collect, intercept, convey, and discharge uncontaminated surface runoff into natural streams not affected by contaminated water in the mine area.

- Prepare preliminary designs for ground-water cutoffs to intercept and discharge uncontaminated ground water into the surface water collection channels.

- Prepare quantity estimates for each of the collection and diversion schemes for determining the costs to be used for the economic trade-off evaluation.

B. Assumptions

The following assumptions were used in the preliminary design of the uncontaminated water collection facilities:

- The rational formula for determining the design peak runoff for the collection channels is assumed applicable to the drainage areas considered in this study. The formula is:

$$Q = CIA$$

where:

Q = peak discharge in cubic feet per second
C = runoff coefficient depending on the characteristics of the drainage area
I = rainfall intensity in inches per hour for a selected rainfall frequency and for duration equal to the time of concentration
A = drainage area in acres tributary to the point being considered

- The values used for the rational formula runoff coefficient C are:

  - Copperton drainage area: 0.25
  - Dry Fork and other drainage areas above the waste dumps: 0.35

- The formula used in determining the time of concentration is the Kirpich equation:

$$T_c = 0.0078 \times (L)^{0.77} \times (S)^{-0.385}$$

where:

T_c = time of concentration in minutes
L = maximum length of travel of water in feet
S = slope, equal to H/L where H is the difference in elevation between the most remote point on the drainage area and the outlet of runoff.

- Minimal blasting is assumed to be required for excavating the collection channels.

- Runoff/Precipitation ratio for determining the volume of runoff from rainfall and snowmelt is assumed to be 0.3.

- An initial infiltration loss of 0.5 inch for the first hour and an infiltration rate of 0.05 inch per hour for the remaining period of the storm were assumed for determining the rainfall excess and the design storm runoff volume for the surface water collection system.

- The values of the permeability of soil and bedrock are assumed to be:

- Bedrock: 5×10^{-5} to 2×10^{-4} cm/sec.
- Alluvium: 1×10^{-2} cm/sec.
- Slurry Cutoff: 1×10^{-7} cm/sec.

o Effective porosity for the alluvium is assumed to be 0.23

o The locations of the water collection and discharge facilities are either within Kennecott-owned property or in private properties which can be acquired or leased.

C. Design Criteria

The design criteria and the procedures followed in this study are in general accordance with the codes, regulations, and standards of engineering practice recommended by governmental agencies and engineering organizations.

The areas where uncontaminated surface runoff can be intercepted and diverted to prevent mixing with contaminated water in the dumps and leach water in Bingham Creek reservoir are:

o Copperton drainage area
o Dry Fork drainage area
o Freeman Gulch and Markham Gulch drainage areas
o Carr Fork drainage area (Cottonwood Gulch, Sap Gulch, Zelnora Gulch, and Log Fork)
o Muddy Gulch and Galena Gulch drainage areas

The criteria used for conceptual design are:

1. Collection Channels

- Design discharge: 10-year flood peak discharge with snowmelt and freeboard to contain the 100-year flood peak discharge.

- Channel section: Concrete-lined triangular section, side slopes of 1(H):1(V) on the hillside, and 3(H):1(V) on the access road side for ease in channel cleaning and maintenance.

- Concrete-lined rectangular section, minimum 2 foot bottom width for steep hillside slopes.

- Concrete-lined trapezoidal section, minimum 2 foot bottom width and side slopes of 1.5(H):1(V) for the Copperton area.

- Minimum radius of channel curve to centerline: 3 to 7 times waterline width.

- Maximum concrete-lined channel velocity: 15 fps.

- Maximum velocity for reinforced sections: 40 fps.

- Manning's "n" value for concrete: 0.015.

2. <u>Channel Structures and Culverts</u>

- Design Discharge: 10-year flood peak discharge.

- Minimum Freeboard: 3 feet above 10-year floodwater line.

- Erosion Protection Material: Riprap.

3. <u>Intercepting Dikes for Collection Channels</u>

- Design water levels: Normal maximum water level for 10-year rainfall.

- Maximum water level: 100-year rainfall without overtopping the top of the dike.

- Minimum top width of dike: 10 feet.

- Minimum side slopes: 1.5(H):1(V).

- Erosion Protection Material: Riprap.

Conceptual designs and costs (including operation and maintenance costs) were developed to reduce the volume of water entering the Bingham Creek reservoir for the following cases:

Case I: Diversion of runoff on Copperton drainage area and Dry Fork drainage area.

Case II: Case I plus diversion of runoff on Freeman Gulch and Markham Gulch drainage areas.

Case III: Case II plus diversion of runoff on Carr Fork drainage area.

Case IV: Case III plus diversion of runoff on Muddy Gulch and Galena Gulch drainage areas.

The surface runoff in the Copperton area was intercepted, conveyed, and discharged downstream of the leach water reservoir. The surface runoff on Dry Fork and on the areas above the west and south dumps were intercepted and collected in the Dry Fork reservoir. The water in Dry Fork reservoir was discharged into the area of Barney's Wash by using either pumps or a discharge tunnel, from where it is conveyed to an appropriate receiving water body. A diversion structure could be considered on Barney's Wash to divert the water into the proposed new concentrator. Another diversion structure could be considered on Barney's Wash near the mining railroad to divert the water into a pipeline that will connect to the existing pipeline to the Jordan River or to an alternate conveyance.

D. Analysis of Surface Water Collection

Kennecott's comments on the Phase I report on surface water control facilities were reviewed and considered in developing alternatives for collecting and diverting the uncontaminated surface runoff in Bingham Canyon watershed area for this study. The following changes in the original assumptions and criteria were adopted based on these review comments:

1. The drainage in the area south of the mine pit will not be discharged into Butterfield Creek.

2. Due to obstructions and inadequate culvert sizes along the course of the Bingham Creek caused by land development between Jordan River and Copperton, large flows cannot be discharged into Bingham Creek without causing flooding problems.

3. The water collected in the Dry Fork reservoir and discharged into the area of Barney's Creek or Barney's Wash will not be allowed to flow beyond the Kennecott property unless a permit is obtained.

4. The type of soil and extensive ponding conditions occurring in the site require lower runoff coefficients and peak flows than the values used and obtained in the Phase I study.

Field reconnaissance work was done on the drainage areas above the south and west waste dumps from Galena Gulch to Dry Fork, in the Copperton area, and along the natural course of the Bingham Creek. Kennecott personnel have assisted in the field reconnaissance to observe site conditions relative to possible alignment of the surface water collection channel, location of ground-water cutoffs, type of soil and rock formation, general pattern and direction of natural drainage flows, possible discharge points for the uncontaminated water, and vegetative characteristics of the drainage areas. Guided by the comments received from Kennecott on the Phase I study, by the site conditions observed during the field reconnaissance, and by the

experiences and observations related by Kennecott personnel on the soil and drainage conditions at the site, the possible areas for uncontaminated runoff collection, channel alignment, points of diversions and discharges were established.

The preliminary alignment and approximate inverts of the surface water collection channels and intercepting dikes were laid out on topographic maps with scales of 1-inch equals 2,000 feet, 600 feet, and 200 feet. The drainage areas were determined from the 2,000 foot scale map using a planimeter. The drainage areas obtained are given in Table 4.3-1. The preliminary alignments, slopes, and diversion facility locations are shown in Figure 4.3-1.

The annual volume of runoff which can be diverted for each alternative were calculated from the 37.6 inches of design annual precipitation plus the 10-year, 24-hour design storm of 2.4 inches, using a runoff-precipitation ratio of 0.3. The uncontaminated runoff volumes are given in Table 4.3-2.

The preliminary design and quantity estimates for the uncontaminated water collection and discharge facilities were done for the different alternatives considered as follows:

1. Copperton Area - The runoff from the area northwest of Copperton with a drainage area of 339 acres will be diverted and conveyed by a 36-inch diameter pipeline starting from the Bingham Highway crossing, passing around the south side of Copperton, and discharging into a ponding area upstream of the existing main drainage culvert (66-inch diameter reinforced concrete pipe) for the town of Copperton. The 10-year and the 100-year peak flows for this area were calculated as 127 cfs and 212 cfs respectively. The runoff from the area north of Copperton and the Copperton town area will follow the natural drainage pattern up to the ponding area upstream of the 66"Ø culvert. The combined flows for the 860-acre Copperton drainage area will be collected and conveyed by a concrete-lined trapezoidal channel

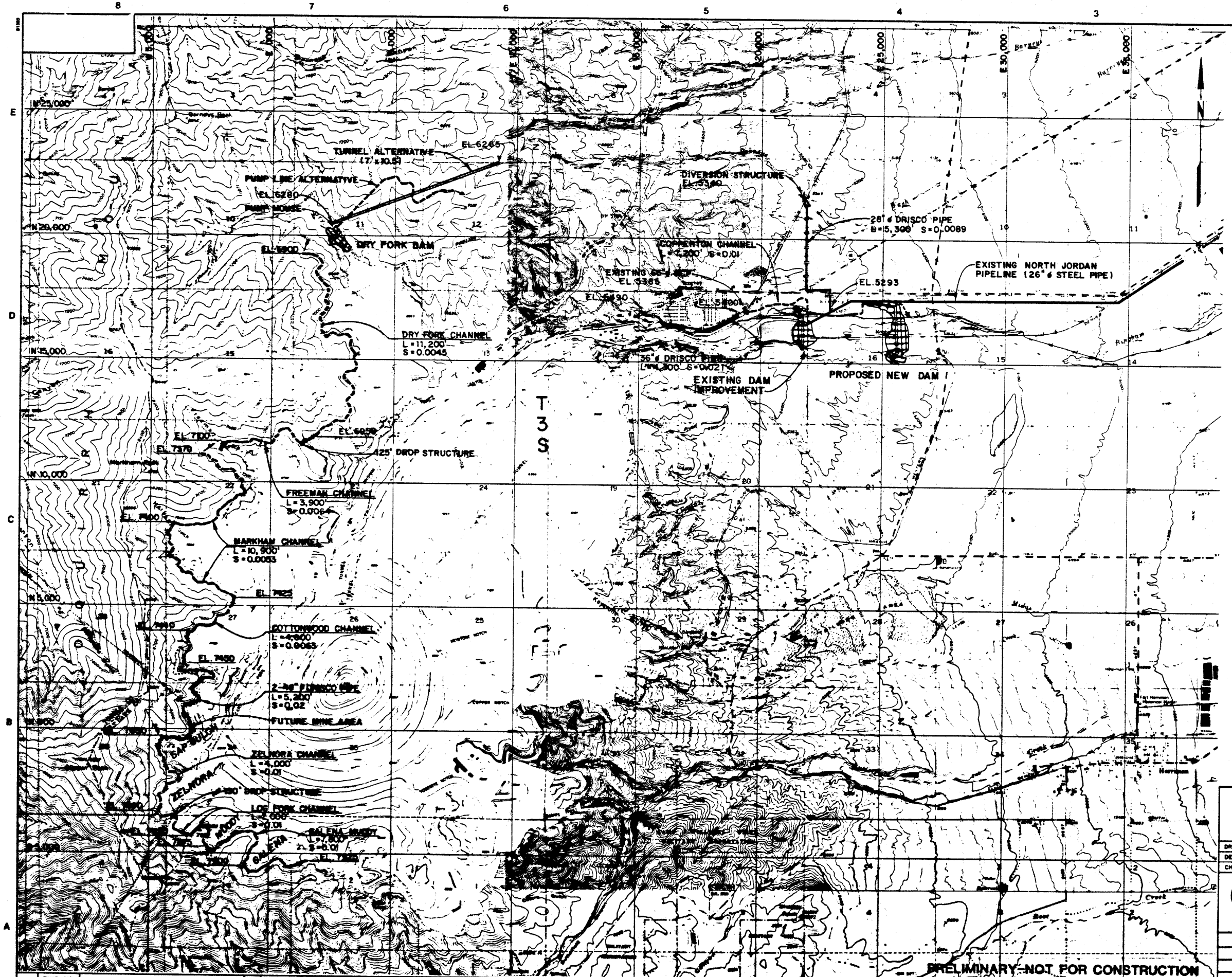
TABLE 4.3-1

DRAINAGE AREAS FOR THE SURFACE WATER COLLECTION SYSTEM

Location	Drainage Areas (acres)
Copperton area	860
Dry Fork area	1,855
Freeman and Markham area:	
Freeman Gulch	819
Markham Gulch	403
Upper Carr Fork area:	
Cottonwood Gulch	164
Sap and Zelnora Gulch	363
Log Fork	65
Muddy and Galena Gulch area	171

Notes:

- Muddy Gulch and Galena Gulch are tributary to the mine pit.
- Copperton, Dry Fork, Freeman, Markham, and Upper Carr Fork with combined areas of 4,529 acres are tributaries to Bingham Creek.
- The total drainage area tributary to Bingham Creek is 8,758 acres.



NOTES:

1. ALL ELEVATIONS AND DIMENSIONS SHOWN ON THIS DRAWING ARE PRELIMINARY AND SHALL BE VERIFIED FOR THE FINAL DESIGN OF ALL DISCHARGE FACILITIES.

2000 0 2000 4000
SCALE FEET

REFERENCE	DWG. NO.	DESCRIPTION

REFERENCE	DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

	BY	DATE		BY	DATE
APPROVED BY			DESIGN		
APPROVED BY			DRAWN		
APPROVED BY			CKD.		
APPROVED BY			CKD.		
APPROVED BY					

PHASE II PROJECT REPORT

UNCONTAMINATED WATER COLLECTION

DRAWN BY: CCR	APPROVED BY: PMG
DESIGN BY: RPP	DATE: 16 SEPT. 1985
CHECKED BY: JDL	DWG. NO.: FIGURE 4.3-1

MORRISON-KNUDSEN ENGINEERS
A MORRISON-KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

DRAWING ISSUE

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED
DESTROY ALL PRINTS BEARING EARLIER DATE AND OR REVISION

ISSUED FOR	DATE

BY:

MICROFILM	JOB NO.

SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO.: FIGURE 4.3-1

REV.: △ PLANT

TABLE 4.3-2

ANNUAL VOLUME OF UNCONTAMINATED WATER
DIVERTED FROM BINGHAM CREEK RESERVOIR

Location	Volume (acre-feet)
Copperton	860
Dry Fork	1,855
Freeman and Markham	1,221
Upper Carr Fork	589
Muddy and Galena Gulch	171
Diversion Alternative 1	2,715
Diversion Alternative 2	3,936
Diversion Alternative 3	4,525
Diversion Alternative 4	4,696

Notes:

- The total volume of wet-year runoff into Bingham Creek reservoir obtained from the hydrological study is estimated as 13,808 acre-feet.
- The design wet-year volume of contaminated water to be handled without diversion of uncontaminated water is 13,058 acre-feet, determined by using an estimated mine operating condition with a net annual mine water use of 1,371 acre-feet, together with the 10-year, 24-hour design storm runoff of 525 acre-feet and a leach water volume of 96 acre-feet (21,600 gpm) for a one-day precipitation plant shutdown condition.

starting from the outlet of the existing 66-inch diameter culvert, passing around the reservoirs on the north side, and will be discharged into Bingham Creek downstream of the proposed new reservoir. The 10-year and 100-year peak flows for the Copperton Channel are 221 cfs and 365 cfs respectively. The bottom width of the channel is 4 feet and the height is 5 feet, with side slopes of 1.5(H) to 1(V).

2. Dry Fork Area - The runoff from the Dry Fork drainage area could be collected in the Dry Fork reservoir with the dam located at about 1000 feet upstream of the present Dry Fork waste dump. The uncontaminated water could either be pumped, or discharged through a 6,900-ft. modified horseshoe tunnel with a nominal size of 7-feet wide x 10.5-feet high and with a controlled flow of 15,000 gpm (33.4 cfs) into the area of Barney's Wash. The water could be diverted at the mine railroad crossing into a 28-inch diameter pipeline, which would be connected to the existing 26-inch diameter pipeline to the Jordan River, which would subsequently discharge the diverted water into an irrigation canal or the Jordan River. The conceptual design of the Dry Fork dam is discussed in more detail later in this section.

The diverted flow from Dry Fork reservoir was limited to 15,000 gpm to match the conveyance capacity of the North Jordan pipeline. These diversion and conveyance conditions would preclude the alternative of using Dry Fork dam as a diversion dam, diverting and passing the peak flood flows through a tunnel and discharging into the area of Barney's Wash.

The reservoir flood water levels and the corresponding height of the dam at Dry Fork were determined for each of the alternative areas draining into the reservoir using the HEC computer programs for developing design flood hydrographs and for flood routing. The starting reservoir water level of elevation 6,280 feet was used, which corresponds to a storage capacity of 320 acre-feet. This storage volume is equivalent to an assumed water supply requirement of 400 gpm for a period of 6 months, intended for dust control or for other culinary water use in the mine area. The 100-year flood runoff was

routed through the reservoir with the pumps or intake into the tunnel discharging at 15,000 gpm as the reservoir water level exceeds elevation 6,280 feet.

The results of the flood routing calculations for the different water collection alternatives are given in Table 4.3-3. An additional surcharge of 3 feet (about 45 acre-feet) was added to the maximum water levels to allow for the maximum daily runoff from rainfall and snowmelt on the drainage areas for the month of May 1984, derived from the results of the hydrological study. A minimum freeboard of 3 feet is added to determine the top of dam elevation.

Four pumps with 4,000 gpm capacity each will be used for the pump alternative of discharging Dry Fork reservoir water into the area of Barney's Wash. The horsepower of the pump engine is estimated at 1,000 hp for an effective pumping head of 800 feet and an efficiency of 85%. The discharge pipe will be a 24-inch dia. steel pipe with a length of 6,800 feet to the point of discharge in Barney's Wash.

3. Freeman Gulch and Markham Gulch Area - The runoff from Freeman Gulch and Markham Gulch will be intercepted by collection channels and intercepting dikes located above the waste dumps and will be drained into the Dry Fork reservoir. A concrete-lined triangular channel will be used, excavated with side slopes of 1(H):1(V) on the hillside and 3(H):1(V) on the side of the access road. A minimum width of 10 feet for the access and maintenance road will be provided. Draining Freeman Gulch into the Dry Fork reservoir will involve placing an intercepting dike across the gulch, constructing a channel with a length of about 15,100 feet, and providing a 125-foot drop structure at the drainage divide of Freeman Gulch and Dry Fork. Draining Markham Gulch will involve a channel with a length of about 10,900 feet starting from the drainage divide of Cottonwood Gulch, passing through an intercepting dike at the main channel of Markham Gulch, and discharging into a tributary of Freeman Gulch above the Freeman dike.

TABLE 4.3-3

DRY FORK RESERVOIR MAXIMUM FLOOD WATER LEVELS

Alternative	Maximum Water Surf. Elev. (feet)	Elevation of Top of Dam (feet)	Reservoir Storage (acre-feet)
1) Divert Dry Fork	6,300.0	6,303	500
2) Divert Dry Fork, Freeman, and Markham	6,309.9	6,313	650
3) Divert Dry Fork, Freeman, Markham, and Upper Carr Fork	6,314.0	6,317	720
4) Divert Dry Fork, Freeman, Markham, Upper Carr Fork, Muddy, and Galena	6,315.8	6,319	750

The design discharges for the Markham and Freeman collection channels were determined and the corresponding sizes for the different diversion alternatives were calculated. Table 4.3-4 shows the hydraulic design data and the channel depths used in estimating the quantities for the Markham and Freeman collection channels.

4. Upper Carr Fork Area - The Upper Carr Fork drainage area consists of the drainage areas of Cottonwood Gulch, Sap Gulch, Zelnora Gulch, and Log Fork. The alternative to collect and discharge the surface runoff in the Upper Carr Fork area into Dry Fork reservoir through the Markham and Freeman channel will involve additional channels with a length of about 10,600 ft. A double line of 48-inch diameter pipe with a total pipe length of 10,400 feet will be needed to convey the water from Sap Gulch to Cottonwood. The pipe will pass over an area which is planned to be excavated in the future as an extension of the mine pit. A 150-foot drop structure will be needed to convey the water from the Log Fork area to Zelnora Gulch.

The design flows for the collection channel and the calculated channel depth for the alternative of diverting the runoff from the Upper Carr Fork area, Markham and Freeman are shown in Table 4.3-4.

5. Muddy Gulch and Galena Gulch Area - The runoff from Muddy and Galena Gulches drains through the south dumps and into the mine pit. The alternative to collect the uncontaminated surface runoff is considered to effect a reduction on the moderately contaminated water accumulating in the mine pit and possibly improve the mine pit slope stability conditions in the area below the gulches. The surface runoff on Galena and Muddy can be collected by a channel located above the dumps and directed into the Upper Carr Fork, Markham and Freeman collection channels and into the Dry Fork reservoir. The length of the runoff collection channel for Galena and Muddy is about 7,800 feet.

The design discharges and depths required for the runoff collection channels for the alternative of diverting surface runoff from Galena, Muddy, Upper Carr Fork, Markham, and Freeman are given in Table 4.3-4.

TABLE 4.3-4

COLLECTION CHANNEL HYDRAULIC DESIGN DATA FOR DIFFERENT DIVERSION ALTERNATIVES

Alternative	Channel Location	Design Discharges (cfs) 10-year	100-year	Average Slope	Channel Depth (feet)
Divert Freeman and Markham	- Freeman-Dry Fork	449	727	.005	5.5
	- Markham-Freeman	282	451	.005	4.5
	- Markham	109	182	.006	3.0
Divert Freeman, Markham, and Upper Carr Fork	- Freeman-Dry Fork	465	766	.005	5.5
	- Cottonwood-Markham-Freeman	320	534	.006	4.5
	- Sap-Cottonwood	300	480	.02	(2-48"Ø Pipe)
	- Zelnora-Sap	300	480	.01	4.0
	- Log Fork-Zelnora	71	114	.01	2.5
Divert Freeman, Markham, Upper Carr Fork, Muddy, and Galena	- Freeman-Dry Fork	465	766	.005	5.5
	- Cottonwood-Markham-Freeman	320	534	.006	4.5
	- Sap-Cottonwood	315	524	.02	(2-48"Ø Pipe)
	- Zelnora-Sap	315	524	.01	4.0
	- Log Fork-Zelnora	140	231	.01	3.5
	- Muddy-Log Fork	120	192	.01	3.0
	- Galena-Muddy	51	82	.01	2.0

E. Analysis of Ground-Water Cutoffs

An analysis of ground-water movement was performed to evaluate the effectiveness of cutoffs to trap and divert ground water to the surface stream. Fourteen cutoff locations above the south and west waste dumps were studied with site-specific drainage information. These locations are shown in the Phase II Geotechnical Report (Ref. 2). The permeability and thickness of alluvium for each site are delineated from test pit logs and seismic refraction tests. Bedrock permeability estimates were based on Packer test results.

The study assumes the following for each cutoff area:

- The ground-water basin has the same areal shape as that of the watershed above it.
- The ground-water movement is in the same direction as surface runoff.
- The ground-water hydraulic gradient in the alluvium is the same as the topographic gradient.
- The flow section of the alluvial aquifer has a parabolic shape.
- The cutoffs are triangular in cross section.
- The phreatic surface in the alluvium behind the cutoff is horizontal.
- The volume of infiltration seeping out from behind each cutoff is taken as the excess amount after satisfying the seepage and storage requirements.
- The slope of the contact between the alluvium and the bedrock behind the cutoff is the same as the average topographic gradient.

The analysis involved two stages. The first stage was to distribute the infiltration into alluvium and bedrock flows based on their respective Darcy's law flow components. The second stage dealt with the alluvium flow that has been intercepted by the cutoff, distributing it among different components such as seepage through the cutoff and into the bedrock, storage, and discharge to the surface stream. Analyses were conducted for a wet year, a dry year, and an average precipitation year.

By defining the cutoff efficiency as the percentage of infiltration that will emerge as surface water due to the cutoff, the efficiency was found to vary from 20% to 60% for the areas where bedrock permeability is estimated at 5.0×10^{-5} cm/sec. For those areas where bedrock permeability is estimated at 2.0×10^{-4} cm/sec, the efficiency drops to below 15%. A summary of cutoff efficiencies for a wet year are presented in Table 4.3-5.

To evaluate peak flow conditions on a monthly basis, a separate calculation was performed using adjusted monthly runoff curves. These curves were developed by assuming that the general shape of the curve would be the same as the general runoff curve for the water basin from the hydrological study. (For water-year 1984, for example, 24% of the annual basin runoff occurred during the month of May.)

The annual precipitation was distributed into surface runoff (30%), evapo-transpiration (35%), and ground water infiltration (35%). This ground water infiltration value was then distributed on a monthly basis proportional to the basin runoff curve.

F. Dry Fork Dam Conceptual Design

1. General - The purpose of Dry Fork Dam is to intercept uncontaminated surface water runoff and to prevent it from entering the mine waste dumps. Quantities and costs were generated for the following cases:

TABLE 4.3-5

GROUND-WATER CUTOFF EFFICIENCY*

Cutoff No.	Volume of Infiltration (acre-feet)	Volume Diverted to the Surface (acre-feet)	Cutoff Efficiency* (%)
1	25.76	16.74	65
2	37.03	21.85	59
3	29.40	6.47	22
4	113.61	59.08	52
5	60.97	19.51	32
6	148.68	49.06	33
7	44.17	7.95	18
8	34.23	3.77	11
9	54.18	13.00	24
10	51.73	9.83	19
11	129.43	47.89	37
12	316.96	50.79	16
13	70.63	15.54	22
14	17.57	3.87	22

* This efficiency is defined as the percent of infiltration which emerges as surface water due to the cutoff. It should not be confused with collection efficiency, which has been conceptually designed at 100% for the lined collection channel system. These efficiencies represent water volumes in addition to the collection of surface runoff.

Dam Crest Elevation (feet)	Normal Max. Res. W.S. El. (feet)	Approximate Reservoir Capacity (acre-feet)
6,400	6,390	2,500
6,375	6,365	1,600
6,325	6,315	600

The plan and typical conceptual cross-section for the case with the dam crest at elevation 6,400 feet are shown on Figures 4.3-2 and 4.3-3, respectively. Cross-sections for the lower crest levels are similar to the maximum section.

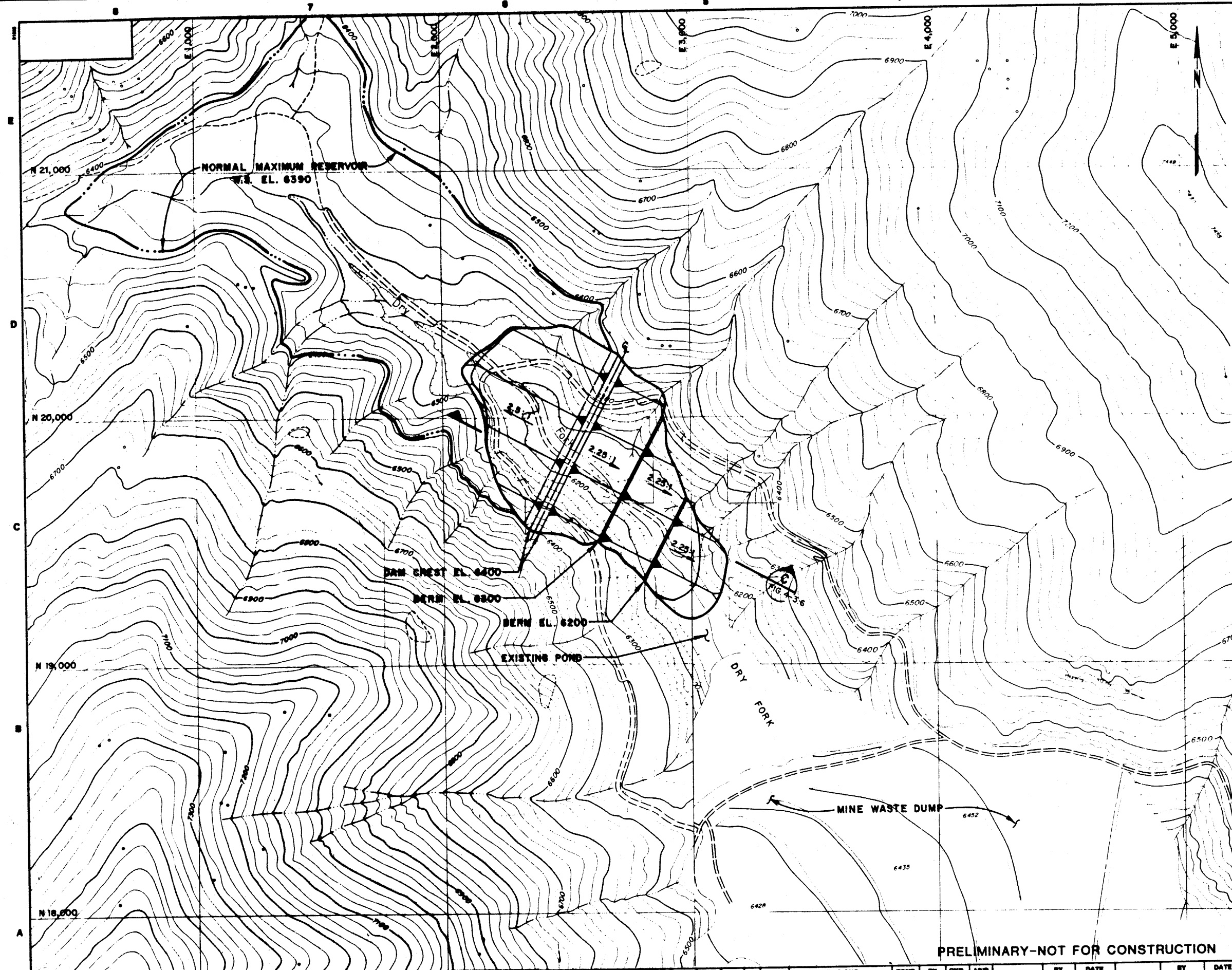
The dam on Dry Fork Creek is designed as a zoned earthfill dam. For the conceptual design studies, the upstream and downstream slopes were selected to be 2.5(H):1(V) and 2.25(H):1(V), respectively. Total embankment volumes and heights of the three cases are as follows:

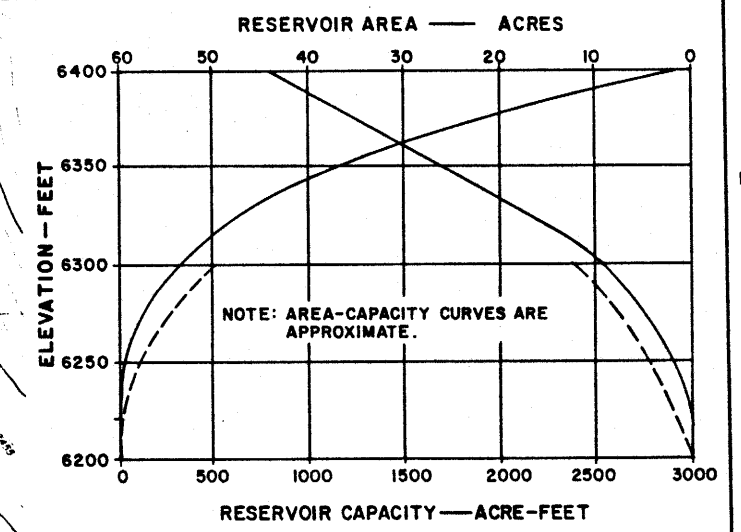
Dam Crest Elevation (feet)	Total In-Place Volume (cubic yards)	Max. Height Above Foundation (feet)
6,400	2,282,000	290
6,375	1,681,000	265
6,325	869,000	215

2. Embankment Design - The various zones of the dam are discussed in the following paragraphs.

a. Zone 1 - The central impervious core of the dam (Zone 1) is founded on bedrock. A sufficient quantity of suitably impervious local material has not been verified. Therefore, for the purpose of cost estimation, Zone 1 material will consist of silty clay, which is hauled approximately 13 miles to the damsite from the clay borrow area. The Zone 1 core is relatively thin in order to reduce costs.

b. Zone 2 - The shells (Zone 2) will consist of locally available sand and gravel. If sufficient quantities of soil materials suitable for Zone 2 do not occur locally, then a quarry may have to be developed to provide rockfill for Zone 2.





RESERVOIR AREA-CAPACITY CURVE

LEGEND:

- - - - - DAM CREST EL.6300

——— DAM CREST EL.6400

REFERENCE DRAWINGS:

1. TOPOGRAPHY COMPILED FROM PHOTOGRAMMETRIC METHODS DATED NOV. 23, 1954, NOV. 3, 1955, AND OCT. 10, 1963 BY AERO SERVICE CORPORATION (WESTERN) - SALT LAKE CITY, UTAH.

200 0 200 400
SCALE FEET

PHASE II PROJECT REPORT

DRY FORK DAMSITE
PLAN

DRAWN BY: CCR	APPROVED BY: PMG
DESIGN BY: MPF	DATE: 16 SEPT. 1985
CHECKED BY: JDL	DWG. NO.: FIGURE 4.3-2

MORRISON-KNUDSEN ENGINEERS
A MORRISON KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

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BY:

MICROFILM	JOB NO.

SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.3-2

REV. PLANT

REFERENCE	DWG. NO.	DESCRIPTION

REFERENCE	DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

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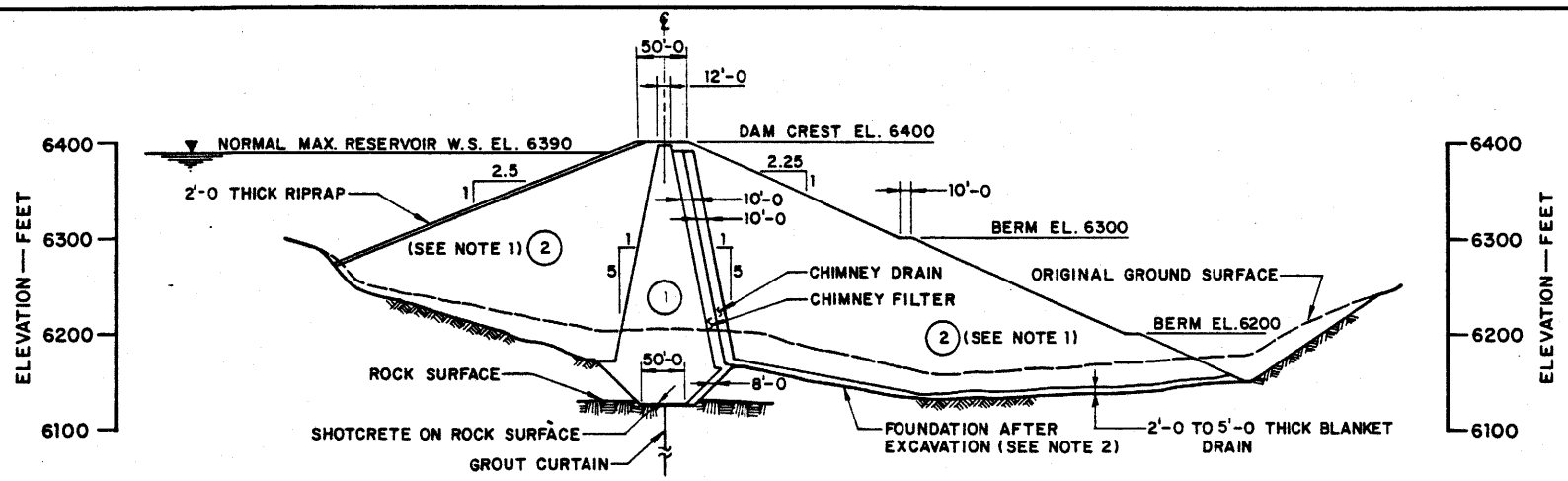

DRY FORK DAM
SECTION C
FIG. 4.3-5

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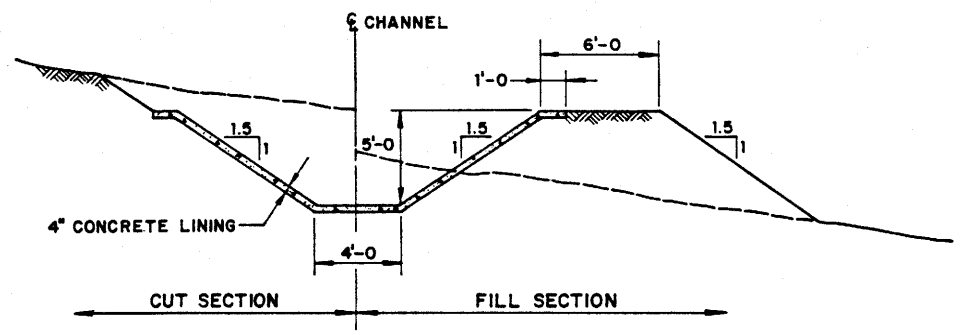
SCALE FEET

DRY FORK DAM
SUMMARY OF MATERIALS

ZONE	MATERIAL DESCRIPTION	SOURCE
1	SILTY CLAY	CLAY BORROW AREA
2	SAND, GRAVEL AND COBBLES	RESERVOIR AREA
CHIMNEY FILTER	PROCESSED SAND	IMPORT
CHIMNEY AND BLANKET DRAINS	PROCESSED SANDY GRAVEL	IMPORT
RIPRAP	GRAVEL TO BOULDERS	RESERVOIR AREA



TYPICAL SECTION — COPPERTON CHANNEL
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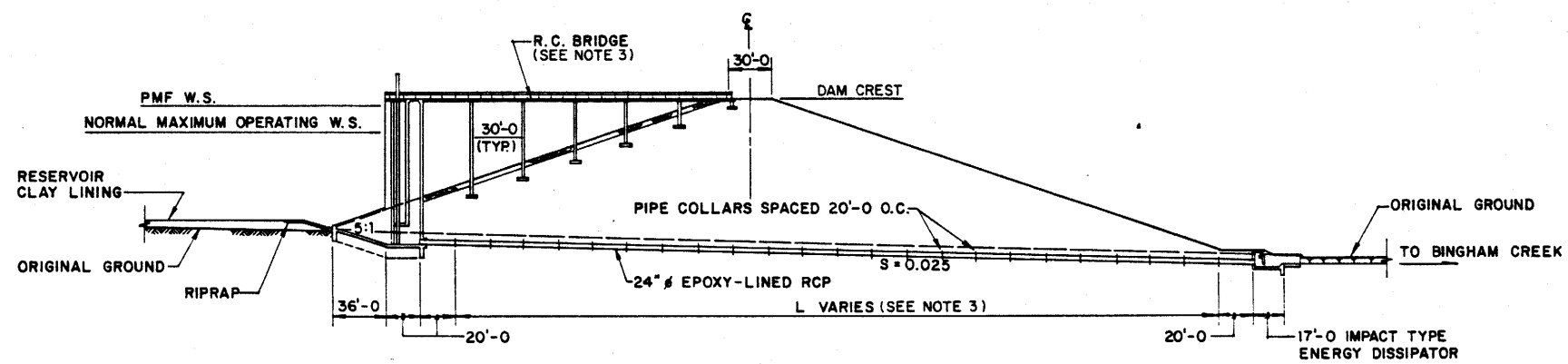
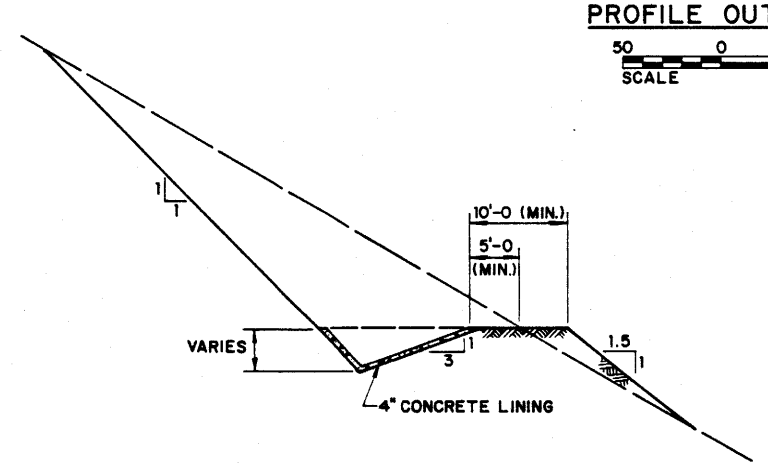


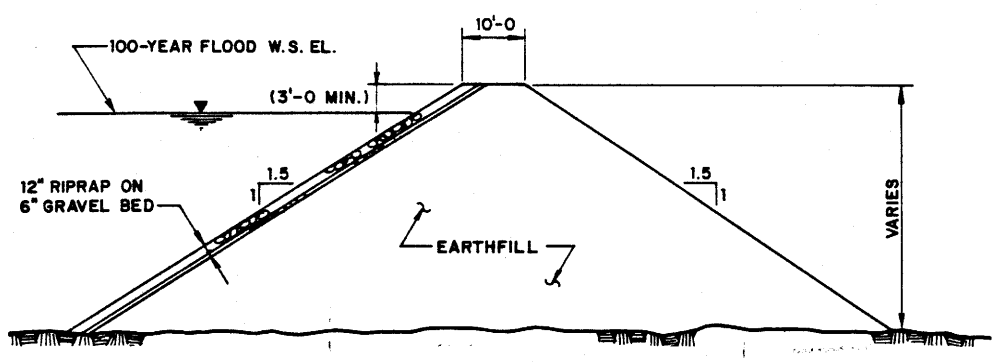
PROFILE OUTLET WORKS
50 0 50 100
SCALE FEET

NOTES:

1. COARSE MATERIALS SHALL BE PLACED TOWARDS UPSTREAM AND DOWNSTREAM SLOPES.
2. FINAL FOUNDATION SURFACE SHALL BE SCARIFIED AND RECOMPACTED.
3. THE LENGTH OF DISCHARGE PIPE AND ACCESS BRIDGE FOR THE OUTLET WORKS VARY WITH THE DAM CREST ELEVATION.



TYPICAL SECTION
RUNOFF COLLECTION CHANNEL
NOT TO SCALE



TYPICAL SECTION — INTERCEPTING DIKE
NOT TO SCALE

PRELIMINARY-NOT FOR CONSTRUCTION

PHASE II PROJECT REPORT
DRY FORK DAM
& HYDRAULIC STRUCTURES
CONCEPTUAL SECTIONS

DRAWN BY:	CCR	APPROVED BY:	PMG
DESIGN BY:	MPF/RPP	DATE:	16 SEPT. 1985
CHECKED BY:	JDL	DWG. NO.:	FIGURE 4.3-3

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KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.3-3
REV. PLANT

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

	BY	DATE		BY	DATE
APPROVED BY			DESIGN		
APPROVED BY			DRAWN		
APPROVED BY			CKD.		
APPROVED BY			CKD.		
APPROVED BY					

c. Chimney Filter - The chimney filter was designed with a 10 foot width (an equipment width) and is located immediately downstream of Zone 1. Chimney filter material consists of clean processed sand, which is imported from commercial sources. The nearest commercial sources are about 16 to 19 miles from the site. The filter intercepts seepage through Zone 1 and prevents piping of Zone 1 material into the chimney drain. The chimney filter also extends into the core trench as shown in Figure 4.3-3 to prevent internal erosion or piping of Zone 1 into the foundation soils.

d. Chimney and Blanket Drains - The 10-foot wide chimney drain is located immediately downstream of the chimney filter. The chimney drain is incorporated into the design because Dry Fork Dam will be relatively high, between 200 and 300 feet, and the drain will be needed to convey seepage to the blanket drain. The blanket drain is 2 feet thick on the abutments and 5 feet thick on the valley bottom. This drain layer will serve to conduct seepage from the chimney filter and foundation to the downstream toe of the dam. Chimney and blanket drain material consists of clean sandy gravel, which is imported from the same commercial sources as the chimney filter material.

e. Riprap - Protection against erosion from wave action is provided by a 2-foot thick layer of dumped riprap. Riprap is well-graded (from gravel to boulder sizes) and is selectively obtained from the Zone 2 borrow area or is quarried rock.

3. Foundation Preparation and Seepage Control - The results of the geotechnical exploration indicate that 30 to 40 feet of soils in the valley bottom will need to be removed because they do not have adequate strength to support a dam 200 to 300 feet high. Additional exploration will be needed to confirm the depth of excavation beneath the dam. Also, an abandoned water tunnel in the soils in the valley bottom will have to be completely excavated from the dam foundation area (Ref. 2).

As stated in the Phase II Geotechnical Report (Ref. 2), some of the loose to medium dense sandy soils in the foundation may be subject to liquefaction during earthquakes. The extent of potentially liquefiable soils would need to be verified by additional studies during final design.

Soils and highly weathered rock materials will need to be excavated beneath Zone 1. The results of the exploration indicate that the depth of excavation beneath Zone 1 could be about 80 feet. The rock is closely jointed and should be sealed to prevent potential piping of Zone 1 into these rock joints. After cleaning the rock surface, shotcrete will be applied to the entire Zone 1 contact with the rock surface.

Ground water is anticipated in the excavation beneath Zone 1 and for the downstream portion of Zone 2. Ground water was encountered at about elevation 6,162 feet in August 1985. This level is expected to vary with the pond level downstream of the damsite and with seasonal rainfall. Control of ground water during excavation and subsequent fill placement will be necessary. Ground water control measures include lowering the pond level and pumping from well points.

Results of water pressure tests conducted in the proposed dam foundation and abutments indicate moderate fracture permeability of about 10^{-4} cm/sec (Ref. 2). In order to effectively minimize seepage through the dam foundation and abutments, a thorough and carefully controlled grouting program will be necessary. A single-line grout curtain should follow the center of the core contact. The depth, spacing, and orientation of the grout holes will be determined during final design. However, for the purpose of cost estimation, the hole depths were assumed to vary from 50 to 150 feet; the deeper holes are located in the valley bottom. Primary holes are spaced on 20-foot centers; secondary and tertiary holes are located by split-spacing methods.

4.4 DAMS AND RESERVOIRS

A. Introduction

Conceptual design studies and comparison evaluations were performed for the following contaminated water impoundment locations:

- New Reservoir Site in Bingham Canyon
- Existing Reservoir Site in Bingham Canyon
- New Impoundment Site South of Bingham Creek

The results of the study discussed in the following sections were developed only for the purpose of cost estimation for use in the "trade-off" studies. No seepage and stability analyses were performed. Therefore, all conclusions and designs presented herein are at a conceptual level. Engineering analyses and final design will be the subject of a subsequent phase of work.

B. New Reservoir Site in Bingham Canyon

1. General - The purpose of a new dam and reservoir in Bingham Canyon is to store leach water from the Precipitation Plant. Quantities and costs were developed for the following cases:

Dam Crest Elevation (feet)	Normal Max. Res. W.S. El. (feet)	Approximate Reservoir Capacity (acre-feet)
5,310	5,306*	14,200
5,295	5,285	10,400
5,275	5,265	7,200
5,250	5,240	4,200
5,240	5,230	3,300
5,225	5,215	2,000

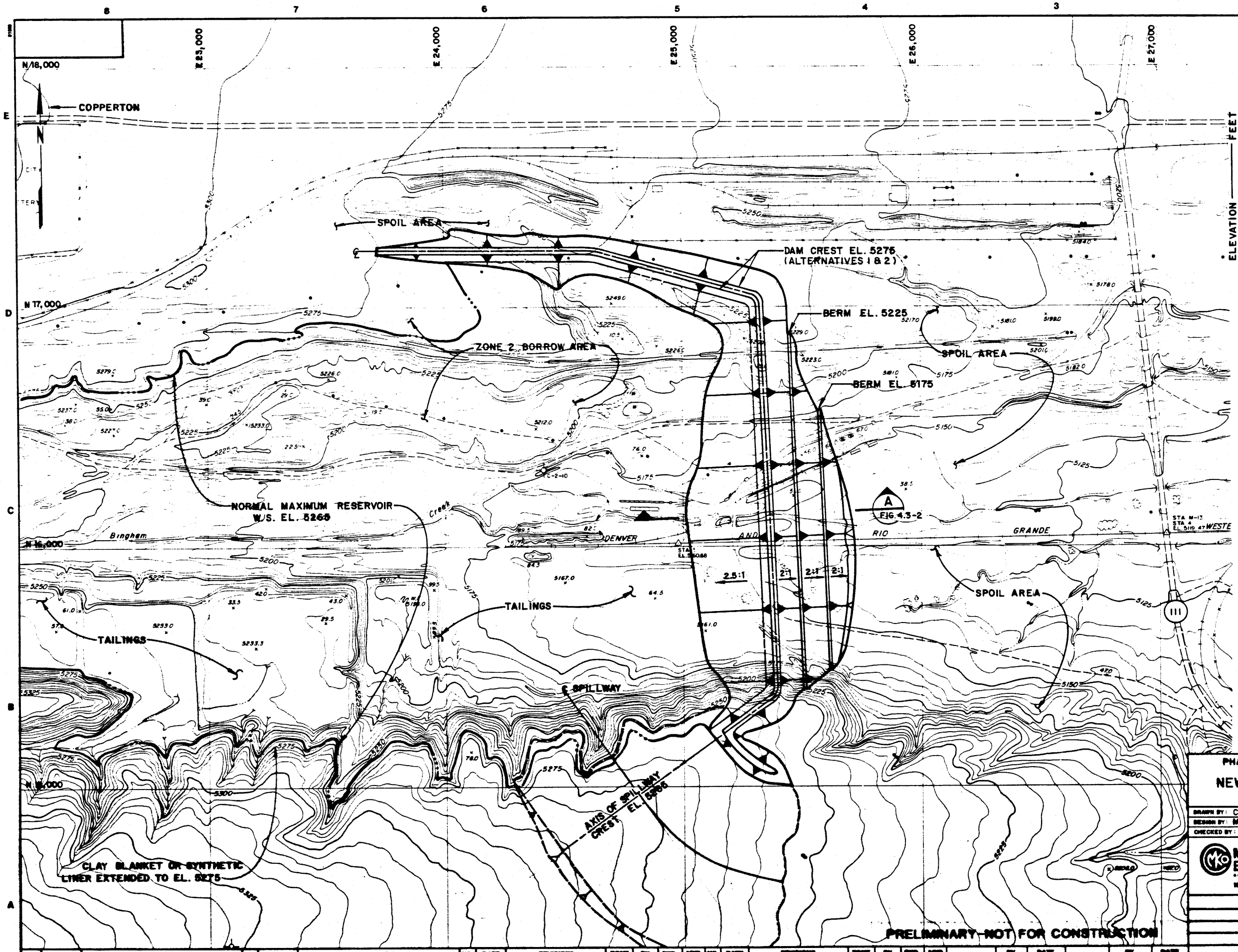
*W.S. El. for storage of PMF.

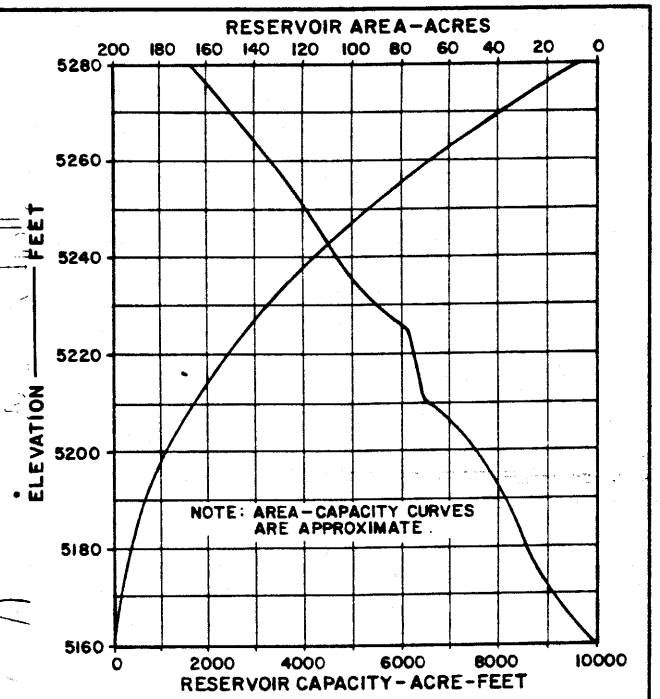
The plan and typical conceptual sections for the case with dam crest at elevation 5,275 feet are shown on Figures 4.4-1 and 4.4-2, respectively. Cross-sections for other crest levels are similar to those shown in Figure 4.4-2. The dam with crest at elevation 5,310 feet was established to store the Probable Maximum Flood (PMF) runoff without spilling; spillways are provided for the lower crest elevations.

The reservoir capacities shown above are based on the assumption that the upstream existing reservoir will not be used to provide additional storage for the new reservoir. It does not appear that it would be economical to use the existing reservoir area for additional storage for the new reservoir downstream. This is due to the cost of lining the existing reservoir and because only a small storage volume (less than 1,200 to 1,600 acre-feet) is available below elevation 5,306 feet (the maximum reservoir elevation for the largest new dam alternative). After sediments are removed from the existing reservoir (Section 4.4-C), the existing reservoir area can be used as a site for disposal of spoil materials resulting from construction of the new dam.

Two alternative designs have been prepared for this new dam and reservoir. Alternative 1 is a zoned earthfill dam with a clay-blanketed reservoir; Alternative 2 is a homogeneous earthfill dam with a synthetic membrane-lined reservoir. For the conceptual design studies, the upstream and downstream slopes were selected to be 2.5(H):1(V) and 2(H):1(V), respectively. Total embankment volumes and heights for the cases studied are as follows:

Dam Crest Elevation (feet)	Total In-Place Volume (cubic yards)	Max. Height Above Foundation (feet)
5,310	4,664,000	175
5,295	3,358,000	160
5,275	2,144,000	140
5,250	1,191,000	115
5,240	943,000	105
5,225	646,000	90





RESERVOIR AREA-CAPACITY CURVES

REFERENCE DRAWINGS:

1. TOPOGRAPHY COMPILED FROM PHOTOGRAPHY DATED JULY 23, 1968 AND MAY 2, 1969 BY OLYMPUS AERIAL SURVEY INCORPORATED—SALT LAKE CITY, UTAH.

200 0 200 400
SCALE FEET

PHASE II PROJECT REPORT

NEW BINGHAM CANYON DAMSITE PLAN

DRAWN BY: CCR	APPROVED BY: PMG
DESIGN BY: MPF/RPP	DATE: 16 SEPT. 1985
CHECKED BY: JDL	DWG. NO.: FIGURE 4.4-1

MORRISON-KNUDSEN ENGINEERS
A MORRISON-KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

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BY:
DESCRIPTION JOB NO.
SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.4-1 REV. PLANT

REFERENCE	DWG. NO.	DESCRIPTION	REFERENCE	DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CHD.	APD	NO.	DATE	REVISIONS	ZONE	BY	CHD.	APD

	BY	DATE		BY	DATE
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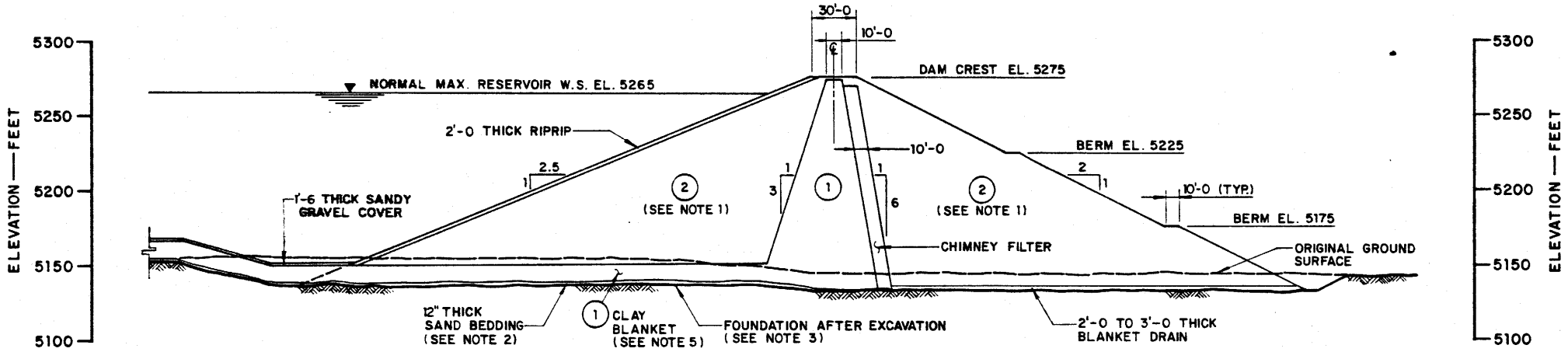
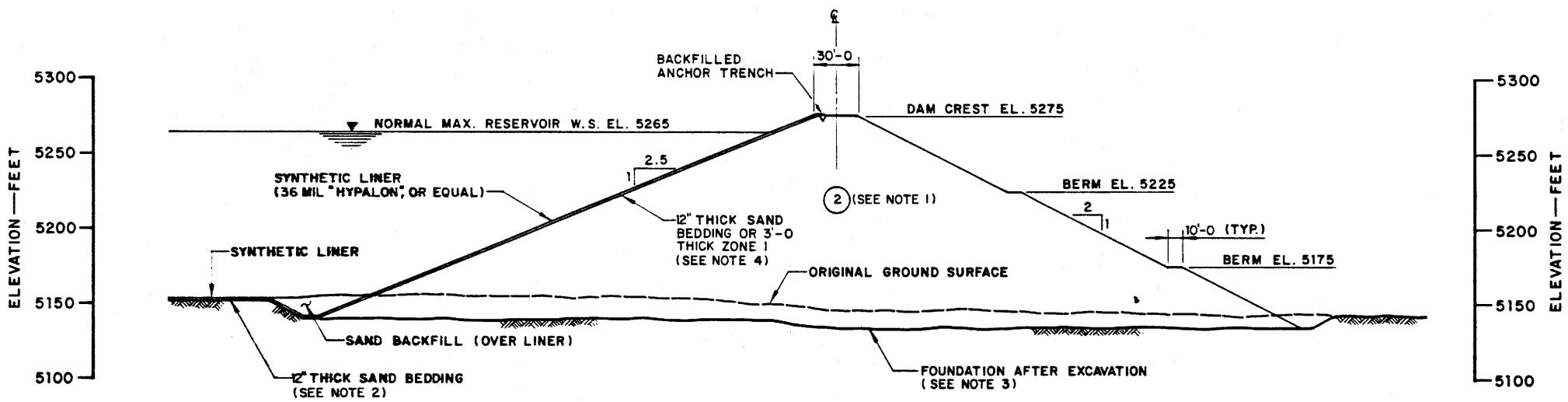


ALTERNATIVE 1
SECTION A
FIG.4.3-1



ALTERNATIVE 2
SECTION A
FIG.4.3-1

NOTES:

1. COARSE MATERIALS SHALL BE PLACED TOWARDS UPSTREAM AND DOWNSTREAM SLOPES FOR ALTERNATIVE 1 AND TOWARDS DOWNSTREAM SLOPE FOR ALTERNATIVE 2.
2. SAND BEDDING SHALL BE PLACED OVER GRAVEL AND COBBLE FOUNDATION SOILS.
3. FINAL FOUNDATION SURFACE SHALL BE SCARIFIED AND RECOMPACTED.
4. LINER BEDDING MATERIAL TYPE ON DAM TO BE DETERMINED IN A SUBSEQUENT DESIGN PHASE.
5. SEE REPORT TEXT FOR CLAY BLANKET THICKNESS.

SUMMARY OF MATERIALS

ZONE	MATERIAL DESCRIPTION	SOURCE
1	SILTY CLAY	CLAY BORROW AREA
2	SAND, GRAVEL & COBBLES	RESERVOIR SIDES & SPILLWAY EXCAVATION
CHIMNEY FILTER	PROCESSED SAND	IMPORT
BLANKET DRAIN	PROCESSED SANDY GRAVEL	IMPORT
RIPRAP	GRAVEL TO BOULDERS	RESERVOIR SIDES & SPILLWAY EXCAVATION
SAND BEDDING	PROCESSED SAND	RESERVOIR SIDES & SPILLWAY EXCAVATION
1 CLAY BLANKET	SILTY CLAY-CLAYEY SILT	CLAY BORROW AREA & RESERVOIR BOTTOM

50 0 50 100
SCALE FEET

PRELIMINARY-NOT FOR CONSTRUCTION

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

	BY	DATE		BY	DATE
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PHASE II PROJECT REPORT
NEW BINGHAM CANYON DAM
CONCEPTUAL SECTIONS

DRAWN BY: CCR	APPROVED BY: PMG
DESIGN BY: MPF	DATE: 16 SEPT. 1985
CHECKED BY: JDL	DWG. NO.: FIGURE 4.4-2

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UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.4-2
REV. PLANT

2. Embankment Design - Alternative 1 - The embankment design for this alternative is discussed in the following paragraphs.

a. Zone 1 - The central core of the dam (Zone 1) is the impervious zone. Zone 1 material will consist of silty clay from the clay borrow area, which will involve a haul distance of about 1 to 3 miles. The core will be connected to the clay blanket as shown in Figure 4.4-2.

b. Zone 2 - The shells (Zone 2) will consist of sand, gravel, and cobbles excavated from the spillway and reservoir sides. Cobbles and boulders will be placed toward the downstream face for erosion protection and toward the upstream face to act as a transition beneath the riprap layer. The finer Zone 2 materials will be placed toward the upstream side of Zone 1 and toward the chimney filter to provide transitions.

c. Chimney Filter - The chimney filter will be 10 feet wide (an equipment width) and is located immediately downstream of Zone 1. The filter material will consist of clean sand imported from commerical sources located 8 to 11 miles from the damsite. The purposes of the chimney filter are (1) to intercept seepage emerging through the Zone 1 core and to conduct the seepage to the blanket drain, and (2) to prevent internal erosion (piping) of Zone 1 material into Zone 2.

d. Blanket Drain - The blanket drain will be 2 to 3 feet thick and will conduct seepage to the downstream toe of the dam. Blanket drain material will consist of clean sandy gravel, which will be imported from the same commercial sources as the chimney filter material.

e. Riprap - Protection against erosion from wave action will be provided by a 2-foot thick layer of dumped riprap. Riprap material will be well-graded from gravel to boulder sizes and, for estimating purposes, will be assumed to be selectively obtained from the Zone 2 borrow areas.

3. Embankment Design - Alternative 2 - The embankment design for this alternative is discussed in the following paragraphs.

a. Zone 2 - The entire embankment will be constructed of Zone 2 sand, gravel, and cobbles, which will be excavated from the spillway and reservoir sides. Cobbles and boulders will be placed toward the downstream face for erosion protection; they will be routed away from the upstream face, where a sand bedding will be placed.

b. Liner Bedding - A 1-foot thick compacted bedding layer consisting of processed sand will be placed on the upstream face of the dam to reduce the potential of puncturing the liner with gravels or cobbles in the embankment. The bedding material will be processed from Zone 2 borrow materials; silt and clay fines will not be removed. Alternatively, a 3-foot thick layer of Zone 1 silty clay may be used as a liner bedding. The silty clay would also act as a secondary impervious element should a tear or puncture develop in the liner material. The specific liner bedding material on the embankment will be determined in a subsequent design phase.

4. Reservoir Seepage Control - The geotechnical exploration results (Ref. 2) indicate that 15 to 18 feet of clayey sandy silt and silty clay underlie the reservoir area. However, the sides of the reservoir consist of permeable sands, gravels and cobbles. The silty and clayey layer will not be relied upon as an impervious blanket because its continuity, thickness and permeability cannot be reliably defined over the reservoir area. Therefore, reservoir seepage will have to be controlled by covering the entire reservoir area with a clay blanket (Alternative 1) or synthetic liner material (Alternative 2).

a. Clay Blanket System (Alternative 1) - The clay blanket, which connects with the central Zone 1 core, will cover the entire reservoir area and will extend up the reservoir banks to the level of the dam crest. For conceptual design and cost estimating, the blanket thickness will be 10% of the reservoir depth, but will not be less than 3 feet. In order to reduce the potential for erosion, shrinkage, and

cracking of the blanket, a 1.5-foot thick layer of sandy gravel will be placed on the clay blanket.

Some shaping of the reservoir banks will be required in order to construct the blanket. The reservoir area will be stripped of loose materials, organic matter, and debris; the final surface will be scarified and compacted. Where the blanket will overlie clean sand and gravel deposits, a 1-foot thick processed sand layer will be placed to act as a filter bed to prevent piping of the clay blanket material.

Material for the sandy gravel cover and the processed sand filter bed will be obtained from Zone 2 borrow areas. The sand will be obtained by screening out gravel materials; the coarser-sized materials will be used in Zone 2 embankment fill. The blanket material will be obtained from clayey sandy silt and silty clay from the reservoir area and, if needed, from the clay borrow area located in the wheat fields to the south of the reservoir site. Results of laboratory tests indicate that the permeability of compacted clayey soils from both areas are comparable (i.e., about 10^{-6} cm/sec) (Ref. 2).

b. Synthetic Liner System (Alternative 2) - A synthetic liner will cover the entire reservoir area and will extend up the reservoir banks and upstream face of the dam to the level of the dam crest. For preliminary cost estimation purposes, 36 mil "Hypalon" was selected for lining the entire reservoir. "Hypalon" is a chlorosulfonated polyethylene synthetic rubber reinforced with polyester yarn.

Shaping of the reservoir banks will be necessary in order to place the liner. The reservoir area will be stripped of loose materials, organic matter, and debris; the final surface will be scarified, compacted, and rolled smooth. A 1-foot thick sand bedding will be placed over areas of coarse deposits to prevent puncturing the liner. The bedding material will be processed from Zone 2 borrow materials as described for Alternative 1 above. Sand-backfilled trenches radiating outward from the center of the reservoir area will serve the purpose of gas venting.

The upper edges of the liner will be held in place by backfilled anchor trenches. On the upstream slope of the dam and reservoir banks, intermediate anchor trenches will be installed in berms. All material seams will be oriented downslope; seams parallel to slopes should not be used. To keep the liner from billowing in the wind, 4-inch diameter tubes of the synthetic liner material filled with sand will extend down the slopes of the dam and reservoir banks and across the reservoir bottom. The spacing of the tubes would be about 40 to 60 feet. Gas vents will be installed at the top of the liner, around the perimeter of the reservoir, half-way between the sand-filled tubes.

5. Foundation Excavation and Preparation - The geotechnical exploration results (Ref. 2) indicate that a 10- to 15-foot thick layer of medium stiff clayey silt to silty clay covers a portion of the damsite in the valley bottom. This material, along with any loose or soft zones, will be excavated and the resulting foundation surface will be scarified and recompacted. Ground water is not anticipated in the foundation excavation.

Approximately 1-million cubic yards of tailings along the south side of the reservoir area will be excavated and hauled to spoil sites shown in Figure 4.4-1. Alternatively, the tailings could be disposed of in the abandoned existing reservoir as discussed previously. The tailings deposit consists of silty fine sand to fine sandy silt and is as high as 50 feet. Tailings are not considered to be a suitable material under the clay blanket or synthetic liner material because they probably contain metallic sulfides and oxidized metallic sulfides which could be leached out by any reservoir seepage.

C. Existing Reservoir Site in Bingham Canyon

1. General - The purpose of the existing dam is to store leach water from the Precipitation Plant. Two alternative designs have been developed for raising the existing dam. Alternative 1 is a zoned earthfill enlarged embankment with a clay-blanketed reservoir; Alternative 2 is basically a homogeneous enlargement with a synthetic

membrane-lined reservoir. The plan and typical conceptual sections for the case with the raised crest at elevation 5,350 feet are shown on Figures 4.4-3 and 4.4-4, respectively. Cross-sections for the lower crest levels are similar to the maximum section.

Quantities and costs were developed for the following cases:

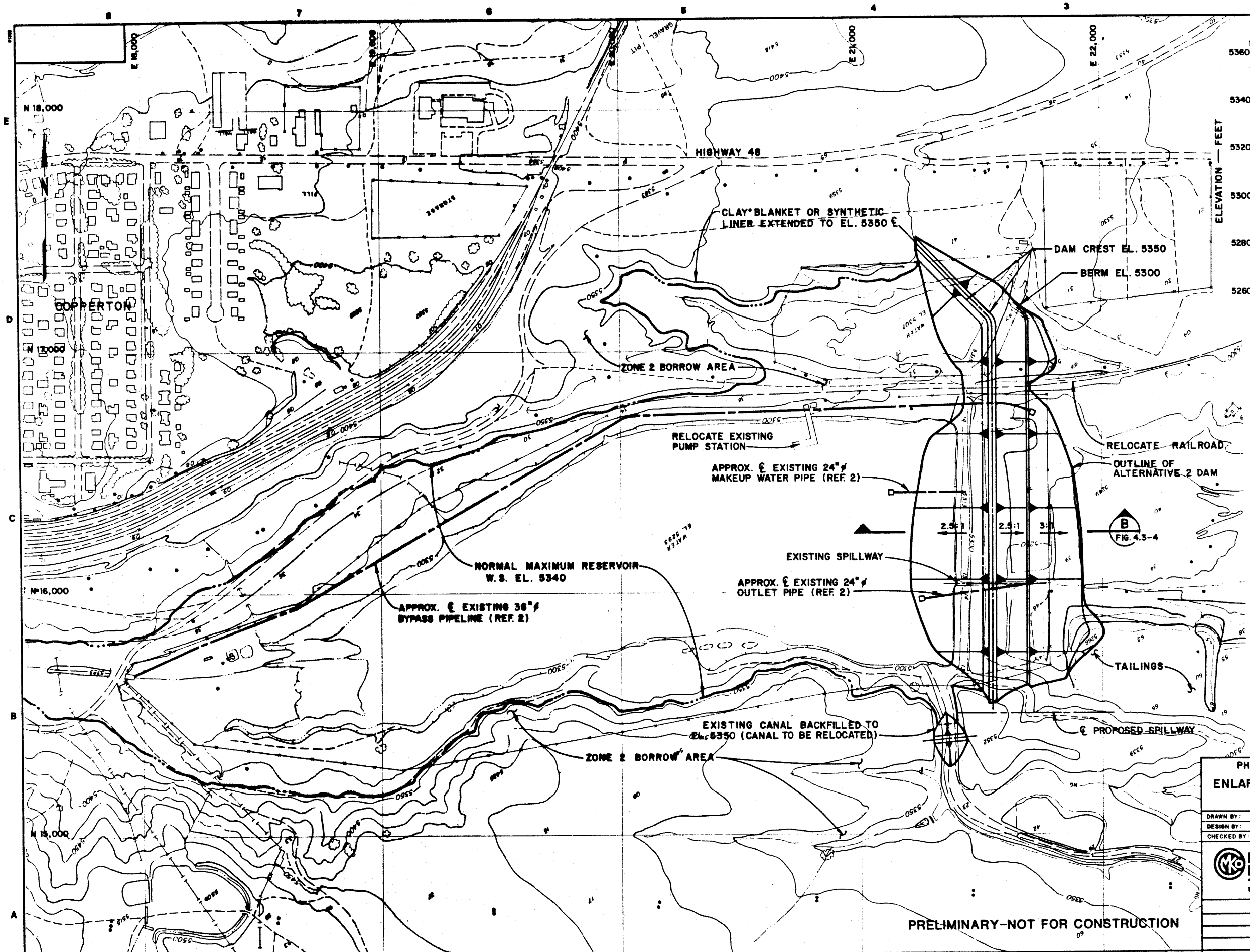
Dam Crest Elevation (feet)	Normal Max. Res. W.S. El. (feet)	Approximate Reservoir Capacity (acre-feet)	
		Alternative 1	Alternative 2
5,350	5,340	3,600	4,400
5,335	5,325	2,400	3,000
5,325	5,315	1,700	2,200
5,314 (existing)	5,304	1,100	1,500

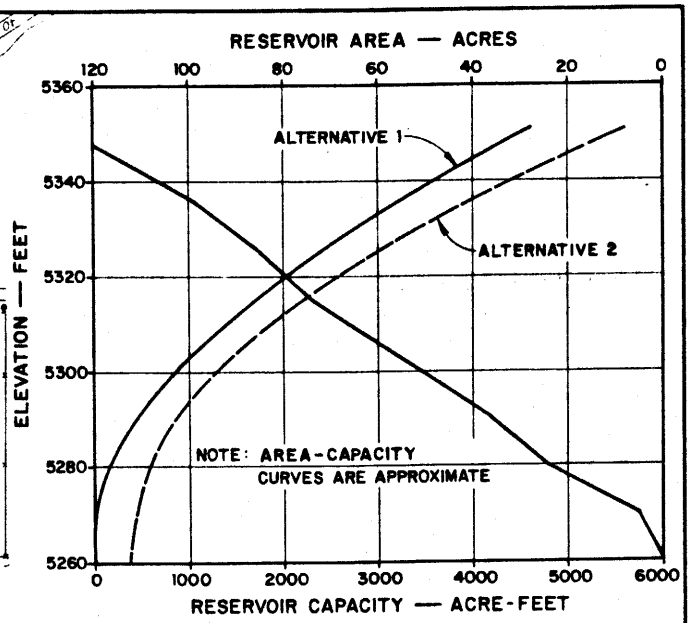
The layouts of the dams with crest levels at elevations of 5,335 and 5,350 feet enclose the existing 20-million-gallon reservoir to the north. The layout of the dam with a crest elevation of 5,325 feet does not enclose the 20-million-gallon reservoir. For this case, the alignment would swing to the west just south of the existing railroad track.

The existing dam has upstream and downstream slopes of 2(H):1(V) above elevation 5,285 feet, and 3(H):1(V) below elevation 5,285 feet. These slopes were used as a basis to select slopes for the raised embankment.

The upstream slope of the raised Alternative 1 dam was selected to be 3(H):1(V). As shown on Figure 4.4-4, the downstream slope is 2.5(H):1(V) above the berm, and 3(H):1(V) below the berm; for the case with the crest at elevation 5,325 feet, the slope is also 2.5(H):1(V) below the berm. For Alternative 2, the upstream slope is 2.5(H):1(V); downstream slopes are the same as for Alternative 1. Upstream buttress zones have slopes of 6(H):1(V) for both alternatives.

Total embankment volumes and heights of the four cases are as follows:





RESERVOIR AREA-CAPACITY CURVES

REFERENCE DRAWINGS:

1. TOPOGRAPHY COMPILED FROM PHOTOGRAPHY DATED OCTOBER 4, 1984 BY OLYMPUS AERIAL SURVEY INCORPORATED - SALT LAKE CITY, UTAH.
2. APPROXIMATE LOCATIONS OF EXISTING APPURTENANT STRUCTURES ARE BASED ON DRAWINGS UP-2001-G, UP-2002-G AND UP-2001-P, IN "FINAL CONSTRUCTION REPORT, BINGHAM CREEK RESERVOIR AND APPURTENANT FACILITIES, COPPERTON, UTAH," BY KETCHUM, KONKEL, RYAN AND FLEMING, AND WOODWARD-CLYDE-SHERARD AND ASSOCIATES, FEBRUARY 1966.

200 0 200 400
SCALE FEET

PHASE II PROJECT REPORT

ENLARGED EXISTING DAMSITE PLAN

DRAWN BY: CCR	APPROVED BY: PMG
DESIGN BY: MPF	DATE: 16 SEPT. 1985
CHECKED BY: JDL	DWG. NO.: FIGURE 4.4-3

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BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.4-3

REV. △ PLANT

REFERENCE	DWG. NO.	DESCRIPTION

REFERENCE	DWG. NO.	DESCRIPTION

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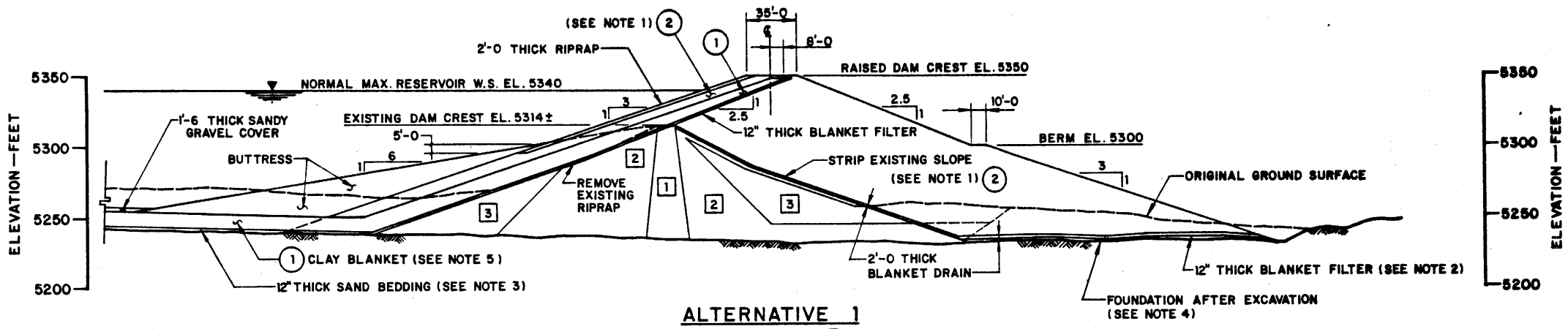
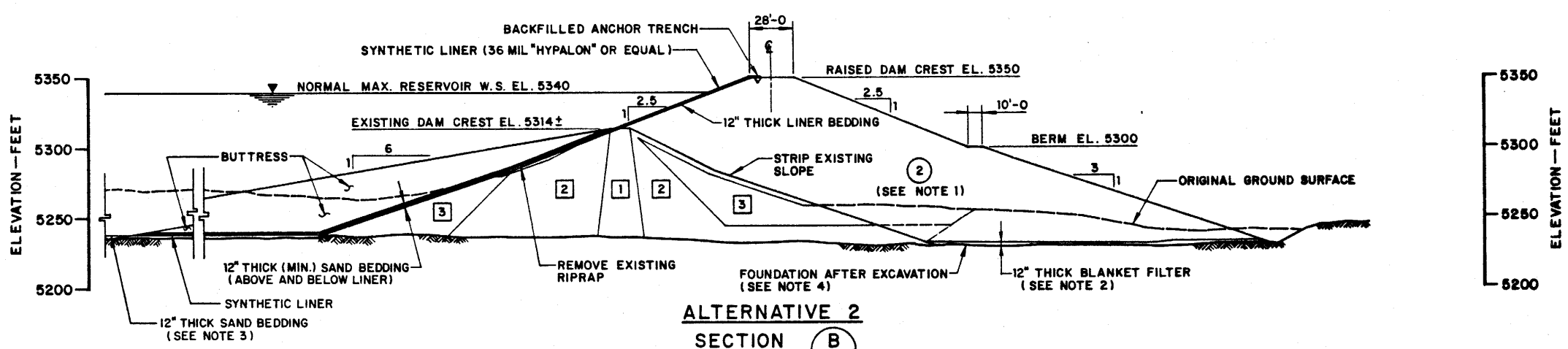


ALTERNATIVE 1
SECTION B
FIG. 4.3-3



ALTERNATIVE 2
SECTION B
FIG. 4.3-3

NOTES:

1. COARSE MATERIALS SHALL BE PLACED TOWARDS UPSTREAM AND DOWNSTREAM SLOPES FOR ALTERNATIVE 1 AND TOWARDS DOWNSTREAM SLOPE FOR ALTERNATIVE 2.
2. BLANKET FILTER SHALL BE PLACED OVER SILTY OR CLAYEY FOUNDATION SOILS.
3. SAND BEDDING SHALL BE PLACED OVER GRAVEL AND COBBLE FOUNDATION SOILS.
4. FINAL FOUNDATION SURFACE SHALL BE SCARIFIED AND RECOMPACTED.
5. SEE REPORT TEXT FOR CLAY BLANKET THICKNESS.

SUMMARY OF MATERIALS

EXISTING DAM ZONE	MATERIAL DESCRIPTION	SOURCE
1	CLAYEY SOIL	LOCAL BORROW
2	SAND AND GRAVEL	LOCAL BORROW
3	WASTE	REQUIRED EXCAVATION
RAISED DAM ZONE	**MATERIAL DESCRIPTION**	**SOURCE**
1	SILTY CLAY	CLAY BORROW AREA
2	SAND, GRAVEL & COBBLES	RESERVOIR SIDES
BLANKET FILTER	PROCESSED SAND	IMPORT
BLANKET DRAIN	PROCESSED SANDY GRAVEL	IMPORT
RIPRAP	GRAVEL TO BOULDERS	RESERVOIR SIDES
SAND BEDDING	PROCESSED SAND	RESERVOIR SIDES
BUTTRESS	RANDOM FILL	REQUIRED EXCAVATION AND RESERVOIR SIDES

50 0 50 100
SCALE FEET

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PHASE II PROJECT REPORT
ENLARGED EXISTING DAM
CONCEPTUAL SECTIONS

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DESIGN BY: MPF	DATE: 16 SEPT. 1985
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DRAWING NO. FIGURE 4.4-4
REV. PLANT

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

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Dam Crest Elevation (feet)	Total In-Place Volume (cubic yards)		Max. Height Above Foundation (feet)
	Alternative 1	Alternative 2	
5350	1,375,000	1,419,000	135
5335	824,000	912,000	120
5325	478,000	575,000	105
5314 (existing)	230,000	262,000	85

2. Existing Reservoir

a. Dam - The existing dam on Bingham Creek was completed in October 1965 (Ref. 3). The dam crest is at approximately elevation 5,314 feet, and the embankment basically consists of three zones as shown in Figure 4.4-4. The Zone 1 core consists of "clayey soils" from a borrow area north of Highway 48; Zone 2 consists of "semi-pervious sand-gravels" (silty or clayey sand and gravel) excavated from the south reservoir bank; and Zone 3, a "waste" zone, consists of material from required excavation (Ref. 3). The 1963 Feasibility Report called for compaction of all three zones to 100% density as determined by test method ASTM D-698-58T (Ref. 4). However, the Final Construction Report (February 1966) indicates compaction control was in accordance with ASTM D-1557 (Ref. 3). Additional information indicates that the embankment fill compaction was specified at 90%, and the core material compaction was specified at 95%, of the maximum dry density as determined by ASTM D-1557, Method A (Ref. 6). The upstream slope is protected from wave action by a 2-foot thick layer of dumped riprap extending from the dam crest to elevation 5,280 feet.

The as-built drawings in the 1966 Final Construction Report indicate that blankets constructed of Zone 2 ("semi-pervious sand-gravels") or recompacted natural soils were extended along both reservoir banks 500 feet upstream of the dam axis. The minimum thickness shown on the drawings is 4 feet. Reported laboratory permeability test results for Zone 2 materials show a permeability value of 108 feet per year (10^{-4} cm/sec) (Ref. 3).

b. Appurtenant Structures - Appurtenant structures consist of two pipelines, an outlet conduit, spillway, and pump station (Figure 4.4-3). A 36-inch diameter concrete bypass pipeline is located on the north bank of the reservoir. A 24-inch diameter stainless steel makeup water pipe is located 3.5 feet below the upstream face of the dam. This pipe extends between a stilling box 318 feet upstream of the dam axis to an air relief and vacuum valve on the dam crest, which is located about 400 feet south of the north abutment. This pipe is connected to the existing pipeline to the Jordan River as shown in Figure 4.4-3. The outlet conduit consists of a 24-inch diameter epoxy-lined pipe, which discharges into the spillway stilling basin. The intake box, which is equipped with a stainless steel trashrack, is located at the upstream toe of the dam. A 1985 hydrographic survey of the reservoir bottom indicates that the intake, which is at approximately elevation 5,245 feet, is probably buried under about 17 feet of reservoir sediment now. An operator for a slide gate (in the intake) is located on the dam crest just south of the spillway. A concrete chute spillway is located on the embankment as shown in plan on Figure 4.4-3. The spillway crest at elevation 5,305 feet (approx.) is located on the dam and is 20 feet wide. After a transition section, the spillway chute is 10 feet wide and 4.5 feet deep. The chute terminates in a stilling basin at the downstream toe of the dam. A pump station is located about 660 feet upstream of the dam axis on the north bank of the reservoir.

c. Reservoir - The existing reservoir has an approximate capacity of 1,150 acre-feet below the spillway crest. This estimate is based on an April 1985 hydrographic survey of the reservoir bottom (scale: 1 inch = 50 feet). The records indicate that the reservoir capacity at the completion of construction in 1965 was about 1,560 acre-feet (Ref. 3). Therefore, about 410 acre-feet have been lost due to the accumulation of sediment and precipitation of iron oxides on the reservoir bottom during the last twenty years. Comparison of the 1985 survey with the original pre-reservoir topography indicates that sediment has accumulated to depths ranging from zero at the upstream end of the reservoir to about 22 feet in the old Bingham Creek channel

near the dam. The average accumulation of sediment is estimated at roughly 8 to 8.5 feet.

Results of borings and test pit excavations by others indicate that tailings underlie the sediments and are locally thicker than 10 feet (Ref. 4). The tailings reportedly consist of silty sand with lenses of clayey silt. A silty clay layer ranging in thickness from 4 to 18 feet underlies the tailings. Geotechnical information (Ref. 5) indicates that the silty clay layer does not extend beneath the reservoir banks. The original Bingham Creek channel has cut into this layer and it is not known whether the channel has cut completely through the silty clay into the underlying sand and gravel deposit. Available data indicates that the reservoir side slopes primarily consist of silty and clayey sand and gravel deposits.

Information indicates that the dam, including the Zone 1 core, is founded on the natural silty clay layer, except near the abutments, where Zone 1 is founded on relatively pervious sand and gravel (Ref. 5). Most of the seepage is probably exiting the reservoir around the dam through the sand and gravel in both abutments. Studies by others indicate that seepage quantities could vary from about 1- to 7-million gallons per day for reservoir levels varying between elevations 5,282 and 5,300 feet, respectively (Ref. 5).

3. Raised Embankment Design - Alternative 1

a. Zone 1 - The impervious zone of the dam consists of an upstream sloping core which is an extension of the reservoir blanket. Zone 1 material will consist of silty clay from the clay borrow area, which will involve a haul distance of about 1 to 3 miles.

b. Zone 2 - This zone consists of sand, gravel and cobbles excavated from the south reservoir bank and from the ridge between the existing reservoir and the 20-million-gallon reservoir to the north (Figure 4.4-3). Cobbles and boulders will be placed towards the

downstream face for erosion protection and toward the upstream face to act as a transition beneath the riprap layer.

c. Blanket Filter - A 1-foot thick blanket filter will be located downstream of the Zone 1 core. The filter material will consist of clean sand imported from commercial sources 8 to 11 miles from the damsite. The purpose of the chimney filter is to prevent internal erosion (piping) of Zone 1 material and to convey seepage to the blanket drain. A blanket filter is also located on the foundation surface where silt or clay is exposed. The purpose of this filter layer is to prevent piping of fine-grained foundation soils into the blanket drain.

d. Blanket Drain - The 2-foot thick blanket drain will be placed on the downstream face of the existing dam and over the blanket filter on the prepared foundation surface for the purpose of conducting seepage to the downstream toe of the dam. The drain material will consist of clean sandy gravel, which will be imported from the same commercial sources as the chimney filter material.

e. Riprap - Protection against erosion from wave action will be provided by a 2-foot thick layer of dumped riprap. Riprap will be well-graded from gravel to boulder sizes and selectively obtained from the Zone 2 borrow areas. The riprap will extend 5 feet below the buttress zone as shown in Figure 4.4-4.

f. Buttress - A buttress fill constructed of required excavation and Zone 2 borrow materials will be placed against the upstream face of the dam. This zone will have a slope of 6(H):1(V) and is needed for adequate upstream slope stability during reservoir drawdown. High pore pressures could develop in the upstream portion of the existing dam between the original dam core and the upstream sloping Zone 1. During drawdown, these pressures could be slow to dissipate which could cause slope failure unless a stabilizing buttress fill is provided.

4. Raised Embankment Design - Alternative 2

a. Zone 2 - Most of the embankment will be constructed of Zone 2 sand, gravel, and cobbles which will be obtained from the south reservoir bank and the ridge as described for Alternative 1 above. Cobbles and boulders will be placed toward the downstream face for erosion protection and will be routed away from the upstream face.

b. Liner Bedding - A 1-foot thick compacted bedding layer consisting of processed sand will be placed on the upstream face of the dam to minimize the possibility of puncturing the liner. The bedding material will be processed from Zone 2 borrow materials as described for the new dam in Section 4.4-B.

c. Blanket Filter - A 1-foot thick blanket filter will be placed on the foundation surface where silty or clayey soil is exposed. The purpose of the filter is to prevent piping of fine-grained foundation soils into any open-graded areas of Zone 2.

d. Buttress - As for Alternative 1 discussed above, a buttress fill composed of required excavation and Zone 2 borrow materials will be placed against the upstream face of the dam in order to provide adequate stability during reservoir drawdown.

5. Reservoir Seepage Control - Reservoir seepage will be minimized by covering the entire reservoir area with a clay blanket (Alternative 1) or 36 mil "Hypalon" synthetic liner (Alternative 2). Clay for Alternative 1 will be obtained from the clay borrow area. Both alternatives would be the same as discussed for the new damsite in Section 4.4-B above.

6. Foundation Excavation and Preparation - Available information indicates that a tailings deposit exists immediately downstream of the existing dam (Ref. 3). This information indicates that the tailings are generally loose and, therefore, will not provide a suitable foundation.

These tailings will, therefore, need to be removed prior to raising the dam. The resulting foundation surface will be scarified and recompacted.

Prior to placing any fill against the dam, the downstream face will be stripped of vegetation, debris, and loose materials. Riprap on the upstream face will be removed. All sediment and tailings remaining in the area of the upstream toe will be removed prior to placing embankment fill.

Before constructing the clay blanket or synthetic liner system, all reservoir sediment and tailings will be removed from the reservoir by dredging or other means and conveyed to containment ponds discussed below. An estimated 670,000 cubic yards of sediment and 350,000 cubic yards of tailings will have to be removed.

For cost estimating purposes, the containment ponds are assumed to be located in the 20-million-gallon reservoir and in the Zone 2 borrow area on the south reservoir bank. Construction of the pond in the borrow area will necessitate that the downstream Zone 2 embankment be placed prior to removing the sediment and tailings from the reservoir. The ponds will be lined with 30 mil polyvinyl chloride (PVC) and a 2-foot thick sandy gravel cap will be placed on the surface of the sediments and tailings.

7. Relocation of Pipelines and Existing Structures - There are several pipelines and structures that will have to be relocated if the existing dam is to be raised. The major structures to be relocated are discussed below.

a. Railroad Track and County Road - The railroad track will not need to be relocated for a dam with a crest at or below elevation 5,325 feet. For the cases with dam crests at elevations 5,335 and 5,350 feet, approximately 5,500 feet and 9,000 feet of track will have to be relocated, respectively. The track will be relocated immediately north of the Bingham City Cemetery and reconnect with the tracks to the west. In order to clear the track, the existing county road, which parallels the track, will be shifted so that it will intersect State Highway 48

approximately 1,500 feet northeast of the present intersection. This relocation of the railroad track and the county road will probably require the acquisition of about 17 acres of land between Highway 48 and the county road.

a. Powerlines and Substation - Approximately 2,000 to 10,900 feet of powerlines will have to be relocated for the raised embankments in order to clear the reservoirs. For dams with crests at elevations 5,335 and 5,350 feet, the division office substation will also need to be relocated.

b. Midas Canal - The Midas Canal will have to be reconstructed in order to feed into the raised reservoirs. For crest levels at elevations 5,325, 5,335, and 5,350 feet, approximately 1,500, 6,800, and 11,000 feet of canal will need to be reconstructed, respectively.

c. Pipelines - Pipelines that are currently operative and which will not clear the raised reservoirs will be relocated. Abandoned pipelines will not be relocated, but will be removed during construction. The pipelines to be relocated are summarized in Table 4.4-1.

d. Pump Station - The reservoir pump station will need to be relocated for all cases involving an increase in dam crest level equal to or greater than elevation 5,325 feet.

e. Access Road - Approximately 1,000 and 4,000 feet of access road to the mine waste dumps will need to be relocated for the cases with dam crests at elevations 5,335 and 5,350 feet, respectively. The relocated access road will also involve the construction of a concrete box culvert.

D. New Impoundment Site South of Bingham Creek

1. General - The purpose of an impoundment south of Bingham Creek is to store leach water from the Precipitation Plant. An impoundment

TABLE 4.4-1

PIPELINE RELOCATION REQUIREMENTS IN FEET

Description	Dam Crest Elevation (feet)		
	5,350	5,335	5,325
Mountain Fuel Supply high pressure steel gas pipeline, 8-inch diameter.	3,500	1,100	0
Transite deep well pipeline, 14-inch diameter.	4,500	0	0
H.D.P.E. pipe to booster pump station, 12-inch diameter.	2,500	1,600	500
H.D.P.E. pipe - N.O.S., 18-inch diameter.	4,600	0	0
H.D.P.E. pipe - booster pump station overflow and pit water, 12-inch diameter.	2,400	1,600	500
Transite pipe, east side collection reservoir to Precipitation Plant, 33-inch diameter.	3,000	0	0

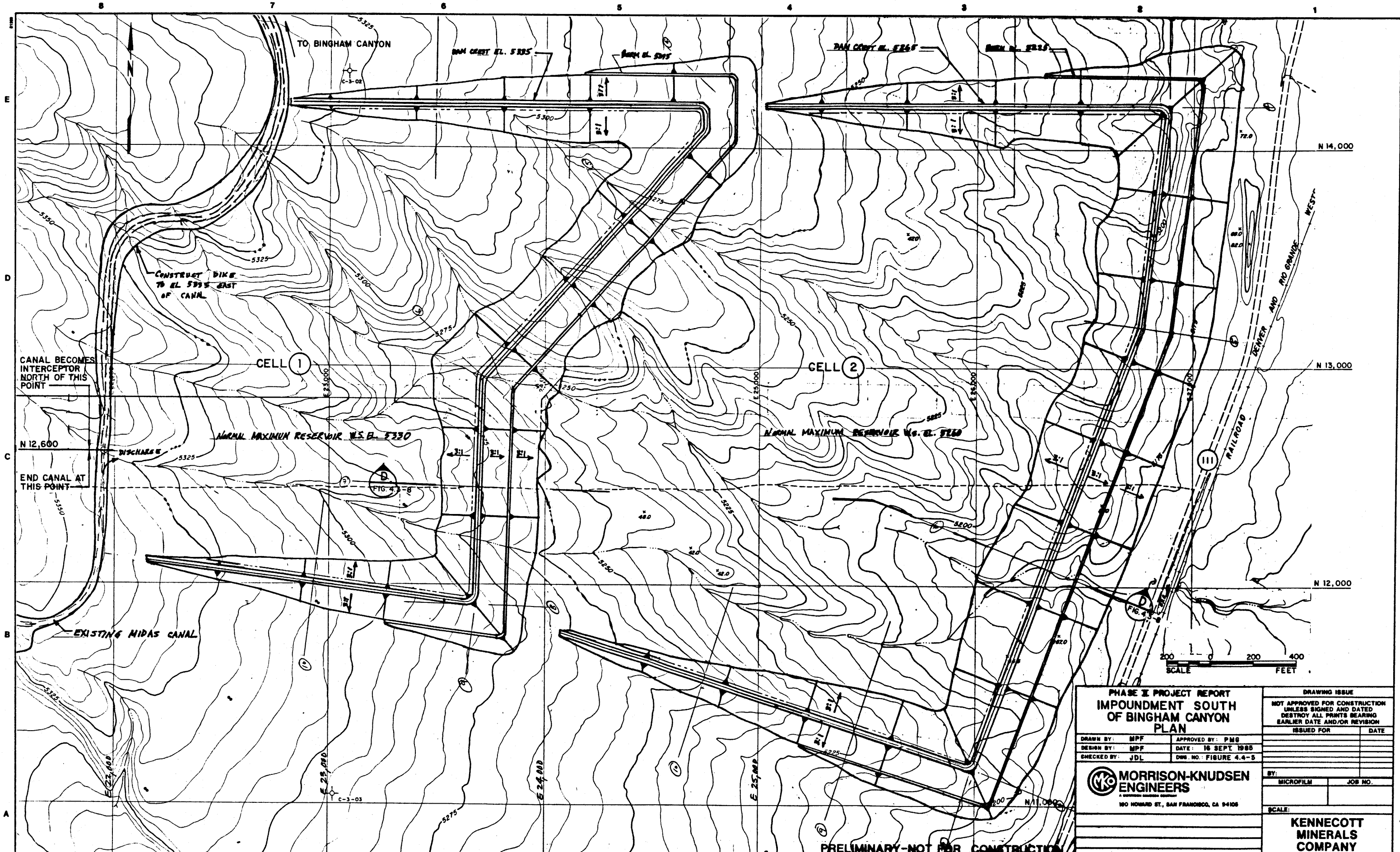
site which is located away from Bingham Creek was studied because this alternative would not have the large catchment area of the Bingham Canyon site discussed in the previous sections. Sufficient freeboard would be established to contain direct rainfall from the design flood (PMF), and a spillway will therefore not be required.

Quantities and costs were developed for two impoundment cells which have been arranged in the wheat fields south of Bingham Creek as shown in Figure 4.4-5. The cells are U-shaped, with the eastern segments oriented approximately parallel to the topographical contours. The cell designs have not been optimized in the present study, and it is possible that other combinations of dam heights and impoundment areas could yield lower costs than the cells shown in Figure 4.4-5.

2. Design of the Impoundment Cells - Characteristics of the two cells are summarized as follows:

Cell No.	Dam Crest Elevation (feet)	Normal Max Res. W.S. El. (feet)	Approx. Res. Capacity (acre-feet)	Total In-place Dam Volume (cubic yards)	Max. Height Above Foundation (feet)
1	5,335	5,330	3,400	2,408,000	85
2	5,265	5,260	6,300	3,558,000	95
Totals			9,700	5,966,000	

Upstream and downstream slopes of 3(H):1(V) were selected for the conceptual design studies as shown in Figure 4.4-6. The embankment design basically consists of a homogenous section for a synthetic membrane-lined impoundment. Construction materials for the embankment will be excavated from the impoundment area. It is estimated that the excavation depth would average about 25 feet.



PHASE II PROJECT REPORT
IMPOUNDMENT SOUTH OF BINGHAM CANYON PLAN

DRAWN BY:	MPF	APPROVED BY:	PMG
DESIGN BY:	MPF	DATE:	16 SEPT. 1985
CHECKED BY:	JDL	DWG. NO.:	FIGURE 4.4-5

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A MORRISON KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

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UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO.: FIGURE 4.4-5
REV.: △
PLANT

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D		BY	DATE		BY	DATE
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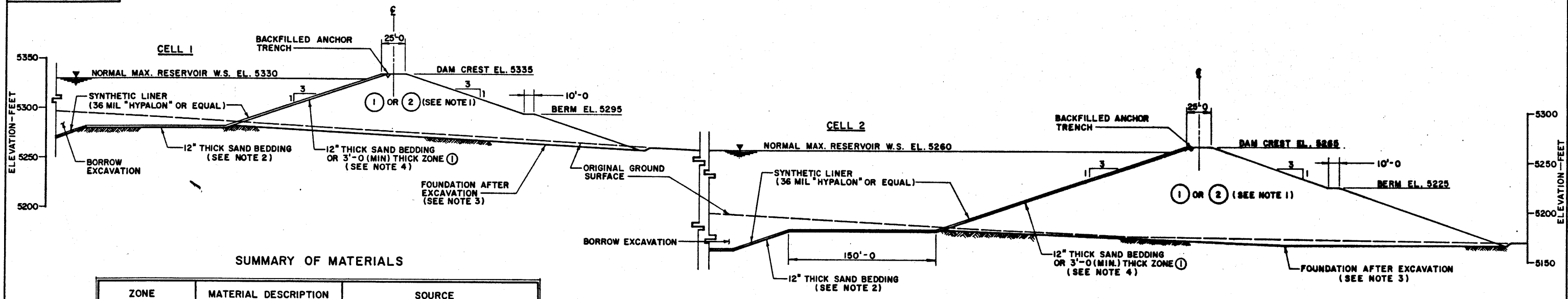


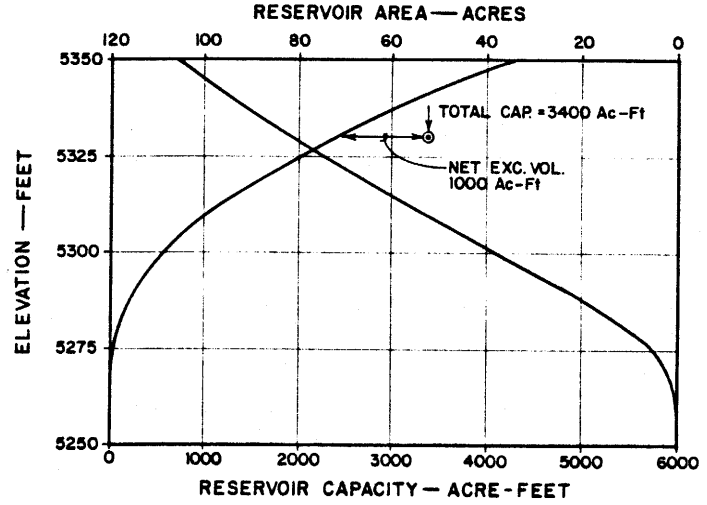
SECTION D
FIG. 4.3-7

SUMMARY OF MATERIALS

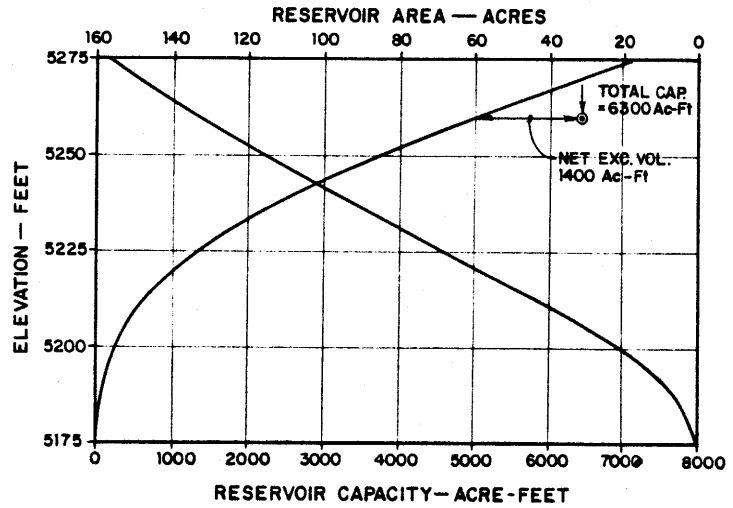
ZONE	MATERIAL DESCRIPTION	SOURCE
1	SILTY CLAY	BORROW EXCAVATION IN RESERVOIRS
2	SAND, GRAVEL & COBBLES	DO.
SAND BEDDING	PROCESSED SAND	DO.

NOTES:

1. COARSER MATERIALS SHALL BE PLACED TOWARDS THE DOWNSTREAM SLOPE.
2. SAND BEDDING SHALL BE PLACED OVER GRAVEL AND COBBLE FOUNDATION SOILS.
3. FINAL FOUNDATION SURFACE SHALL BE SCARIFIED AND RECOMPACTED.
4. LINER BEDDING MATERIAL TYPE ON DAM TO BE DETERMINED IN A SUBSEQUENT DESIGN PHASE.
5. RESERVOIR AREA-CAPACITY CURVES ARE APPROXIMATE.



CELL 1



CELL 2

RESERVOIR AREA-CAPACITY CURVES
(SEE NOTE 5)

SCALE 50 0 50 100 FEET

PRELIMINARY-NOT FOR CONSTRUCTION

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION

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APPROVED BY			DESIGN		
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APPROVED BY			CKD.		
APPROVED BY					

PHASE II PROJECT REPORT
IMPOUNDMENT SOUTH OF BINGHAM CANYON CONCEPTUAL SECTION

DRAWN BY: CCR/EC	APPROVED BY: PMG
DESIGN BY: MPF	DATE: 16 SEPT. 1985
CHECKED BY: ASC	DWG. NO.: FIGURE 4.4-6

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BINGHAM CANYON, UTAH

DRAWING NO. FIGURE 4.4-6
REV. △
PLANT

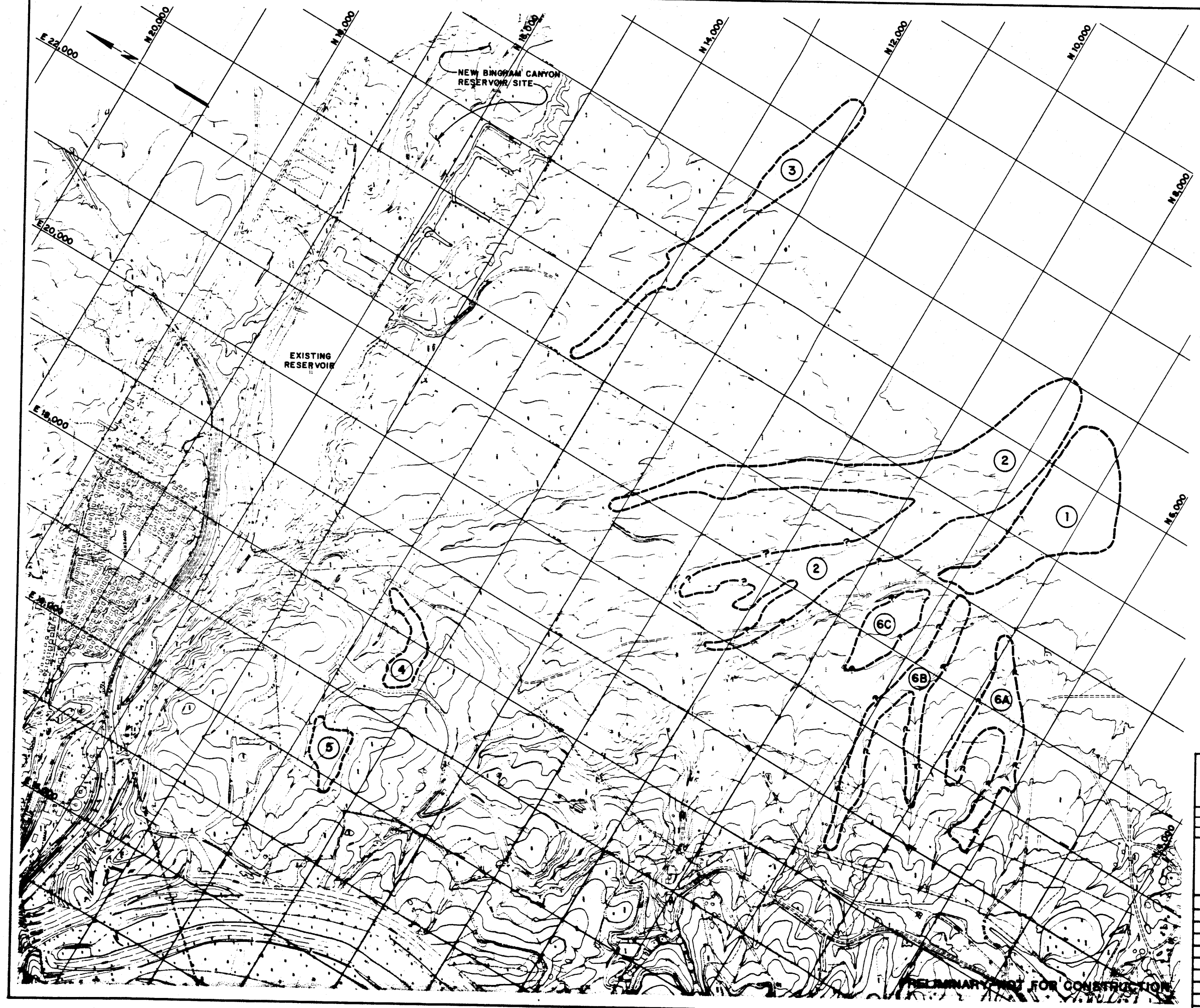
The results of test pit excavations in the proposed impoundment area (Ref. 2) indicate that the soils consist of silty clay over silty sandy gravels in the small drainages. On the ridge tops, the surface materials appear to consist of silty gravels and cobbles. The gravels, cobbles, and any boulders will be placed toward the downstream face for erosion protection; they will be routed away from the upstream face where a sand or silty clay (Zone 1) bedding will be placed to prevent puncturing of the liner. The bedding material type will be determined in a subsequent design phase.

Reservoir seepage will be minimized by covering the impoundment cell areas with a 36 mil "Hypalon" synthetic liner. The liner will extend up the embankment slopes to the dam crest level. After borrow excavations have been completed, the final impoundment surface will be graded, compacted, and rolled smooth. A 1-foot thick sand bedding will be placed over areas of coarse deposits to prevent puncturing of the liner. Bedding material will be processed from granular materials in the impoundment as discussed for the new damsite in Bingham Canyon, Section 4.4-B. Anchorage of the liner will be as discussed for the Alternative 2 reservoir in Bingham Canyon in that same section.

The existing Midas Canal will be terminated where the North 12,600 meridian crosses the canal. Water from the canal will discharge into Cell No. 1. The remainder of the canal will serve to intercept runoff and convey it to the diversion structure in Bingham Creek.

E. Availability of Construction Materials

Silty clay could be obtained from Borrow Areas 1 through 6 which are located in small drainages (Figure 4.4-7). Approximately 2-million cubic yards of clay are estimated to be available in Borrow Areas 1 through 6, A, B, and C; however, this estimate will need to be confirmed by additional exploration. These borrow areas cover a total of about 250 acres. The results of the test pit excavations indicate that the depth of silty clay could be more than 23 feet in some areas, but typically averages about 10 feet.



NOTES:

1. DELINEATIONS OF CLAY BORROW AREAS ARE APPROXIMATE; TO BE CONFIRMED BY ADDITIONAL EXPLORATION.

REFERENCE DRAWING:

TOPOGRAPHY COMPILED FROM PHOTOGRAPHY DATED OCTOBER 4, 1984 BY OLYMPUS AERIAL SURVEY, INCORPORATED - SALT LAKE CITY, UTAH.

600 0 600 1200
SCALE FEET

PHASE II PROJECT REPORT

CLAY BORROW AREAS

DRAWN BY: CCR	APPROVED BY: PMG	
DESIGN BY: MPF	DATE: 16 SEPT. 1985	
CHECKED BY: JDL	DWG. NO.: FIGURE 4.4-7	

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DRAWING NO.: FIGURE 4.4-7

REV.: PLANT

An additional source of clayey and silty soil for the New Damsite blanket is in the new reservoir area on Bingham Creek. Fifteen to 18 feet of silty and clayey soil was encountered in the test pit excavations. It is estimated that roughly 1.4-million cubic yards of silty and clayey soil could underlie the reservoir area; however, this estimate will need to be confirmed by additional exploration.

On the basis of the Phase II exploration and conceptual design studies, there does not appear to be sufficient local clayey material (in the areas that were explored) for construction of a New Bingham Canyon reservoir to store more than about 4,200 acre-feet (dam crest elevation 5,250 feet). If local clayey soil is to be used to construct a reservoir blanket and an impervious embankment zone (Alternative 1 scheme), a double volume of clayey soil borrow material will have to be confirmed. Therefore, additional clay borrow areas will need to be located.

Sources of impervious and granular materials of sufficient quantities have not been verified at the Dry Fork site. The results of seismic refraction surveys indicate that soils may be as deep as 75 to 100 feet. However, the material type is not known.

Granular material for Zone 2 and clay blanket cover will be obtained from the reservoir banks and spillway excavation. For the purpose of cost estimating, it was assumed that riprap can be selectively obtained from the Zone 2 borrow areas. Additional sources of riprap are the mine waste dumps and quarried local rock. Sand bedding for the clay blanket or synthetic liner will be obtained by screening materials from the Zone 2 borrow areas.

There are several commercial sand and gravel sources in the Salt Lake Valley. For cost estimation purposes, commercial sources of sand and gravel are located within 8 to 11 miles of the existing damsite and 16 to 19 miles of Dry Fork damsite.

F. Borrow Area Reclamation

The proposed clay borrow area is currently being used for wheat farming. The intent of borrow area reclamation is to return the area to farming after borrow operations have been completed.

The top 1 to 2 feet of natural soil will be stripped from the clay borrow areas and stockpiled. After sections of the borrow areas have been exhausted, the resulting ground surface will be contoured to conform to natural topographic conditions and to provide drainage. The topsoil in the stockpiles will then be replaced in the borrow areas.

4.5 SPILLWAYS AND OUTLET WORKS

A. Introduction

The purpose of providing spillways and outlet works for the reservoirs involved in this study is to pass the design floods, prevent overtopping of the dams by flood waters, and to evacuate the reservoir water within a specified time during an emergency, all in accordance with the Federal and State rules and regulations governing dam safety. This study determined the preliminary location, type, size, and cost of the spillways and outlet works for each alternative reservoir storage requirement. Typical spillway profiles and sections are presented in Figure 4.5-1.

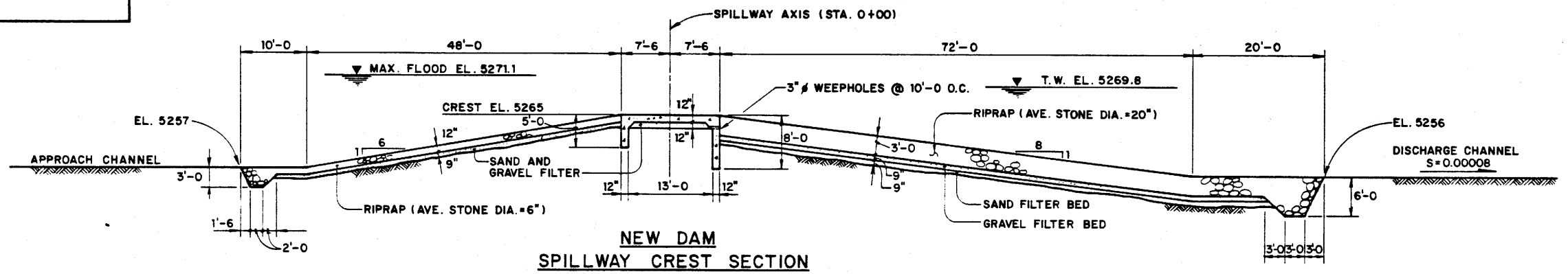
The scope of the work involved in this study for the spillways and outlet works includes:

- Preliminary design and estimate of quantities for the spillways and outlet works for the new Bingham Creek Reservoir.

- Preliminary design and estimate of quantities for the spillways and outlet works for the improvement and raising of the existing Bingham Creek dam.

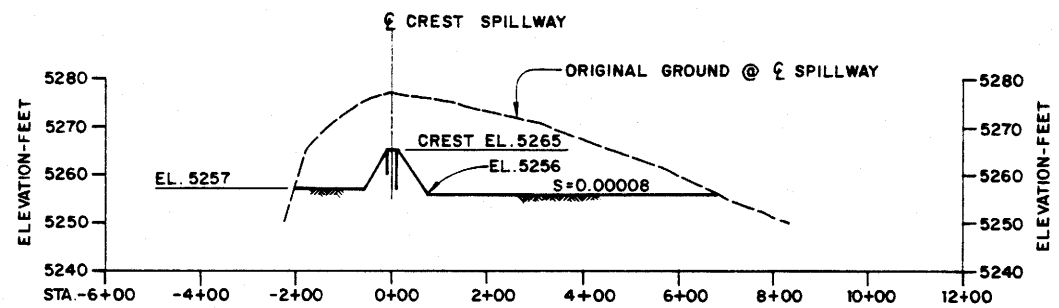
NOTES:

1. SPILLWAY SECTIONS PRESENTED CORRESPOND TO NEW DAM CREST EL. 5275 AND RAISED EXISTING DAM CREST EL. 5350.



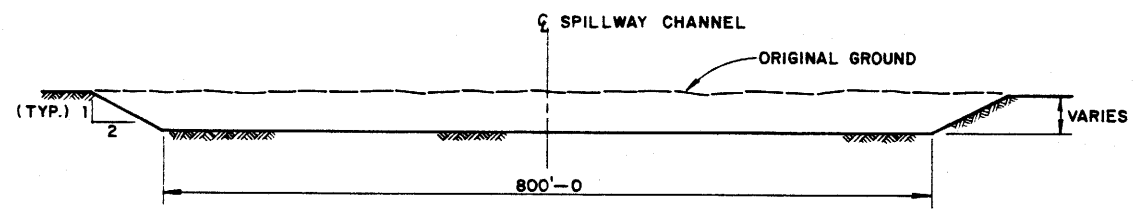
NEW DAM
SPILLWAY CREST SECTION

SCALE 10 0 10 20 FEET



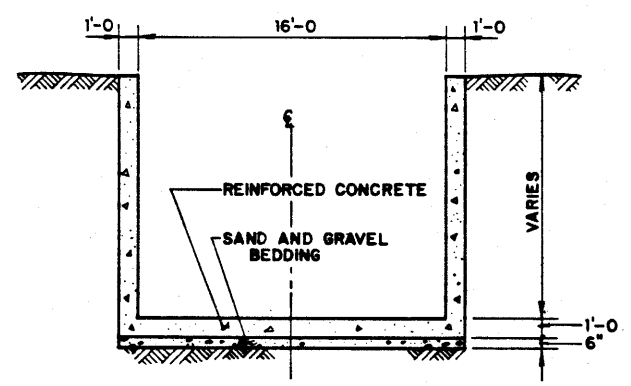
NEW DAM
SPILLWAY PROFILE

SCALE 20 0 20 40 FEET



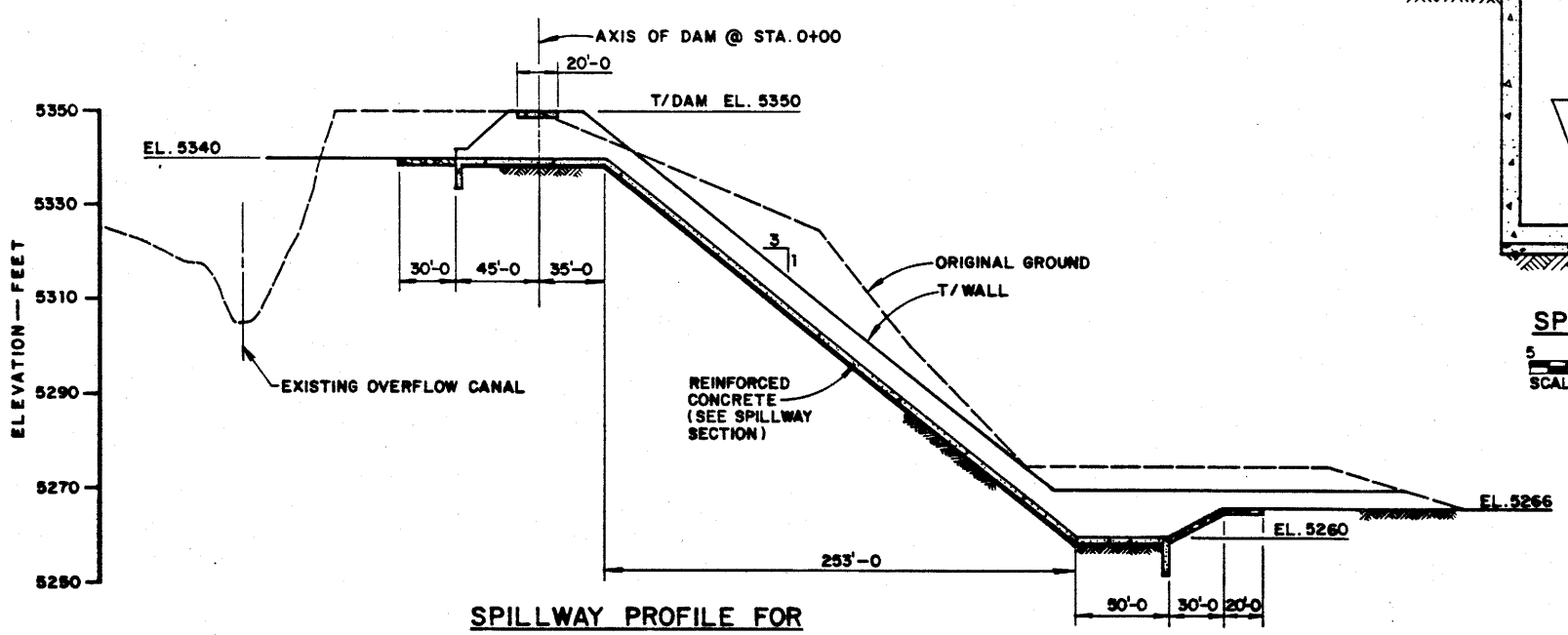
SPILLWAY CHANNEL SECTION

SCALE 100 0 100 200 FEET



SPILLWAY SECTION

SCALE 5 0 5 10 FEET



SPILLWAY PROFILE FOR
EXISTING DAM IMPROVEMENT

VERTICAL SCALE 20 0 20 40 FEET

HORIZONTAL SCALE 50 0 50 100 FEET

PRELIMINARY-NOT FOR CONSTRUCTION

PHASE II PROJECT REPORT

TYPICAL SPILLWAY PROFILES AND SECTIONS

DRAWN BY: CCR	APPROVED BY: PMG		
DESIGN BY: RPP	DATE: 16 SEPT. 1985		
CHECKED BY: JDL	DWG. NO.: FIGURE 4.5-1		

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DRAWING NO. FIGURE 4.5-1 REV. PLANT

REFERENCE	DWG. NO.	DESCRIPTION

REFERENCE	DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

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APPROVED BY			DESIGN		
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APPROVED BY			CKD.		
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- Preparation of cost curves for the spillways and outlet works to be combined with the cost curves developed for the dams.

- For comparison, the cost curves for the spillways with 1/2 PMF capacity will be developed to show the cost difference from the spillways with PMF capacity.

B. Assumptions

The following assumptions were made:

- The maximum enlarged capacity of the existing dam will not be sufficient to provide the storage requirements for the tradeoff alternatives considered. The location of the spillway with a PMF design capacity will be at the new reservoir downstream of the existing dam.

- The analysis made in the Phase I study for the PMF hydrographs (Ref. 1), the results of the flood routing calculations, and the hydraulic design conditions of the spillway with a PMF capacity will be assumed as applicable to the spillway for the new dam downstream of the existing reservoir.

- The spillway at the existing dam will be designed for 25% PMF capacity. It will be assumed that, in the event of the occurrence of the PMF, overtopping of the existing dam by flood waters will not cause a dam breach action that will affect the safety of the new dam downstream. This assumption has to be verified in the final design of the facilities.

- Bedrock is not present at the location of the spillway.

C. Design Criteria

The existing Bingham Creek dam has been classified as an intermediate size dam with high hazard potential in the Phase I Inspection Report

prepared by the U.S. Army Corps of Engineers for the State of Utah in October, 1980 (Ref. 16). The report recommended that the dam should be provided with a spillway that will pass a probable maximum flood (PMF) without overtopping the dam.

A new or enlarged dam for storing contaminated water on Bingham Creek with either a greater height or a larger reservoir capacity than the existing dam will be classified as a large size dam with high hazard potential per Utah Dam Safety Rules and Regulations, January, 1982 (Ref. 6). For this classification, the specified spillway design flood is 1/2 PMF to PMF. Accordingly, the spillway for a dam on Bingham Creek will be sized to pass a PMF without overtopping the dam. For comparison, the size and cost of a spillway that will pass 1/2 PMF will also be studied.

For the case where the entire PMF would be stored in the leach water reservoirs, a small emergency overflow spillway will be designed to assure safety against overtopping. Because the maximum design flood would be completely contained, the criteria for spillway sizing will be based exclusively on construction ease and existing topography.

Because of its height, storage size, and location, the proposed dam on Dry Fork for storing uncontaminated runoff will be considered as a large size dam with low hazard classification. The dam would be located less than 1000 feet upstream of the present waste dumps on Dry Fork. In the unlikely event of a dam failure, it is assumed that water would be blocked by the waste dumps and would not cause damage or loss to private property or loss of life. The Dry Fork dam spillway will be designed to pass a 100-year flood without overtopping the dam.

The spillway design capacity for the existing dam was changed to 25% of the PMF based on the assumptions stated in Section 4.5-B. Outlet works will not be provided at Dry Fork dam because of the possibility that Dry Fork waste dumps may extend to the location of the dam.

D. Analysis

1. New Reservoir Spillway and Outlet Works - The type of spillway for the new reservoir in Bingham Creek to pass the PMF will be the auxiliary type of spillway to be excavated in the area on the south abutment of the dam. Locating this type of spillway on the north abutment area of the dam will require the relocation of a highway, railroad tracks, and the scrap metal stock pile and loading area. This type of spillway is the same type used for the PMF spillway during the Phase I study (Ref. 1). A crest length of 800 feet and a crest level of 10 feet below the top of the dam will be used to discharge the PMF derived during the Phase I study. The spillway will discharge into an area leading into the Bingham Creek downstream of the dam.

Unlike the spillway in the Phase I study, this spillway will be relatively inexpensive because there is considerably less excavation involved as currently located, and also because all of this excavation will be used as construction material for the new embankment.

The spillways for different crest levels of the dam were laid out on a 200-foot scale map. Profiles were plotted along the center line of the spillways and the quantities required for the spillways were estimated.

The outlet works for the new reservoir will be located at the creek bed. The type that will be used is the same type presented in the Phase I study. The lengths of the discharge pipe and the access bridge to the intake are affected by the elevation of the dam crest.

2. Existing Reservoir Spillway and Outlet Works - Based on the assumptions made in Section 4.5-B, the spillway for the existing dam will be designed for a discharge capacity that can route the flood with a magnitude of 25% of the PMF without the flood waters overtopping the dam. A chute type of concrete spillway located on the south abutment area of the dam and excavated on natural ground will be used for the spillway of the existing reservoir with the proposed raising of the dam crest. An uncontrolled crest length of 16 feet and a crest level of 10

feet below the top of the dam will be used. The spillway will be discharging to a point downstream of the dam and into the new reservoir. The quantities were estimated for the spillways for different crest levels of the dam.

The outlet works for the enlarged capacity of the existing reservoir will be located at the creek channel bed. The type of outlet works will be the same type that will be used in the new reservoir outlet works. If the top of the existing dam will not be raised, the existing outlet works will be improved as presented in the Phase I study.

3. Dry Fork Reservoir Spillway and Outlet Works - The intake and tunnel for the tunnel alternative discussed in Section 4.3 for diverting and discharging water collected in Dry Fork reservoir will serve as a spillway for the reservoir. Two conditions were analyzed to pass the 100-year peak inflow through the tunnel intake. The first condition is when the intake flow is uncontrolled. The maximum peak outflow obtained is about 1,600 cfs with an initial reservoir elevation of 6,280 feet, and with the alternative of draining surface runoff from the Galena area to the Dry Fork area. The problem of controlling and discharging the 100-year peak outflow through the tunnel into the area of Barney's Wash and into an acceptable point of discharge led to analyzing the other condition of controlling and limiting the outflow through the intake and tunnel.

The 100-year flood runoff into the reservoir was routed through the intake and tunnel with a constant outflow of 15,000 gpm when the reservoir level exceeds elevation 6,280 feet. The flood routing for different alternatives of surface runoff collection were done to determine the maximum reservoir water surface elevation and the top of dam required for Dry Fork.

An alternative to the intake and tunnel arrangement is to provide pumps with the same capacity as the controlled intake flow. The water will be pumped over the ridge and into the area of Barney's Wash. The maximum reservoir levels will not differ for the two discharge

alternatives. The maximum reservoir levels and the top of dam required for the different diversion alternatives are given in Section 4.3.

The future waste dump area in Dry Fork is expected to reach the location of the Dry Fork dam. Due to this condition and the assumption that this could happen in the immediate future, outlet works are not provided at Dry Fork reservoir.

4.6 BINGHAM CANYON GROUND-WATER INTERCEPT

A. Geohydrology

Geohydrologic tests were conducted in Bingham Canyon to obtain aquifer parameters, water quality data and other geologic and hydrologic information which would contribute to an understanding of the hydrologic regime in the Canyon. With this information, concepts for controlling ground water flow in alluvial and rock aquifers were established. These concepts all entail the use of artificial ground-water barriers coupled with systems to collect waters containing metals and other inorganics which would deteriorate or degrade water quality. Details of the field investigation program are given in the Phase II Geotechnical Report (Ref. 2).

B. Analysis of Pumping Test Data

Two field pumping and well recovery tests were conducted in late August and early September, 1985. Water level drawdown and recovery measurements were taken in the pumping wells and nearby monitoring wells. Production Well No. W-1 was constructed to allow testing of the alluvial aquifer. Monitor wells BC-4 and MW-1A were constructed as alluvial monitoring wells. Production Well No. W-2 and monitor wells BC-3 and MW-1R were constructed to allow testing of the upper portion of the bedrock aquifer.

Drawdown and recovery measurements were plotted on semi-logarithmic paper and aquifer transmissivities (T) and storage coefficients (S)

were calculated using the Jacob straight line method for solution of the Theis formula. Values of T are in gallons per day per foot (gpd/ft).

Approximate T and S values were calculated as shown in Table 4.6-1.

Using the more conservative value for T obtained by pumping the alluvial aquifer (approximately 50,000 gpd/ft), and an average alluvial aquifer thickness of 35 feet, the calculated hydraulic conductivity, K (formerly referred to as coefficient of permeability), would be approximately 6.2×10^{-2} cm/sec. (1.3×10^{-1} ft/min.). As storativity ranges from approximately 1×10^{-1} to 1×10^{-2}, the alluvial aquifer is slightly confined, possibly due to thin clay and silt layers or mineral deposits.

Permeability of quartzite and weathered intrusives was estimated to be 2×10^{-4} cm/sec from water pressure tests at the Dry Fork damsite, and from water pressure tests conducted in Bingham Mine during November 1984 (Ref. 2). Water pressure tests in highly fractured quartzite zones encountered in BC-3 and BC-4 indicate a coefficient of permeability ranging from 0.6×10^{-4} to 1.6×10^{-4} (Ref. 2). It is probable that hydraulic conductivities will be relatively high in fractured and jointed zones caused by faulting, folding, and weathering.

The bedrock aquifer, then, exhibits anisotropy due to rock fracture patterns, with variable sizes, shapes, and orientations. Where anisotropy in a confined aquifer is the result of lower vertical than horizontal hydraulic conductivity, but the vertical hydraulic conductivity is still a large component, and a partial penetrating well is installed, the decrease in yield or increase in drawdown from a well may be significant when compared to an ideal aquifer. For an approximate average aquifer hydraulic conductivity, the bottom of the well may be considered to be the base of the aquifer. Assigning an aquifer thickness of 60 feet and a T of 10,000 gpd/ft, K would be approximately 7.8×10^{-3} cm/sec (1.5×10^{-2} ft/min).

TABLE 4.6-1

APPROXIMATE T AND S VALUES
CALCULATED FROM PUMPING TESTS

ALLUVIAL AQUIFER

Well No.	T (gpd/ft)	S
	Pumping Phase	
MW-1A	49,500	8×10^{-3}
BC-4	46,588	9×10^{-2}
	Recovery Phase	
W-1	33,767	-
MW-1A	29,040	-

ROCK AQUIFER

Well No.	T (gpd/ft)	S
	Pumping Phase	
MW-1R	6,285	4×10^{-5}
BC-3	14,505	1×10^{-3}
	Recovery Phase	
MW-1R	713	-
BC-3	25,384	-

Drawdown of less than 1 foot was achieved in bedrock monitoring wells during the pumping of alluvial aquifer production well W-1. Less than 1 foot was also observed in alluvial monitoring wells during pumping of production well W-2. Transmissivities calculated from Jacobs curves for these wells were not considered valid as the pumping rate or quantity of water being removed from these aquifers are not definable.

Monitoring of Bingham Creek and distant monitor wells (BC-1, BC-2, W-76) was accomplished during the pumping operation. No significant changes in water levels were noted. Some infiltration from Bingham Creek occurred in Monitoring Well BC-4. Water level measurements taken with an electric probe were difficult to obtain at this site, as perched mineralized water seeped through well screen perforations approximately 70 feet below the ground surface.

The storage coefficient in the bedrock monitoring wells is low and indicates confined aquifer conditions exist in bedrock. Confining layers may include, in addition to structural features, mineralization at the alluvium bedrock contact.

The gradient measured between BC-1 and W-1 is approximately three feet per 100 feet. Recharge to both aquifers is by infiltration from rainfall and snowmelt in the uplands with direct recharge to rock aquifers and runoff to Bingham Canyon. Recharge is also added from leaching of mine waste.

Some recharge to the alluvium in Bingham Canyon at this time is by leakage from the bedrock aquifer due to existing differential heads. The bedrock aquifer exhibits a potentiometric surface elevation generally 5 feet or more above water levels measured in the alluvial monitoring and production wells. During periods of heavy runoff in Bingham Canyon this head differential may be altered or reversed, but this has not been observed.

This leakage or transfer of water is important as water quality in the bedrock aquifer is significantly better than the alluvial aquifer water quality. A typical chemical analysis (by Kennecott) of water samples taken from production wells W-1 and W-2 is shown in Table 4.6-2.

Submersible pumps, utilized for development of the well and pumping tests, were partially clogged at the intake and were coated with native copper after removal from W-1. Clogging of the well screen also probably occurred and could have been partially responsible for erratic water level readings and well inefficiency during the performance of the pumping test.

A conceptual ground-water model was constructed utilizing aquifer parameters obtained from the pumping tests. From this model an approximation of flow through the alluvium was derived, using formulae developed by Darcy and Dupuit (Ref. 8). With the construction of a ground-water barrier to preclude infiltration from downstream, flow into a collection system is expected to be less than 500 gpm. Additional ground-water contribution through leakage from the bedrock aquifer to the alluvial aquifer could be expected to occur if potentiometric heads were not lowered by pumping of the bedrock aquifer. As moderately contaminated water is present in the bedrock aquifer, a collection system is also deemed necessary for removal of this water. Flow into this collection system is estimated to be around 400 gpm.

Calculated quantities are based on existing conditions and do not include ground-water quantities being pumped from West Mountain Shaft. The current yield at the shaft is approximately 400-600 gpm, with pumping level at appoximately 134 feet (Ref. 13).

Due to the anisotropic and complex nature of the bedrock, with varying horizontal and vertical hydraulic conductivities, additional studies of this aquifer are needed to further define its hydrologic characteristics. These studies should include additional pumping tests

TABLE 4.6-2

WATER QUALITY TEST RESULTS
FROM PUMPING TEST SAMPLES

Item	Units	Measured Values	
		Alluvium	Bedrock
pH	-	3.45	6.11
Total Suspended Solids	mg/l	26.4	5.4
Total Dissolved Solids	mg/l	24,000	5,880
Copper	mg/l	242	1.68
Arsenic	mg/l	0.013	0.004
Sulfate	mg/l	12,000	3,500
Zinc	mg/l	70	39
Lead	mg/l	0.38	0.19
Magnesium	mg/l	1,450	560
Aluminum	mg/l	770	< 1
Iron	mg/l	99	1
Mercury	mg/l	< .0001	< .0001

and geophysical, geological, geochemical, and geohydrologic studies to gather information on recharge areas, sources of contamination, and structural features in the area. Tracer tests may be beneficial to define vertical hydraulic conductivities.

C. Remedial Action Alternatives

Water high in total dissolved solids, sulfates, and heavy metals is moving through permeable alluvial sediments in Bingham Canyon. To a much lesser degree, moderately contaminated water is also present and moving through the fractured bedrock aquifer.

To minimize continued contamination of the aquifers downstream of the site, a remedial action plan is proposed. The following components would be common to all alternatives to be considered in a remedial action plan:

- A ground-water barrier in the alluvium to minimize further down-gradient movement of moderately contaminated water.
- A ground-water collection system in the alluvial aquifer upstream of the barrier.
- A ground-water collection system in the bedrock aquifer which would collect moderately contaminated water and reverse the local ground-water gradient.
- A treatment plant to treat moderately contaminated water before discharge.

The Phase I Hydrologic/Geotechnical Study (Ref. 1) presented detailed descriptions of ground-water control methods including advantages and disadvantages of slurry trenches, grout curtains, and well collection systems. With the acquisition of additional data, these remedial action alternatives can be reconsidered.

The following criteria are applicable for the specific site recommended for the ground-water barrier and collection system:

- Ground-water barrier should extend at least 60 feet above bedrock at its deepest point in the alluvial valley, as alluvial aquifer thickness is approximately 40 feet and could be expected to rise somewhat during heavy runoff periods.

- Ground-water collection system in alluvial aquifer should extend to bedrock and be capable of collecting 600 gpm. Stainless steel pumps and non-corrosive piping should be planned for the system.

- Permeability of barrier wall should be 10^{-6} cm/sec or lower.

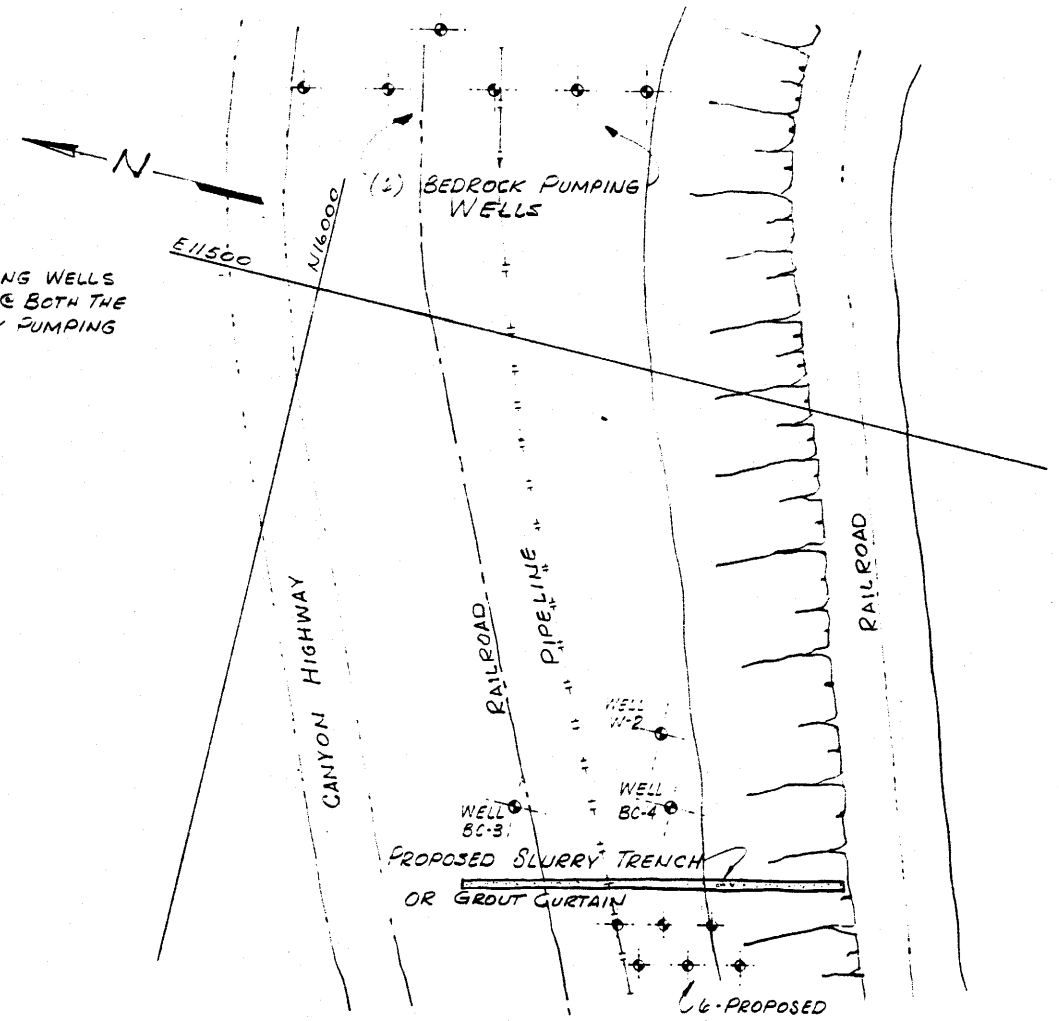
The following alternatives for remedial action were considered.

- Alternative 1: A slurry trench from the ground surface extending to bedrock with a deep well collection system in the alluvium and bedrock.

- Alternative 2: A grout curtain extending to bedrock with the top of the grout curtain at approximate elevation 5,451 with a deep well collection system in alluvium and bedrock.

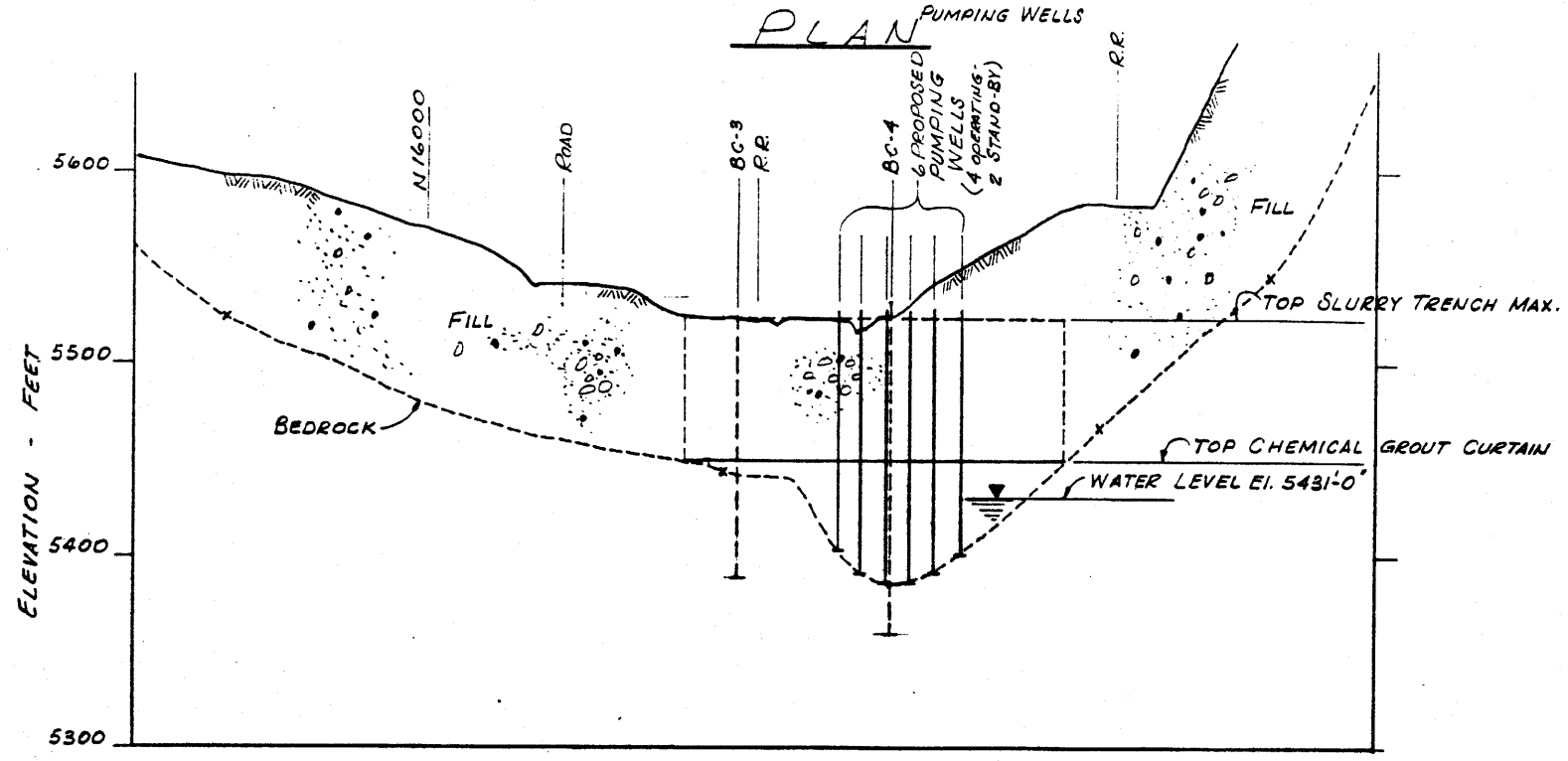
- Alternative 3: Sinking of a shaft to bedrock with lateral extensions for collection of ground water at the alluvium-bedrock contact, in lieu of deep wells.

The proposed location and conceptual design of this system is illustrated on Figure 4.6-1. Ideally, the final location of the barrier and collection system should be down-gradient of all potential sources of ground-water contamination. If the cutoff is placed up-gradient from the Precipitation Plant, steps must be taken to assure against spilling of contaminated liquors at the Precipitation Plant



NOTE - 5 MONITORING WELLS WILL BE INSTALLED @ BOTH THE ALLUVIUM & BEDROCK PUMPING WELL LOCATIONS.

PLAN



SECTION @ SLURRY WALL

50 0 50 100
SCALE FEET

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PHASE II PROJECT REPORT
BINGHAM CANYON
GROUNDWATER CONTROL SYSTEM
PLAN & CONCEPTUAL SECTION

DRAWN BY:	RCB	APPROVED BY:	PMG
DESIGN BY:	LCV	DATE:	16 SEPT. 1985
CHECKED BY:	JDL	DWG. NO.:	FIGURE 4.6-1

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DRAWING NO. FIGURE 4.6-1
REV. PLANT

REFERENCE DWG. NO.	DESCRIPTION

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facility. Consideration of potential sources of contaminated leakage in the Precipitation Plant system was beyond the scope of this study, but its importance cannot be ignored.

The slurry trench described in Alternative 1 appears feasible when dug from a working platform at existing ground level. Due to limited working space and the existence of railroads and pipelines, excavation would most likely be done by a clamshell which would excavate panels two feet wide and around 22 feet in length. As deep cement-bentonite trenches tend to set-up prior to completion of excavation, an excavation through bentonite with a tremied lean cement backfill is recommended. As a coating of bentonite would exist in the trench, waters of low pH would not appear to be a problem with this backfill method (Ref. 9). However, chemical tests will be necessary to define the effects of acidic water on various types of bentonite and the accompanying interaction with cement. A chemical analysis of water should be sent to slurry wall contractors prior to final design.

In lieu of the lean cement mixture for backfill, chemically resistant bentonite based backfill is available from some specialty contractors. Also, the vibrating beam slurry trench with a cold asphaltic emulsion backfill is a viable alternative, although disadvantages as listed in Ref. 1 are still valid.

A chemical grouting operation (Alternative 2) utilizing sodium silicate or urea grouts could provide the most economical barrier owing to least placement and cost. Drilling of grout holes would be accomplished from the surface. Directional drilling could be accomplished under the ore haulage railroad fill, existing D&RG railroad, utilities, and stream channel. Therefore, relocation costs would be minor. Three rows of grout holes would be drilled on 3-foot centers, and chemical grout could be injected in the buried alluvial channel below elevation 5,451 feet (Ref. 10). With air drilling methods, boulders and cobbles will present no severe problems to installation of grout pipes. Penetration of clay, silt, and fine sand layers with chemical grout may not occur,

hence these zones may not meet the imposed 10^{-6} cm/sec. permeability criteria.

Alternative 3, a mined shaft with lateral drainage holes in lieu of deep wells to collect contaminated water, was also considered. Costs would be comparable to deep wells. A single operating pump, with a standby pump, could be used and maintenance would probably be less costly than for a series of deep well pumps. However, the presence of clay and silt layers would inhibit the vertical movement of ground water. Also, precipitation of heavy metals, in the presence of oxygen, will likely occur at the shaft and along the collection gallery, and would curb the movement of ground water. Alternative 3 therefore is not technically viable as deep wells would appear to be a more effective method for collection of ground water.

The construction of an open sump, extending from the ground surface to bedrock, may be another alternative method of water control. This method would provide for interception and collection of all water migrating horizontally through the alluvium. The excavation slopes would need to be approximately 1.5(H):1(V).

A ramp for excavation equipment and to provide access to pumping equipment and for sump maintenance would likely be required. Piping, railroads, Bingham Creek, and the paved access road would have to be diverted or bridged across the excavation. Also, extensive bracing operations or excavation would be necessary along the mine waste fill area. This alternative would appear technically and economically infeasible; however, additional studies and economical analyses could be undertaken before this water control method is removed from consideration.

4.7 WATER TREATMENT PLANTS

A. Introduction

Water from different sources in the mine area have varying degrees of contamination. The cost and effectiveness of treatment using lime for

pH adjustment and precipitation of impurities varies with the degree of contamination. The water from the various sources in the Bingham Mine can be grouped into three classifications based on the degree of contamination. Following are the classifications and comments on each:

1. Uncontaminated Surface Runoff - This water originates from the runoff of precipitation on areas that have not been disturbed by mining operations. Examples are the runoffs from Copperton, Dry Fork, Markham, Freeman, and Upper Carr Fork drainage basins. This water may be discharged without treatment provided it is collected before it enters the mined area.

2. Moderately Contaminated Mine Drainage Water - This water originates from dewatering areas that have been disturbed by mining operations. Examples are Pit drainage water, Carr Fork Ditch water, Carr Fork underground mine water, NOS underground mine water, and Bingham and Butterfield Tunnel discharge water. The quality of these waters varies: As an example, NOS water is only slightly contaminated and could possibly be discharged for agricultural use following settlement of the suspended solids, whereas the Pit water and Carr Fork Ditch water require treatment to remove dissolved metals as well as suspended solids. These waters can be treated with lime followed by flocculation and clarification to meet EPA effluent limitations. Even though the treated water meets the EPA discharge limitations, it must also meet the standards that apply to the receiving body of water in the drainage. It is expected that the treated mine waters will meet the C-4 Agricultural Standard required for discharge into an irrigation canal and, as an alternate, discharge into the C-7 Canal is also possible.

3. Leach Water - This water originates from the leaching of oxidized copper in the mine waste dumps and is highly contaminated but not classified as hazardous under the existing regulations. Leach water is subject to a zero discharge provision in the EPA regulations except in cases where the regulator specifically allows discharge of treated leach water in the applicable NPDES permit. If discharge is

allowed, the treated leach water must meet the applicable NPDES permit limitations, and must also meet the receiving body or beneficial use standards that apply to the point at which the treated water is discharged. Lime treatment of leach water is expected to produce an effluent that meets the EPA effluent limitations; however, the total dissolved solids content will exceed the C-4 agricultural standard. Therefore, treated leach water must be discharged to a waterway classified as a special condition. The C-7 Canal which discharges into the Great Salt Lake is classified as a special condition. Therefore, the only point considered for discharge of treated leach water is the C-7 Canal.

B. Treatment Method

Test work on the treatment of leach water carried out at Hazen Research, Inc., in 1974 indicated that lime addition to obtain a pH of approximately 9.0 followed by flocculation and settlement will produce a discharge that meets the EPA effluent limitations. Treatment of leach solution in this manner has several limitations, and these are:

- Lime consumption is high -- approximately 135 lb / 1,000 gal
- Treated water is saturated with calcium sulphate (gypsum) and scaling of pipes and equipment is a serious problem
- Total Dissolved Solids, primarily calcium and magnesium salts, will be high and will exceed the allowable limitation for agricultural use.

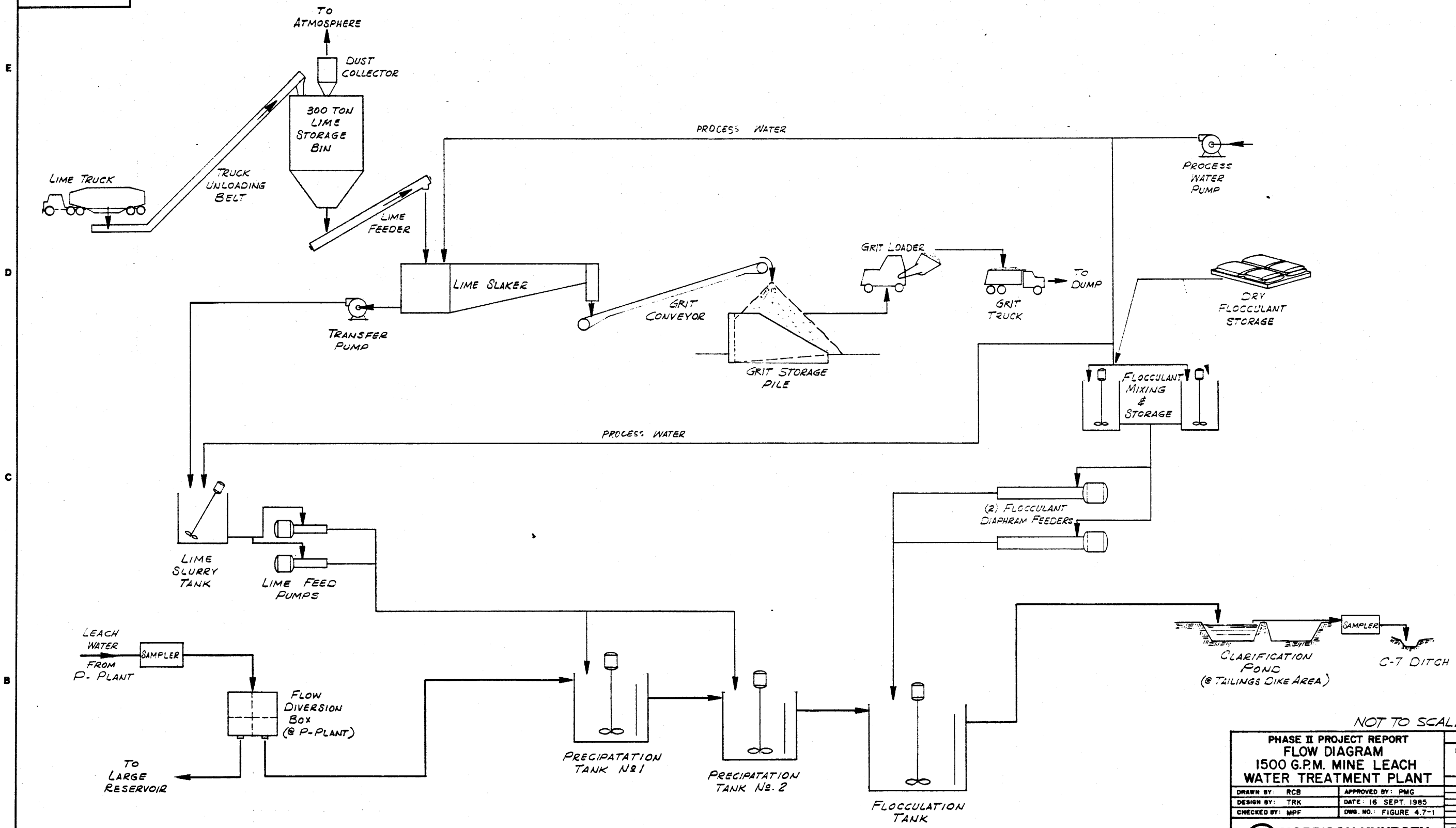
Treatment of leach water with conventional lime neutralization is probably feasible, but will be costly. The scaling problem can be reduced by pumping untreated leach water to the vicinity of the C-7 Canal for treatment. Lime addition and flocculation will be carried out in agitated tanks; however, settling will be performed in settling ponds that allow a clear overflow directly into the C-7 Canal. This arrangement will minimize the possibility of scaling up both pipes and

equipment. A flow diagram for a 1,500 gpm leach water treatment plant is shown in Figure 4.7-1.

The treated leach water discharge should meet the EPA effluent limitations, but will not meet the receiving body or beneficial use limitations for streams or irrigation canals in the vicinity of the mine. Therefore, discharge of the treated leach water will only be allowed into the Great Salt Lake or the C-7 Canal which discharges into the Great Salt Lake. This is considered a special condition because these waters contain a high concentration of naturally-occurring dissolved solids. Case I(a) deals with the treatment of leach water and discharge to the C-7 Canal as described above.

The Pit drainage water and Carr Fork Ditch water contain fairly high dissolved solids concentrations. These levels are much lower than the dissolved solids concentration of the leach water but are such that the treated discharge will exceed the receiving body or beneficial use limitations unless these waters are diluted with a higher quality water such as the NOS underground mine discharge. For the purpose of this study, the Pit drainage water and Carr Fork Ditch water are combined and treated in a separate treatment plant similar to that used for leach water treatment. The plant will be located in the concentrator tailings disposal area, and a separate pipeline has been included to convey this water from the precipitation plant to the treatment plant. The treated discharge will overflow the settling pond into the C-7 Canal as in the previous case. This forms the basis for Case I(b). In both Case I(a) and I(b) a new lime receiving, storage and slaking system is required and has been included.

Case II considers treatment of NOS mine drainage and Carr Fork underground mine drainage. The quantity of each is based on present estimates. Both of these waters are only moderately contaminated. The NOS water very nearly meets the EPA effluent limitations after settlement of the suspended solids. The quality of the Carr Fork underground mine drainage is not known at this time because of the difficulty in obtaining a sample. When the Carr Fork mine was in



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PHASE II PROJECT REPORT FLOW DIAGRAM 1500 G.P.M. MINE LEACH WATER TREATMENT PLANT	
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DESIGN BY: TRK	DATE: 16 SEPT. 1985
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operation, the water quality was such that treatment was required during the spring runoff but was not required for the remaining nine months of the year. Therefore, it is assumed that these waters are similar and only slightly contaminated. As a result, the treatment method will be conventional and the treated discharge is expected to meet the EPA effluent limitations and the allowable limitations for agricultural use. The treatment plant in this case will be located in the area adjacent to the Bingham City Cemetery and will make use of the existing lime receiving, storage, and slaking facilities. Discharge of treated water in this case will be to a new concentrator, the C-7 Canal, or an irrigation canal. The irrigation canal will probably be the Utah and Salt Lake Canal, but the North Jordan Irrigation Canal is also a possibility. Discharge of this water to the Jordan River is not being considered because it will not meet the receiving body standards for this waterway.

Case III considers the treatment of projected quantities of water from the following sources:

- NOS mine drainage
- Carr Fork underground mine drainage
- Bingham Tunnel discharge water
- Butterfield Tunnel discharge water
- Bingham Canyon subsurface bedrock dewatering

The quantity of NOS mine drainage water is projected to increase as the development of the mine progresses and the increased quantity is included. Carr Fork underground mine drainage remains as in Case II. The possibility exists that both the Bingham and Butterfield Tunnel discharge water will require treatment prior to discharge and, therefore, these waters are also included in this case. Allowance also

has been made for a small quantity of water from the dewatering of the bedrock aquifer in Bingham Canyon.

The treatment process proposed for Case II and Case III is a conventional sludge recycle system using agitated precipitation and floculation followed by a clarifier/thickener. A metered portion of the thickened sludge will be recycled to the feed water to promote more efficient lime utilization and to provide more effective floculation. The plant is visualized as a two-module operation with each module designed for 6,250 gpm. The plant will be instrumented so that minimum operator attention is required. Sampling of feed and discharge will be in accord with EPA requirements. A flow diagram for the plant with future module is shown in Figure 4.7-2.

C. Assumptions

Simulated hydrological balances based on the application of certain controlled conditions and the precipitation from the 1984 water year (October 83 through September 84) were developed. The water volumes for reservoir storage, water treatment, and water diversion given in the Trade-off Matrix (Section 4.1) are based on this study. The simulated balances were discussed in detail in Chapter 3.

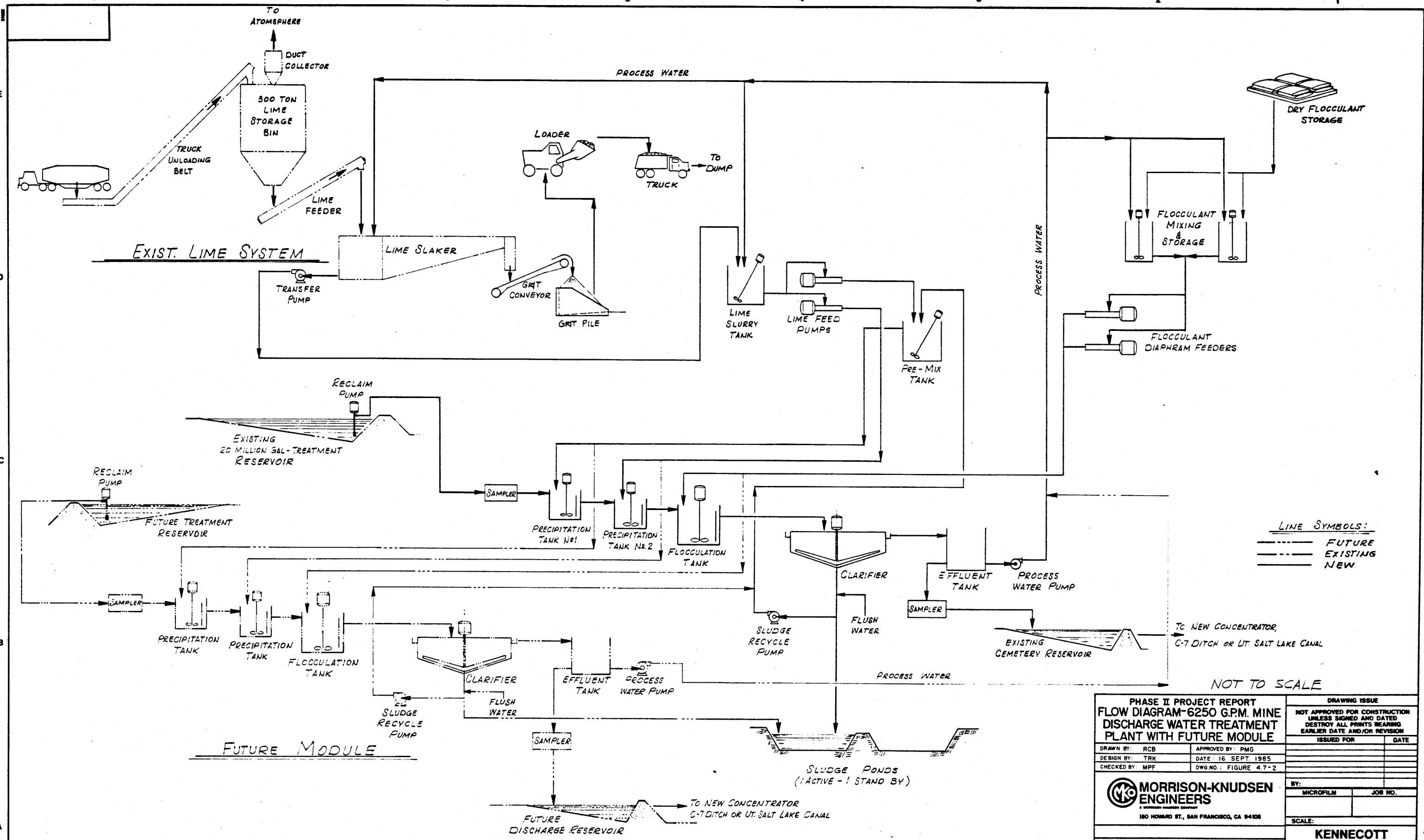
1. Sizing

The following additional assumptions were made on sizing for treatment facilities:

1. Feed Rate:

a. Case I(a)

	Average Flow (gpm)	Design Flow (gpm)
Leach Water	1,000	1,500



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PHASE II PROJECT REPORT
FLOW DIAGRAM-6250 G.P.M. MINE DISCHARGE WATER TREATMENT PLANT WITH FUTURE MODULE

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CHECKED BY:	MPF	DWG.NO.:	FIGURE 4.7-2

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b. Case I (b)

Pit Water	908	1,500
Carr Fork Ditch	900	1,500
Total	1,808	3,000

c. Case II
(one module)

NOS Water	2,500	3,250
Carr Fork Underground	2,500	3,000
Total	5,000	6,250

d. Case III
(two modules - future conditions)

NOS Water	5,000	6,250
Carr Fork Underground	2,500	3,000
Bingham Tunnel	1,250	1,550
Butterfield Tunnel	700	1,000
Bingham Canyon Bedrock Dewatering	550	700
Total	10,000	12,500

2. Plant Location

a. Case I(a) & I(b) - In the area adjacent to C-7 Canal to the east of the concentrator tailings area.

b. Case II & III - In the area adjacent to the existing lime receiving and slaking system and to the west of the Bingham City Cemetery. Both cases will make use of the existing lime receiving, storage, and slaking facilities. Case II will make use of the existing 20-million-gallon reservoir for feed storage and the existing Cemetery Reservoir for treated water storage. Case III will require new feed

and discharge reservoirs. All feed and discharge reservoirs will be lined with 30 mil HDPE liner.

3. Reagent Consumption

a. Lime - Pebble Lime as pounds of CaO.

Water Source	Lime Consumption (pounds per 1,000 gallons)
Leach Water	135.0
Pit Water	5.0
Carr Fork Ditch	5.0
NOS	1.5
Carr Fork Underground	1.5
Bingham Tunnel	1.5
Butterfield Tunnel	1.5
Bingham Canyon Cutoff	80.0

b. Flocculant - American Cyanamide #206 - 0.003 lb per 1,000 gallons in all cases.

4. Operating Parameters

- Continuous operation, 24 hours/day, 365 days/year
- Lime Precipitation Retention - 5 minutes at design flowrate
- Flocculation Retention - 5 minutes at design flowrate
- Clarifier Sizing - 0.3 sq.ft./ton of water per day.

4.8 WATER DISCHARGE

A. Introduction

Water discharged outside the boundaries of the Bingham Canyon Mine property must meet the EPA effluent limitations. In addition, the selection of a point of discharge for each of the classifications of water depends on the standards imposed for discharge into a particular drainage or watercourse. These standards are referred to as the receiving body or beneficial uses standard.

The purpose of this section is to identify the system for collection of the water from its source on the mine property and conveying it to its point of discharge outside the mine property. Each system was evaluated for feasibility and the cost of pipelines and pumping stations. Following is a listing of the systems considered:

1. Uncontaminated water - Diversion and collection of the uncontaminated runoff is discussed in Section 4.3. Discharge of this water will be to the Jordan River because it is considered normal storm runoff. This water will be conveyed by gravity in the existing pipeline to the Jordan River. Discharge capacity is assumed to be approximately 15,000 gallons per minute (gpm).

2. Moderately contaminated mine drainage water

- Pit water and Carr Fork drainage water will be combined and piped by gravity to the concentrator tailings area for treatment and discharge to the C-7 Canal.

- NOS water and Carr Fork underground water will be combined. Pumps and piping for the Carr Fork underground water have been included. The NOS and Carr Fork Underground water will be combined near the NOS shaft in the existing 18-inch diameter line and flow by gravity to the new lime treatment area.

Treated water from the Cemetery Reservoir will have three alternate routes:

(a) pumped to the new concentrator
(b) gravity flow to the C-7 Canal
(c) gravity flow to the North Jordan or Utah and Salt Lake canal.

In addition, the water from the following sources will be considered as moderately contaminated mine drainage water.

- Bingham Tunnel discharge water will be piped and gravity flowed to the new lime treatment plant.

- Butterfield tunnel discharge water will be piped and gravity flowed to the new lime treatment plant.

- Water from the Bingham Canyon ground-water intercept will be pumped to the lime treatment plant or to the Precipitation Plant depending on the water level in the reservoir and the copper content of the water.

3. Leach Water - This water will be diverted after copper removal in the Precipitation Plant and will be gravity-flowed to the concentrator tailings disposal area near the C-7 Canal for lime treatment. Lime treatment at the mine will not be feasible because the treated solution will be saturated with gypsum and will scale up the pipeline. Therefore, it must be pumped prior to lime addition, and treatment will be located in the concentrator tailings disposal area adjacent to the C-7 Canal.

B. Assumptions

The following assumptions were made to simplify the costing of the systems for this study.

- The rights-of-way for the various pipelines were assumed to be available for use and costs have been included based on the present status of rights-of-way.

- The existing water pipeline to the Jordan River was assumed to be adequate for gravity discharge to the Jordan River at 15,000 gpm. No pressure testing has been performed.

- The Carr Fork underground mine shaft will be pumped down to 200 feet below the ventilation shaft collar.

- Barney's and Bingham Creeks were assumed to be restricted to small flows because of housing development and small culverts under the existing roads. Therefore, these drainages cannot be used for drainage of the diverted uncontaminated runoff.

C. Design Criteria/Sizing Considerations

Following are the design criteria used for conceptual design of the water piping system. The design of the surface water diversion system is discussed in Section 4.3.

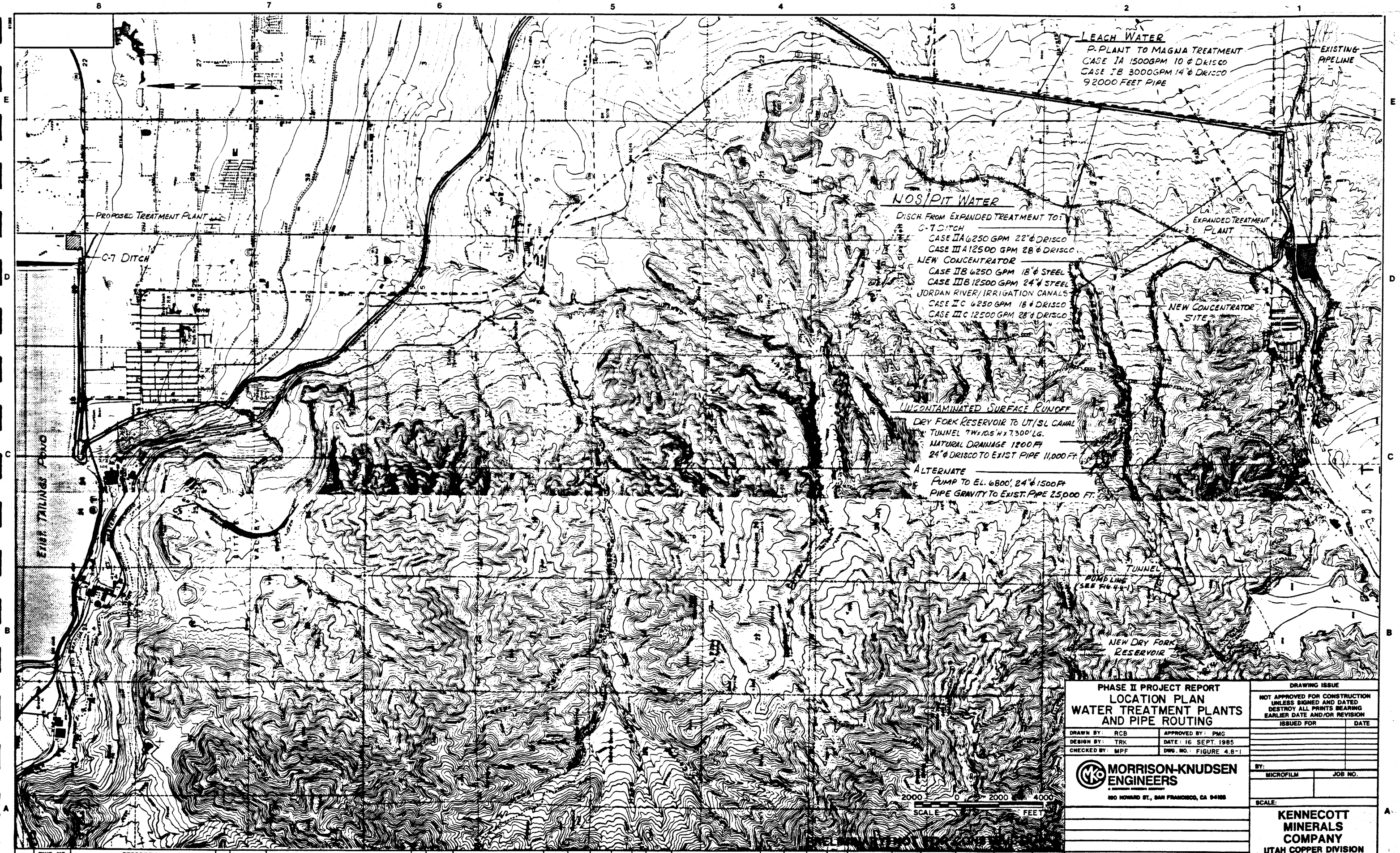
- Pipelines will be Driscopipe for gravity lines and steel pipe where design pressure dictates.

- Pipelines are sized for velocities between 6 and 7 feet per second for both gravity and pumped discharge.

- Excavation of trenches is based on 80% common excavation, 20% broken rock excavation and excavated material is assumed suitable for use as backfill.

- Pipelines inside the mining property will be run on surface. Hold-down will be provided by truckloads of fill at 100-foot spacing.

A location plan showing the conceptual pipe routing along with associated project facilities is shown in Figure 4.8-1.



PHASE II PROJECT REPORT

LOCATION PLAN
WATER TREATMENT PLANTS
AND PIPE ROUTING

DRAWN BY: RCB	APPROVED BY: PMG
DESIGN BY: TRK	DATE: 16 SEPT. 1985
CHECKED BY: MPF	DWG. NO.: FIGURE 4.8-1

MORRISON-KNUDSEN ENGINEERS
A MORRISON KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

DRAWING ISSUE

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED
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ISSUED FOR	DATE

BY:

MICROFILM	JOB NO.

SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO.: FIGURE 4.8-1

REV. / PLANT

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

	BY	DATE		BY	DATE
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APPROVED BY			DRAWN		
APPROVED BY			CKD.		
APPROVED BY			CKD.		
APPROVED BY					

CHAPTER 5
COST ESTIMATES

5.1 BASIS OF ESTIMATES

A. Introduction

Preliminary grade cost estimates have been prepared for each of the alternatives identified by the engineering studies. This section describes the basis on which these estimates have been prepared to enable valid comparisons.

In general, each estimate consists of a schedule of quantities and unit rates with allowances added for engineering, construction supervision and unlisted items. This format has been deviated from only where there is insufficient data to quantify the work.

B. Quantities

Quantities have been calculated from sketch drawings of the proposed facilities and by scaling distances for pipelines and similar work from maps of the area. Earthwork quantities are based on depths of topsoil and other materials developed from the preliminary site investigations.

C. Unit Prices

Prices shown in the estimates are the equivalent of prices which would be bid by a contractor for performing the work and include contractor's direct cost, indirect cost and markup.

The large number of alternates precludes the detailed calculation of costs for each item. Detailed estimates have therefore been made for representative quantities of each of the major work classifications, and other prices have been interpolated from the results. For insignificant items, costs have been estimated on the basis of recently bid prices for similar work.

D. Bulk Materials

Telephone quotations were obtained for all major bulk material items, and allowances were added where appropriate for freight, taxes and waste.

E. Labor Rates

Labor rates used in the estimates are construction union rates for the Copperton area based on a 40-hour work week.

F. Construction Equipment

Construction equipment ownership and operating costs used in the estimates are taken from monthly rates listed in the Contractor's Equipment & Cost Guide published by Dataquest, Inc. for the Associated General Contractors of America.

G. Indirect and Overhead Costs and Profit

Estimates of cost for construction work performed by a contractor include contractor incurred indirect and overhead costs, which encompass the following:

- Mobilization of construction equipment and materials
- Salaries for supervisory, office and engineering personnel
- Wages for personnel not allocated to direct cost items
- Construction, operation and maintenance of temporary utilities, buildings and services
- Subsistence, travel and transportation for overhead and supervisory personnel
- Home office costs
- Non-payroll insurance and taxes
- Bonds, permits and licenses
- Contractor financing costs

- General site maintenance during construction
- Contractor's profit and contingency.

H. Unlisted Items - Allowance

Since the estimates are based on preliminary sketches, a 15% allowance has been added to each estimate for unlisted items to cover the cost of detail features which may be incoporated in the work during preparation of final designs.

I. Land Costs

Land acquisition costs shown in the estimates are based on prices provided by Kennecott's real estate personnel.

J. Estimate Base Date

The Estimate Base Date is Third Quarter 1985, and all estimates are based on prices in effect during that time. No escalation factor is included to accommodate inflation prior to or during the construction period.

K. Contingency

Unit prices shown in the estimates are made up of contractor's direct cost and indirect cost components. Direct costs are based on productivity forecasts which include contingency allowances for day-to-day occurrences, such as inclement weather and equipment breakdown, which affect the progress of the work. Indirect costs include a contingency allowance for risks which are assigned to the contractor by the Contract Documents.

In addition to the contingency allowances incorporated in the unit prices as described above, a project contingency based on corporate

procedures and policy for budgeting of capital cost expenditures must be added by Kennecott. Interest cost during construction should also be added.

5.2 SUMMARY OF ESTIMATED CAPITAL COSTS

The estimated capital costs for the various project alternative facilities and components are included on Tables 5.2-1 through 5.2-40, which appear at the conclusion of this chapter.

5.3 ECONOMIC EVALUATION OF TRADE-OFFS

Capital and operating cost estimates were prepared for each variant of the matrix combination shown in Tables 4.1-1 and 4.1-2 respectively. Estimates were grouped as follows.

A. Diversion

The captial cost for diversion of each of the drainages was developed from the size and length of the channels involved and a quantity take-off of materials. Unit prices were applied to these volumes to develop the capital cost.

Operating and maintenance costs were developed from estimated machine and operator hours required on an annual basis plus a percentage of capital cost for replacement of damaged channel sections.

B. Dry Fork Dam

The capital costs for three impoundment capacities for the Dry Fork Dam were developed based on quantity take-offs for embankments foundations, excavations and reservoir seepage control measures. Unit prices were applied to the separate quantities and the results were used to develop

a cost curve, as shown in Figure 5.3-1, showing total construction cost versus reservoir capacity. The capital costs of the dams at various capacities were taken from this curve and used in Table 4.1-1.

Operating costs were developed on the basis of a monthly inspection labor cost and a fixed maintenance cost.

C. Dry Fork Pumping

The capital cost was developed from material and equipment quantity take-offs for the pump station and piping required to pump the collected runoff over the divide to Burney's creek drainage and then pipe it to the existing pipeline for discharge to the Jordan River.

The operating cost was developed from the cost of power consumed per annum plus an allowance of a percentage of the capital cost for maintenance of the pump station and pipelines.

D. Dry Fork Tunnel

The use of a water drainage tunnel was considered as an alternative to the use of a pumping station. Water will be discharged from the dam and flow by gravity through a tunnel into the area of Barney's Creek and down the creek into a diversion structure. It will be piped by gravity from this structure into the existing pipeline for discharge into the Jordan River. Costs were prepared on the basis of quantities and unit prices for each item.

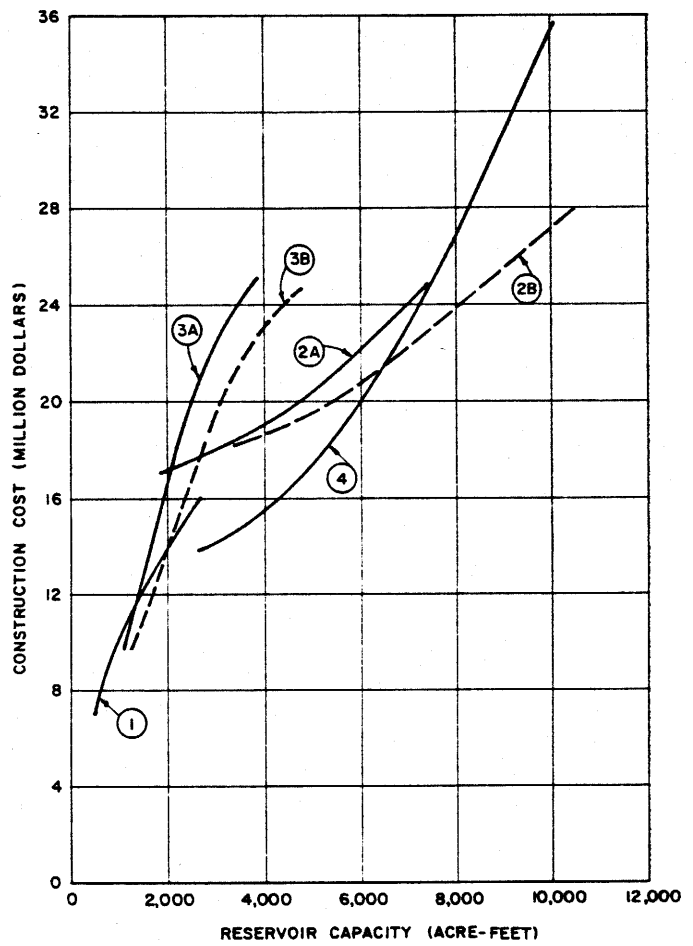
The operating and maintenance cost for this system was based on a fixed percentage of capital cost per annum.

E. Treatment of Carr Fork Ditch/Pit Water and Leach Water

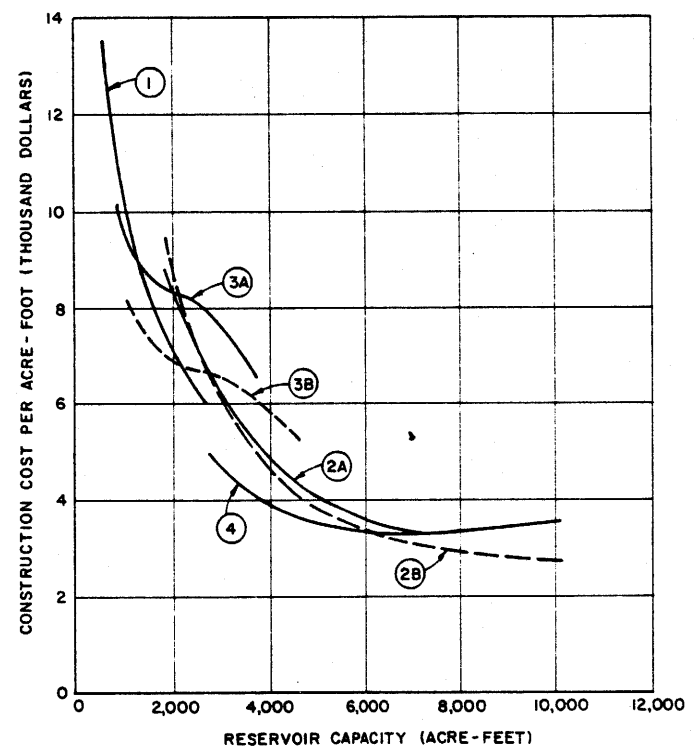
The capital costs of the plants, located near the concentrator tailings disposal area, were prepared by factoring the cost of the plants from Phase I. The cost of the lime receiving, storage, and slaking system

NOTES:

1. COST CURVES AND NORMALIZED COST CURVES ARE APPROXIMATE.
2. FOR INFORMATION ON COMPONENTS OF CONSTRUCTION COSTS, SEE TEXT SECTION 5.3.



COST CURVES



NORMALIZED COST CURVES

LEGEND:

1	DRY FORK DAMSITE (EMBANKMENT ONLY)
2A	NEW DAMSITE IN BINGHAM CANYON-ALTERNATE 1-CLAY LINER.
2B	NEW DAMSITE IN BINGHAM CANYON-ALTERNATE 2-SYNTHETIC LINER.
3A	EXISTING DAMSITE-ALTERNATE 1-CLAY LINER.
3B	EXISTING DAMSITE-ALTERNATE 2-SYNTHETIC LINER.
4	IMPOUNDMENT SOUTH OF BINGHAM CANYON.

PHASE II PROJECT REPORT

STORAGE COSTS
DAMS AND RESERVOIRS

DRAWN BY: R.C.	APPROVED BY: P.M.G.
DESIGN BY: M.P.F.	DATE: 12 NOV. 1985
CHECKED BY: P.M.G.	DWG. NO.: FIGURE 5.3-1

MORRISON-KNUDSEN ENGINEERS
A MORRISON KNUDSEN COMPANY
180 HOWARD ST., SAN FRANCISCO, CA 94105

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BY:

MICROFILM	JOB NO.

SCALE:

KENNECOTT MINERALS COMPANY
UTAH COPPER DIVISION
BINGHAM CANYON MINE
BINGHAM CANYON, UTAH

DRAWING NO.: FIGURE 5.3-1

REV.: PLANIT

PRELIMINARY-NOT FOR CONSTRUCTION

REFERENCE DWG. NO.	DESCRIPTION	REFERENCE DWG. NO.	DESCRIPTION	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D	NO.	DATE	REVISIONS	ZONE	BY	CKD.	AP'D

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APPROVED BY			CKD.		
APPROVED BY			CKD.		
APPROVED BY					

for each plant was based on a similar system recently built by Kennecott. Plant pipeline and settling pond costs were estimated from the quantities and unit prices of each item. The cost of right-of-way from the mine to the tailings disposal area was priced on the basis of recent land costs obtained from Kennecott. The cost of the mudcat dredging system was based on a telephone quotation from the manufacturer.

Operating costs for water treatment were developed from estimated labor requirements, power consumption, and reagent consumption using appropriate unit prices furnished by Kennecott. Maintenance costs were based on estimated labor factor plus an allowance of a fixed percentage of capital costs for maintenance supplies.

F. Storage Cost - Reservoirs

Cost curves showing total construction cost vs. reservoir capacity were prepared for each of the four impoundment alternatives. Normalized cost curves (cost per acre-foot of reservoir storage) vs. reservoir capacity are presented for comparison in Figure 5.3-1. The curves include the costs for the embankments, foundation excavation, and reservoir seepage control measures. For the present study, estimates for clay-blanketed reservoirs were not prepared for a new dam in Bingham Canyon with crest at or above elevation 5,295 feet and for the impoundments south of Bingham Canyon; only synthetic membrane-lined reservoirs were estimated for these two cases. The cost curve for the Dry Fork site pertains to the dam only.

Spillway and outlet works costs are included for the new and existing dams in Bingham Canyon; outlet works costs are included for the impoundments south of Bingham Canyon. Conveyance structures, such as canals and pipelines, are not included in any of the cost curves but are in the cost estimates.

Sediment and tailings removal costs are included in the cost curve for improvement or enlargement of the existing dam. Costs for removal of

sediment from the existing reservoir and breaching of the existing dam for alternatives which require decommissioning of the existing reservoir are not included in the cost curves. Tailings removal from the new reservoir site in Bingham Canyon is included in the cost curves.

Relocation of existing structures, pipelines, powerlines, roads, and railroads are included where applicable. Pump station costs for leach water return are included in the curves for the new dam in Bingham Canyon, the existing dam (as a relocation cost), and in the impoundments south of Bingham Canyon.

G. Treatment Plant Costs - 6.25K and 12.5K gpm Modules

These treatment plant modules will be located near the Bingham City Cemetery and the estimated costs have been developed accounting for alternate discharge to the new concentrator, C-7 canal, and the North Jordan canal. Capital costs were estimated assuming the continued use of the existing lime receiving, slaking, and storage facilities; the existing 20-million-gallon reservoir; and the existing discharge water reservoir. However, costs of lining these reservoirs have been included.

Phase I study capital costs and equipment price estimates were used to determine similar costs for this study. The capital costs of discharge pipelines are based on length and unit prices. Allowances are included where required for rental or purchase of right-of-way.

The cost of pumps, pump columns with support structure, and pipeline to the reservoir for Carr Fork underground, and a bed lining for Bingham Creek are included in the estimated cost of the first module.

The cost of collection piping from Bingham Tunnel, Butterfield Tunnel and Bingham Canyon subsurface water cutoffs and the cost of lined feed and discharge reservoirs are included in the price of the second module. The capital cost shown in Table 4.1-1 for the second module is

an incremental cost based on the assumption that a first module has already been constructed.

The operating costs for water treatment were developed from estimated labor requirements, power consumption and reagent consumption using the appropriate unit prices furnished by Kennecott. Maintenance costs were based on estimated labor factor plus an allowance of a fixed percentage of capital costs for maintenance supplies.

TABLE 5.2-1

CAPITAL COST ESTIMATE

SURFACE WATER COLLECTION CHANNELS

COPPERTON CHANNEL AND PIPELINE

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	EXCAVATION-COMMON	CY	16,400	$ 3.00	$ 49,200
2	FILL	CY	12,800	3.00	38,400
3	REINFORCED CONCRETE	CY	400	300.00	120,000
4	CONCRETE LINING	CY	1,800	250.00	450,000
5	PIPE (48" RCP)	LF	600	100.00	60,000
6	PIPE (36" HDPE)	LF	4,300	96.00	412,800
	SUBTOTAL				$1,130,400
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				169,560
	SUBTOTAL				$1,299,960
	UNLISTED ITEMS - ALLOWANCE (15%)				194,994
	TOTAL ESTIMATED COST				$1,494,954
	USE				$1,494,000

TABLE 5.2-2

CAPITAL COST ESTIMATE

SURFACE WATER COLLECTION CHANNELS

MARKHAM AND FREEMAN

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	EXCAVATION-COMMON	CY	400,000	$ 3.00	$1,200,000
2	FILL	CY	152,000	3.00	456,000
3	REINFORCED CONCRETE	CY	520	300.00	156,000
4	CONCRETE LINING	CY	6,500	250.00	1,625,000
5	RIP RAP	CY	4,400	20.00	88,000
6	FILTER BEDDING	CY	2,200	5.00	11,000
	SUBTOTAL				$3,536,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				530,400
	SUBTOTAL				$4,066,400
	UNLISTED ITEMS - ALLOWANCE (15%)				609,960
	TOTAL ESTIMATED COST				$4,676,360
	USE				$4,677,000

TABLE 5.2-3

CAPITAL COST ESTIMATE

SURFACE WATER COLLECTION CHANNELS

MARKHAM, FREEMAN, AND UPPER CARR FORK

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	EXCAVATION-COMMON	CY	563,000	$ 3.00	$1,689,000
2	FILL	CY	220,000	3.00	660,000
3	REINFORCED CONCRETE	CY	820	300.00	246,000
4	CONCRETE LINING	CY	9,100	250.00	2,275,000
5	RIP RAP	CY	6,800	20.00	136,000
6	FILTER BEDDING	CY	3,400	5.00	17,000
7	PIPE (48" HDPE)	LF	10,400	123.00	1,279,200
	SUBTOTAL				$6,302,200
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				945,330
	SUBTOTAL				$7,247,530
	UNLISTED ITEMS - ALLOWANCE (15%)				1,087,130
	TOTAL ESTIMATED COST				$8,334,660
	USE				$8,335,000

TABLE 5.2-4

CAPITAL COST ESTIMATE

SURFACE WATER COLLECTION CHANNELS

MARKHAM, FREEMAN, UPPER CARR FORK,

MUDDY, AND GALENA

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	EXCAVATION-COMMON	CY	621,000	$ 3.00	$1,863,000
2	FILL	CY	254,000	3.00	762,000
3	REINFORCED CONCRETE	CY	820	300.00	246,000
4	CONCRETE LINING	CY	10,300	250.00	2,575,000
5	RIP RAP	CY	7,800	20.00	156,000
6	FILTER BEDDING	CY	3,900	5.00	19,500
7	PIPE (48" HDPE)	LF	10,400	123.00	1,279,200
	SUBTOTAL				$6,900,700
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,035,105
	SUBTOTAL				$7,935,805
	UNLISTED ITEMS - ALLOWANCE (15%)				1,190,371
	TOTAL ESTIMATED COST				$9,126,176
	USE				$9,126,000

TABLE 5.2-5

CAPITAL COST ESTIMATE

DRY FORK DIVERSION TUNNEL

TO BARNEY'S WASH

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	PUMPS & PUMP HOUSE	LS	-	-	$ 6,000
2	PIPE (4" STEEL)	LF	14,000	$ 8.00	112,000
3	TUNNEL	LF	6,900	506.00	3,491,400
4	REINFORCED CONCRETE	CY	560	300.00	168,000
5	STEEL SLIDE GATE	EA	2	3,500.00	7,000
6	EXCAVATION - COMMON	CY	30,000	3.00	90,000
7	TRASH RACK & STOPLOG	LS	-	-	6,000
8	PIPE (28" HDPE)	LF	5,300	90.00	477,000
	SUBTOTAL				$4,357,400
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				653,610
	SUBTOTAL				$5,011,010
	UNLISTED ITEMS - ALLOWANCE (15%)				751,651
	TOTAL ESTIMATED COST				$5,762,662
	USE				$5,763,000

TABLE 5.2-6

CAPITAL COST ESTIMATE

DRY FORK DIVERSION PUMPING

TO BARNEY'S WASH

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	PUMP HOUSE (4X4000'GPM)	LS	-	-	$ 720,000
2	PUMP HOUSE (400GPM)	LS	-	-	6,000
3	PIPE (24" STEEL)	LF	6,800	$ 72.00	489,600
4	PIPE (4" STEEL)	LF	14,000	8.00	112,000
5	REINFORCED CONCRETE	CY	60	300.00	18,000
6	EXCAVATION - COMMON	CY	30,000	3.00	90,000
7	PIPE (28" HDPE)	LF	5,300	-	477,000
8	STEEL SLIDE GATE	EA	1	3,500.00	3,500
	SUBTOTAL				$1,916,100
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				287,415
	SUBTOTAL				$2,203,515
	UNLISTED ITEMS - ALLOWANCE (15%)				330,527
	TOTAL ESTIMATED COST				$2,534,042
	USE				$2,534,000

TABLE 5.2-7

CAPITAL COST ESTIMATE

DRY FORK DAMSITE

CREST ELEVATION 6,325 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 288,900
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	106,000	$ 8.00	848,000
2-2	ZONE 2 (SHELLS)	CY	684,000	2.10	1,436,400
2-3	CHIMNEY FILTER	CY	24,000	19.00	456,000
2-4	CHIMNEY DRAIN	CY	23,000	19.00	437,000
2-5	BLANKET DRAIN	CY	21,000	19.00	399,000
2-6	RIPRAP	CY	11,000	10.00	110,000
3	FOUNDATION				
3-1	EXCAVATION				
3-2	ROCK	CY	48,000	18.00	864,000
3-1-1	COMMON	CY	191,000	2.10	401,100
3-2	PREPARATION				
3-2-1	UNDER ZONE 1	SY	3,000	14.00	42,000
3-2-2	UNDER ZONE @	SY	34,000	6.00	204,000
3-3	SHOTCRETE	CY	180	320.00	57,600
3-4	GROUTING				
3-4-1	DRILLING (ROTARY)	LY	5,800	25.00	145,000
3-4-2	CEMENT	SK	900	18.00	16,200
3-4-3	NO. OF HOLES	EA	90	80.00	7,200
3-5	DEWATERING	LS	-	-	300,000
4	RESERVOIR CLEARING	AC	18	2,500.00	45,000
5	BORROW AREA RECLAMATION	AC	21	450.00	9,450
	SUBTOTAL				$6,066,850
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				910,027
	SUBTOTAL				$6,976,877
	UNLISTED ITEMS - ALLOWANCE (15%)				1,046,531
	TOTAL ESTIMATED COST				$8,023,408

TABLE 5.2-8

CAPITAL COST ESTIMATE

DRY FORK DAMSITE

CREST ELEVATION 6,375 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 454,600
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	180,000	$ 7.50	135,000
2-2	ZONE 2 (SHELLS)	CY	1,376,000	2.00	2,752,000
2-3	CHIMNEY FILTER	CY	36,000	18.50	666,000
2-4	CHIMNEY DRAIN	CY	35,000	18.50	647,500
2-5	BLANKET DRAIN	CY	38,000	18.50	703,000
2-6	RIPRAP	CY	16,000	9.50	152,000
3	FOUNDATION				
3-1	EXCAVATION				
3-2	ROCK	CY	70,000	16.00	1,120,000
3-1-1	COMMON	CY	279,000	2.00	558,000
3-2	PREPARATION				
3-2-1	UNDER ZONE 1	SY	5,000	13.00	65,000
3-2-2	UNDER ZONE 2	SY	59,000	5.50	324,500
3-3	SHOTCRETE	CY	270	310.00	83,700
3-4	GROUTING				
3-4-1	DRILLING (ROTARY)	LY	8,600	22.00	189,200
3-4-2	CEMENT	SK	1,400	16.00	22,400
3-4-3	NO. OF HOLES	EA	110	75.00	8,250
3-5	DEWATERING	LS	-	-	350,000
4	RESERVOIR CLEARING	AC	35	2,500.00	87,500
5	BORROW AREA RECLAMATION	AC	29	450.00	13,050
	SUBTOTAL				$ 9,546,700
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,432,005
	SUBTOTAL				$10,978,705
	UNLISTED ITEMS - ALLOWANCE (15%)				1,646,805
	TOTAL ESTIMATED COST				$12,625,510

TABLE 5.2-9

CAPITAL COST ESTIMATE

DRY FORK DAMSITE

CREST ELEVATION 6,400 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 560,800
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	229,000	$ 7.50	1,717,500
2-2	ZONE 2 (SHELLS)	CY	1,903,000	2.00	3,806,000
2-3	CHIMNEY FILTER	CY	43,000	18.00	774,000
2-4	CHIMNEY DRAIN	CY	42,000	18.00	756,000
2-5	BLANKET DRAIN	CY	44,000	18.00	792,000
2-6	RIPRAP	CY	21,000	9.00	189,000
3	FOUNDATION				
3-1	EXCAVATION				
3-2	ROCK	CY	84,000	15.00	1,260,000
3-1-1	COMMON	CY	336,000	2.00	672,000
3-2	PREPARATION				
3-2-1	UNDER ZONE 1	SY	6,000	12.00	72,000
3-2-2	UNDER ZONE 2	SY	70,000	5.00	350,000
3-3	SHOTCRETE	CY	320	300.00	96,000
3-4	GROUTING				
3-4-1	DRILLING (ROTARY)	LY	11,000	20.00	220,000
3-4-2	CEMENT	SK	1,700	15.00	25,500
3-4-3	NO. OF HOLES	EA	120	75.00	9,000
3-5	DEWATERING	LS	-	-	350,000
4	RESERVOIR CLEARING	AC	44	2,500.00	110,000
5	BORROW AREA RECLAMATION	AC	29	450.00	16,200
	SUBTOTAL				$11,776,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,766,400
	SUBTOTAL				$13,542,400
	UNLISTED ITEMS - ALLOWANCE (15%)				2,031,360
	TOTAL ESTIMATED COST				$15,573,760

TABLE 5.2-10

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE I

CREST ELEVATION 5,225 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 358,200
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	89,000	$ 2.50	222,500
2-2	ZONE 2 (SHELLS)	CY	489,000	0.60	293,400
2-3	CHIMNEY FILTER	CY	31,000	15.50	480,500
2-4	CHIMNEY DRAIN	CY	42,000	18.00	756,000
2-5	BLANKET DRAIN	CY	20,000	15.50	310,000
2-6	RIPRAP	CY	17,000	9.00	153,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	14,000	1.80	252,000
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	49,000	4.50	220,500
4	RESERVOIR CLEARING	AC	44	2,500.00	110,000
4-1	CLAY BLANKET	CY	757,000	2.30	1,741,100
4-2	SAND BEDDING	CY	237,000	0.80	189,600
4-3	SANDY GRAVEL COVER	CY	237,000	0.80	189,600
4-4	"HYPALON", OR EQUAL	SF	-	-	-
4-5	CLEARING	AC	98	1,500.00	147,000
4-6	EXCAV & STRIPPING	CY	158,000	1.00	158,000
4-7	TAILINGS EXCAVATION	CY	594,000	1.00	594,000
5	BORROW AREA RECLAMATION	AC	29	450.00	16,200
6	MONITOR WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	3,200	8.00	25,600
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-10 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$7,521,200
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,128,180
	SUBTOTAL				$8,649,380
	UNLISTED ITEMS - ALLOWANCE (15%)				1,297,407
	TOTAL ESTIMATED COST				$9,946,787

TABLE 5.2-11

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,240 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 482,700
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	106,000	$ 8.00	311,150
2-2	ZONE 2 (SHELLS)	CY	725,000	0.60	435,000
2-3	CHIMNEY FILTER	CY	42,000	15.00	630,000
2-4	BLANKET FILTER	CY	-	-	-
2-5	BLANKET DRAIN	CY	26,000	15.00	390,000
2-6	RIPRAP	CY	23,000	8.50	195,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	175,000	1.75	306,250
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	67,000	4.40	294,800
4	RESERVOIR				
4-1	CLAY BLANKET	CY	1,173,000	2.25	2,639,250
4-2	SAND BEDDING	CY	214,000	7.50	1,605,000
4-3	SANDY GRAVEL COVER	CY	321,000	0.80	256,800
4-4	SYNTHETIC LINER		-	-	-
4-4-1	"HYPALON",OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	132	1,300.00	171,600
4-6	EXCAV & STRIPPING	CY	214,000	1.00	214,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	157	420.00	65,940
6	MONITOR WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,200	8.00	33,600
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-11 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$10,136,090
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,520,413
	SUBTOTAL				$11,656,503
	UNLISTED ITEMS - ALLOWANCE (15%)				1,748,475
	TOTAL ESTIMATED COST				$13,404,978

TABLE 5.2-12

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE I

CREST ELEVATION 5,250 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 556,900
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	158,000	$ 2.40	379,200
2-2	ZONE 2 (SHELLS)	CY	924,000	1.00	924,000
2-3	CHIMNEY FILTER	CY	50,000	14.75	737,500
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	31,000	14.75	457,250
2-6	RIPRAP	CY	28,000	8.00	224,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	198,000	1.70	336,600
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	80,000	4.30	344,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	1,413,000	2.20	3,108,600
4-2	SAND BEDDING	CY	236,000	7.30	1,722,800
4-3	SANDY GRAVEL COVER	CY	254,000	0.80	283,200
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON", OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	146	1,200.00	175,200
4-6	EXCAV & STRIPPING	CY	236,000	1.00	236,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	184	400.00	73,600
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,000	8.00	32,000
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-12 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$11,695,350
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,754,302
	SUBTOTAL				$13,449,652
	UNLISTED ITEMS - ALLOWANCE (15%)				2,017,448
	TOTAL ESTIMATED COST				$15,467,100

TABLE 5.2-13

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,275 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 812,800
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	274,000	$ 2.30	630,200
2-2	ZONE 2 (SHELLS)	CY	1,695,000	1.70	2,881,500
2-3	CHIMNEY FILTER	CY	81,000	13.50	1,093,500
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	49,000	13.50	61,500
2-6	RIPRAP	CY	45,000	7.50	337,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	275,000	1.60	440,000
3-2	PREPARATION	SY	126,000	4.10	516,600
4	RESERVOIR				
4-1	CLAY BLANKET	CY	2,113,000	2.10	4,437,300
4-2	SAND BEDDING	CY	290,000	7.00	2,030,000
4-3	SANDY GRAVEL COVER	CY	435,000	1.10	478,500
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON",OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	179	1,150.00	205,850
4-6	EXCAV & STRIPPING	CY	290,000	1.00	290,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	260	380.00	98,800
6	MONITOR WELLS	LF	1,200	35.00	42,000
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,800	8.00	38,400
8	FENCING	LF	7,500	10.00	75,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-13 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$17,069,450
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,560,417
	SUBTOTAL				$19,629,867
	UNLISTED ITEMS - ALLOWANCE (15%)				2,944,480
	TOTAL ESTIMATED COST				$22,574,347

TABLE 5.2-14

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,225 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 368,500
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	646,000	$ 0.60	387,600
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	LINER BEDDING	CY	8,000	8.00	64,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	14,000	1.80	252,000
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	49,000	4.50	220,500
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	158,000	7.75	1,224,500
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON", OR EQUAL	SF	4,257,000	0.75	3,192,750
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	98	1,500.00	147,000
4-6	EXCAV & STRIPPING	CY	158,000	1.00	158,000
4-7	TAILINGS EXCAVATION	CY	594,000	1.00	594,000
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	3,200	8.00	25,600
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-14 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$ 7,688,950
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,160,842
	SUBTOTAL				$ 8,899,792
	UNLISTED ITEMS - ALLOWANCE (15%)				1,334,969
	TOTAL ESTIMATED COST				$10,234,761

TABLE 5.2-15

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,240 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 483,200
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	943,000	$ 0.60	565,800
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	LINER BEDDING	CY	1,200,000	7.55	90,600
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	175,000	1.75	306,250
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	67,000	4.40	294,800
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	214,000	7.30	1,562,200
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON", OR EQUAL	SF	5,762,000	0.75	4,321,500
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	132	1,300.00	171,600
4-6	EXCAV & STRIPPING	CY	214,000	1.00	214,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,200	8.00	33,600
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-15 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$10,148,050
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,522,207
	SUBTOTAL				$11,670,257
	UNLISTED ITEMS - ALLOWANCE (15%)				1,750,539
	TOTAL ESTIMATED COST				$13,420,796

TABLE 5.2-16

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,250 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 541,400
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	1,191,000	$ 0.85	1,012,350
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	LINER BEDDING	CY	1,400,000	7.50	105,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	198,000	1.70	336,600
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	80,000	4.30	344,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	236,000	7.25	1,711,000
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4	SYNTHETIC LINER		-	-	-
4-4-1	"HYPALON", OR EQUAL	SF	6,362,000	0.75	4,771,500
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	132	1,200.00	175,200
4-6	EXCAV & STRIPPING	CY	236,000	1.00	236,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,000	8.00	32,000
8	FENCING	LF	7,300	10.00	73,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-16 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$11,369,550
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,705,432
	SUBTOTAL				$13,074,982
	UNLISTED ITEMS - ALLOWANCE (15%)				1,961,247
	TOTAL ESTIMATED COST				$15,036,230

TABLE 5.2-17

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,275 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 746,600
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	2,144,000	$ 1.80	3,430,400
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	LINER BEDDING	CY	22,000	6.75	148,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	275,000	1.60	440,000
3-3	PREPARATION	SY	126,000	4.10	516,600
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	290,000	6.50	1,885,000
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON", OR EQUAL	SF	7,814,000	0.75	5,860,500
4-5	CLEARING	AC	179	1,150.00	205,850
4-6	EXCAV & STRIPPING	CY	290,000	1.00	290,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC			
6	MONITER WELLS	LF	1,200	35.00	42,000
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	-	-
7-2	POWER LINES	LF	4,800	8.00	38,400
7-3	PIPE LINES	LF			
8	FENCING	LF	7,500	10.00	75,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-17 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$15,678,850
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,351,827
	SUBTOTAL				$18,030,677
	UNLISTED ITEMS - ALLOWANCE (15%)				2,704,602
	TOTAL ESTIMATED COST				$20,735,279

TABLE 5.2-18

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,295 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 897,000
2	EMBANKMENT				
2-2	ZONE 2	CY	3,358,000	$ 1.50	5,037,000
2-7	LINER BEDDING	CY	32,000	6.15	196,800
3	FOUNDATION				
3-1	FOUNDATION EXCAVATION	CY	350,000	1.50	525,000
3-3	PREPARATION	SY	182,000	3.90	709,800
4	RESERVOIR				
4-2	SAND BEDDING	CY	290,000	6.50	1,885,000
4-4-1	"HYPALON"	SF	9,017,000	0.75	6,762,750
4-5	CLEARING	AC	207	1,100.00	227,700
4-6	EXCAV & STRIPPING	CY	334,000	1.00	334,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
6	MONITER WELLS	LF	1,500	35.00	52,500
7	STRUCTURE RELOCATION				
7-2	POWER LINES	LF	5,600	8.00	44,800
8	FENCING	LF	8,400	10.00	84,000
9	PUMP STATION	LS	-	-	1,000,000
	SUBTOTAL				$18,841,950
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,826,292
	SUBTOTAL				$21,668,242
	UNLISTED ITEMS - ALLOWANCE (15%)				3,250,236
	TOTAL ESTIMATED COST				$24,918,479

TABLE 5.2-19

CAPITAL COST ESTIMATE

NEW DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,310 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 1,098,900
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	4,664,000	$ 1.65	7,695,600
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	CHIMNEY DRAIN	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	LINER BEDDING	CY	45,000	6.00	270,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	426,000	1.45	617,700
3-2	PREPARATION	SY	246,000	3.80	934,800
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	362,000	5.75	2,081,500
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON", OR EQUAL	SF	9,768,000	0.75	7,326,000
4-5	CLEARING	AC	224	11.00	246,400
4-6	EXCAV & STRIPPING	CY	362,000	1.00	362,000
4-7	TAILINGS EXCAVATION	CY	1,000,000	1.00	1,000,000
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITOR WELLS	LF	1,800	35.00	63,000
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	2,400	100.00	240,000
7-2	POWER LINES	LF	6,000	8.00	48,000
7-3	PIPE LINES	LF	-	-	-
8	FENCING	LF	9,200	10.00	92,000
9	PUMP STATION	LS	-	-	1,000,000

TABLE 5.2-19 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	SUBTOTAL				$23,075,900
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				3,461,385
	SUBTOTAL				$26,537,285
	UNLISTED ITEMS - ALLOWANCE (15%)				3,980,593
	TOTAL ESTIMATED COST				$30,517,878

TABLE 5.2-20

CAPITAL COST ESTIMATE

NEW RESERVOIR - SPILLWAY AND OUTLET WORKS

DAM CREST ELEVATION 5,230 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	2,270,000	$ 1.75	$3,972,500
1-2	REINFORCED CONCRETE	CY	840	300.00	252,000
1-3	FILTER BEDDING	CY	6,200	5.00	31,000
1-4	RIP RAP	CY	11,500	20.00	230,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,100	1.75	1,925
2-2	REINFORCED CONCRETE	CY	690	300.00	207,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	330	15.00	4,950
2-6	PIPE (24"RCP)	LF	360	50.00	18,000
2-7	STEEL SLIDE GATE-24"	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACK	LS	-	-	5,000
	SUBTOTAL				$4,728,475
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				709,271
	SUBTOTAL				$5,437,746
	UNLISTED ITEMS - ALLOWANCE (15%)				815,662
	TOTAL ESTIMATED COST				$6,253,408
	USE				$6,254,000

TABLE 5.2-21

CAPITAL COST ESTIMATE

NEW RESERVOIR - SPILLWAY AND OUTLET

DAM CREST ELEVATION 5,245 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	1,340,000	$ 1.75	$2,345,000
1-2	REINFORCED CONCRETE	CY	840	300.00	252,000
1-3	FILTER BEDDING	CY	6,200	5.00	31,000
1-4	RIP RAP	CY	11,500	20.00	230,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,200	1.75	2,100
2-2	REINFORCED CONCRETE	CY	860	300.00	258,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	410	15.00	6,150
2-6	PIPE (24" RCP)	LF	420	50.00	21,000
2-7	STEEL SLIDE GATE-24"	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACK	LS	-	-	5,000
	SUBTOTAL				$3,156,350
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				473,453
	SUBTOTAL				$3,629,803
	UNLISTED ITEMS - ALLOWANCE (15%)				544,470
	TOTAL ESTIMATED COST				$4,174,273
	USE				$4,175,000

TABLE 5.2-22

CAPITAL COST ESTIMATE

NEW RESERVOIR - SPILLWAY AND OUTLET WORKS

DAM CREST ELEVATION 5,260 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	650,000	$ 1.75	$1,137,500
1-2	REINFORCED CONCRETE	CY	840	300.00	252,000
1-3	FILTER BEDDING	CY	6,200	5.00	31,000
1-4	RIP RAP	CY	11,500	20.00	230,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,300	1.75	2,275
2-2	REINFORCED CONCRETE	CY	1,050	300.00	315,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	480	15.00	7,200
2-6	PIPE (24" RCP)	LF	500	50.00	25,000
2-7	SLIDE GATE	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACI	LS	-	-	5,000
	SUBTOTAL				$2,011,075
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				301,661
	SUBTOTAL				$2,312,736
	UNLISTED ITEMS - ALLOWANCE (15%)				346,910
	TOTAL ESTIMATED COST				$2,659,646
	USE				$2,660,000

TABLE 5.2-23

CAPITAL COST ESTIMATE

NEW RESERVOIR - SPILLWAY AND OUTLET WORKS

DAM CREST ELEVATION 5,275 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	340,000	$ 1.75	$ 595,000
1-2	REINFORCED CONCRETE	CY	840	300.00	252,000
1-3	FILTER BEDDING	CY	6,200	5.00	31,000
1-4	RIP RAP	CY	11,500	20.00	230,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,400	1.75	2,450
2-2	REINFORCED CONCRETE	CY	1,230	300.00	369,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	560	15.00	8,400
2-6	PIPE (24" RCP)	LF	560	50.00	28,000
2-7	SLIDE GATE	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACK	LS	-	-	5,000
	SUBTOTAL				$1,526,950
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				229,043
	SUBTOTAL				$1,755,993
	UNLISTED ITEMS - ALLOWANCE (15%)				263,399
	TOTAL ESTIMATED COST				$2,019,392
	USE				$2,202,000

TABLE 5.2-24

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,314 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 360,200
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	34,000	$ 3.50	119,000
2-2	ZONE 2 (SHELLS)	CY	43,000	2.50	107,500
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	7,000	16.50	115,500
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	7,000	10.00	70,000
2-7	BUTTRESS	CY	139,000	1.75	243,250
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	84,000	2.00	168,000
3-2	PREPARATION	SY	5,000	5.10	25,500
3-3	DEWATERING	LS	-	-	45,000
3-4	STRIPPING	CY	7,000	2.25	15,750
4	RESERVOIR				
4-1	CLAY BLANKET	CY	593,000	2.35	1,393,550
4-2	SAND BEDDING	CY	127,000	8.00	1,016,000
4-3	SANDY GRAVEL COVER	CY	190,000	2.30	437,000
4-4-1	"HYPALON" OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	21	1,000.00	21,000
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RE.	CY	33,000	1.70	56,100
5	BORROW AREA RECLAMATION	AC	73	400.00	29,200
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	100.00	-
7-2	POWER LINES	LF	-	5.00	-
7-3	PIPE LINES	LS	-	-	-
7-4	PUMP STATION	LS	-	-	-
7-5	CANAL	LF	-	70.00	-
7-6	ACCESS ROAD	LF	-	20.00	-

TABLE 5.2-24 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
8	FENCING	LF	-	$ 10.00	-
9	SEDIMENT/TAILINGS STORAGE POND	LS	-	-	$ 760,000
	SUBTOTAL				$ 7,564,050
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,134,607
	SUBTOTAL				$ 8,698,657
	UNLISTED ITEMS - ALLOWANCE (15%)				1,304,799
	TOTAL ESTIMATED COST				$10,003,456

TABLE 5.2-25

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,325 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 503,200
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	48,000	$ 3.00	144,000
2-2	ZONE 2 (SHELLS)	CY	244,000	2.00	488,000
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	13,000	15.75	204,750
2-5	BLANKET DRAIN	CY	24,000	15.75	378,000
2-6	RIP RAP	CY	10,000	10.00	100,000
2-7	BUTTRESS	CY	139,000	1.75	243,250
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	148,000	1.80	266,400
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	18,000	5.00	90,000
3-4	STRIPPING	CY	14,000	2.00	28,000
3-5	DEWATERING	LS	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	757,000	2.30	1,741,100
4-2	SAND BEDDING	CY	143,000	7.90	1,129,700
4-3	SANDY GRAVEL COVER	CY	214,000	2.30	492,200
4-4-1	"HYPALON" OR EQUAL	SF	-	-	-
4-5	CLEARING	AC	31	900.00	27,900
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RE.	CY	51,000	1.60	81,600
5	BORROW AREA RECLAMATION	AC	104	400.00	41,600
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	100.00	-
7-2	POWER LINES	LF	2,000	8.00	16,000
7-3	PIPE LINES	LS	-	-	20,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	1,500	70.00	105,000
7-6	ACCESS ROAD	LF	-	20.00	-
7-7	WEIR	LS	-	-	20,000

TABLE 5.2-25 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
8	FENCING	LF	60,000	$ 10.00	$ 60,000
9	SEDIMENT/TAILINGS STORAGE POND	LS	-	-	760,000
	SUBTOTAL				$10,567,200
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,585,080
	SUBTOTAL				$12,152,280
	UNLISTED ITEMS - ALLOWANCE (15%)				1,822,842
	TOTAL ESTIMATED COST				$13,975,122

TABLE 5.2-26

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,335 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 680,500
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	70,000	$ 2.75	192,500
2-2	ZONE 2 (SHELLS)	CY	545,000	1.90	1,035,500
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	18,000	15.55	279,000
2-5	BLANKET DRAIN	CY	36,000	15.50	558,000
2-6	RIP RAP	CY	16,000	9.00	144,000
2-7	BUTTRESS	CY	1,390,000	1.75	243,250
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	224,000	1.65	369,600
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	39,000	4.50	175,500
3-4	STRIPPING	CY	14,000	2.00	28,000
3-5	DEWATERING	LS	-	-	45,000
4	RESERVOIR		-	-	-
4-1	CLAY BLANKET	CY	1,109,000	2.25	2,495,250
4-2	SAND BEDDING	CY	191,000	7.50	1,432,500
4-3	SANDY GRAVEL COVER	CY	286,000	2.25	643,500
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON" OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	61	850.00	51,850
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	99,000	1.55	153,450
5	BORROW AREA RECLAMATION	AC	149	400.00	59,600
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	5,500	100.00	550,000
7-2	POWER LINES	LF	7,500	8.00	60,000
7-3	PIPE LINES	LS	-	-	50,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	6,800	70.00	476,000
7-6	ACCESS ROAD	LF	1,000	20.00	20,000

TABLE 5.2-26 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
7-7	PAVED ROAD	LF	1,150	$ 40.00	$ 46,000
7-8	SUBSTATION	LS	-	-	10,000
7-9	CONCRETE BOX CULVERT	LS	-	-	10,000
7-10	WEIR	LS	-	-	20,000
8	FENCING	LF	12,000	10.00	120,000
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	760,000
	SUBTOTAL				$14,290,500
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,143,575
	SUBTOTAL				$16,434,075
	UNLISTED ITEMS - ALLOWANCE - (15%)				2,465,111
	SUBTOTAL				$18,899,186
	LAND ACQUISITION				113,110
	TOTAL ESTIMATED COST				$19,012,296

TABLE 5.2-27

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 1

CREST ELEVATION 5,350 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 680,500
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	97,000	$ 2.50	242,500
2-2	ZONE 2 (SHELLS)	CY	1,042,000	1.80	1,875,600
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	18,000	15.55	279,000
2-5	BLANKET DRAIN	CY	36,000	15.50	558,000
2-6	RIPRAP	CY	16,000	9.00	144,000
2-7	BUTTRESS	CY	1,390,000	1.75	243,250
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	224,000	1.65	369,600
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	39,000	4.50	175,500
3-4	STRIPPING	CY	14,000	2.00	28,000
3-5	DEWATERING	LS	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	1,109,000	2.25	2,495,250
4-2	SAND BEDDING	CY	191,000	7.50	1,432,500
4-3	SANDY GRAVEL COVER	CY	286,000	2.25	643,500
4-4	SYNTHETIC LINER				
4-4-1	"HYPALON" OR EQUAL	SF	-	-	-
4-4-2	CPE	SF	-	-	-
4-5	CLEARING	AC	61	850.00	51,850
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	99,000	1.55	153,450
5	BORROW AREA RECLAMATION	AC	149	400.00	59,600
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	5,500	100.00	550,000
7-2	POWER LINES	LF	7,500	8.00	60,000
7-3	PIPE LINES	LS	-	-	50,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	6,800	70.00	476,000
7-6	ACCESS ROAD	LF	1,000	20.00	20,000

TABLE 5.2-27 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
7-7	PAVED ROAD	LF	1,150	$ 40.00	$ 46,000
7-8	SUBSTATION	LS	-	-	10,000
7-9	CONCRETE BOX CULVERT	LS	-	-	10,000
7-10	WEIR	LS	-	-	20,000
8	FENCING	LF	14,000	10.00	140,000
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	760,000
	SUBTOTAL				$18,105,450
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,715,817
	SUBTOTAL				$20,821,267
	UNLISTED ITEMS - ALLOWANCE (15%)				3,123,190
	SUBTOTAL				$23,944,457
	LAND ACQUISITION				113,100
	TOTAL ESTIMATED COST				$24,057,557

TABLE 5.2-28

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,314 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$389,400
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	-	-	-
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	-	-	-
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	SAND BEDDING	CY	21,000	$ 8.25	173,250
2-7	BUTTRESS	CY	262,000	1.75	258,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	530,000	2.00	106,000
3-2	PREPARATION	SY	-	-	-
3-3	DEWATERING	CY	14,000	2.00	28,000
3-4	STRIPPING	LS	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	127,000	8.00	1,016,000
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON" OR EQUAL	SF	3,406,000	0.75	2,554,500
4-5	CLEARING	AC	21	1,000.00	21,000
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	33,000	1.70	56,100
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	100.00	-
7-2	POWER LINES	LF	-	8.00	-
7-3	PIPE LINES	LS	-	-	-
7-4	PUMP STATION	LS	-	-	-
7-5	CANAL	LF	-	70.00	-
7-6	ACCESS ROAD	LF	-	20.00	-

TABLE 5.2-28 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
8	FENCING	LF	-	$ 10.00	-
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	$ 760,000
	SUBTOTAL				$ 8,177,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,226,550
	SUBTOTAL				$ 9,403,550
	UNLISTED ITEMS - ALLOWANCE (15%)				1,410,532
	TOTAL ESTIMATED COST				$10,814,082

TABLE 5.2-29

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,325 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 520,600
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	310,000	$ 2.00	620,000
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	3,000	16.50	49,500
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	SAND BEDDING	CY	23,000	8.15	187,450
2-7	BUTTRESS	CY	262,000	1.75	458,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	128,000	1.90	243,200
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	17,000	5.00	85,000
3-5	STRIPPING	LS	14,000	2.00	28,000
3-4	DEWATERING	CY	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	143,000	7.90	1,129,700
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON" OR EQUAL	SF	3,857,000	0.75	2,892,750
4-5	CLEARING	AC	31	900.00	27,900
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	51,000	1.60	81,600
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	-	100.00	-
7-2	POWER LINES	LF	2,000	8.00	16,000
7-3	PIPE LINES	LS	-	-	20,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	1,500	70.00	105,000
7-6	ACCESS ROAD	LF	-	20.00	-
7-7	WEIR	LS	-	-	20,000

TABLE 5.2-29 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
8	FENCING	LF	6,000	$ 10.00	$ 60,000
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	760,000
	SUBTOTAL				$10,931,700
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,639,755
	SUBTOTAL				$12,571,455
	UNLISTED ITEMS - ALLOWANCE (15%)				1,885,718
	TOTAL ESTIMATED COST				$14,457,173

TABLE 5.2-30

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,335 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 685,800
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	644,000	$ 1.85	1,191,400
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	6,000	16.50	99,000
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIPRAP	CY	-	-	-
2-7	SAND BEDDING	CY	26,000	7.75	201,500
2-7	BUTTRESS	CY	262,000	1.75	458,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	182,000	1.90	209,400
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	38,000	4.50	171,000
3-5	STRIPPING	LS	14,000	2.00	28,000
3-4	DEWATERING	CY	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	191,000	7.50	1,432,500
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON" OR EQUAL	SF	5,160,000	0.75	3,870,000
4-5	CLEARING	AC	61	850.00	51,850
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	99,000	1.55	153,450
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	5,500	100.00	550,000
7-2	POWER LINES	LF	7,500	8.00	60,000
7-3	PIPE LINES	LS	-	-	50,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	6,800	70.00	476,000
7-6	ACCESS ROAD	LF	1,000	20.00	20,000
7-7	PAVED ROAD	LF	1,150	40.00	46,000

TABLE 5.2-30 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
7-8	SUBSTATION	LS	-	-	$ 10,000
7-9	CONCRETE BOX CULVERT	LS	-	-	10,000
7-10	WEIR	LS	-	-	20,000
8	FENCING	LF	12,000	$ 10.00	120,000
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	760,000
	SUBTOTAL				$14,400,900
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,160,135
	SUBTOTAL				$16,561,035
	UNLISTED ITEMS - ALLOWANCE (15%)				2,484,155
	SUBTOTAL				$19,045,190
	LAND ACQUISITION				113,100
	TOTAL ESTIMATED COST				$19,158,290

TABLE 5.2-31

CAPITAL COST ESTIMATE

EXISTING DAMSITE

ALTERNATIVE 2

CREST ELEVATION 5,350 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 839,000
2	EMBANKMENT				
2-1	ZONE 1 (CORE)	CY	-	-	-
2-2	ZONE 2 (SHELLS)	CY	1,148,000	$ 1.80	2,066,400
2-3	CHIMNEY FILTER	CY	-	-	-
2-4	BLANKET FILTER	CY	9,000	16.50	148,500
2-5	BLANKET DRAIN	CY	-	-	-
2-6	RIP RAP	CY	-	-	-
2-7	SAND BEDDING	CY	29,000	7.75	224,750
2-7	BUTTRESS	CY	262,000	1.75	458,500
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	252,000	1.65	415,800
3-2	EXCAVATION (ROCK)	CY	-	-	-
3-3	PREPARATION	SY	61,000	4.40	268,400
3-5	STRIPPING	LS	14,000	2.00	28,000
3-4	DEWATERING	CY	-	-	45,000
4	RESERVOIR				
4-1	CLAY BLANKET	CY	-	-	-
4-2	SAND BEDDING	CY	212,000	7.50	1,590,000
4-3	SANDY GRAVEL COVER	CY	-	-	-
4-4-1	"HYPALON" OR EQUAL	SF	5,711,000	0.75	4,283,250
4-5	CLEARING	AC	74	800.00	59,200
4-6	EXCAV OF SEDIMENT	CY	1,020,000	2.50	2,550,000
4-7	STRIPPING ABOVE EXISTING RES.	CY	119,000	1.50	178,500
5	BORROW AREA RECLAMATION	AC	-	-	-
6	MONITER WELLS	LF	900	35.00	31,500
7	STRUCTURE RELOCATION				
7-1	RAILROAD	LF	9,000	100.00	900,000
7-2	POWER LINES	LF	10,900	8.00	87,200
7-3	PIPE LINES	LS	-	-	608,000
7-4	PUMP STATION	LS	-	-	1,000,000
7-5	CANAL	LF	11,000	70.00	770,000
7-6	ACCESS ROAD	LF	4,000	20.00	80,000
7-7	PAVED ROAD	LF	1,150	40.00	46,000

TABLE 5.2-31 (continued)

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
7-8	SUBSTATION	LS	-	-	$ 10,000
7-9	CONCRETE BOX CULVERT	LS	-	-	10,000
7-10	WEIR	LS	-	-	20,000
8	FENCING	LF	14,000	$ 10.00	140,000
9	SEDIMENT/TAILINGS STORAGE PONDS	LS	-	-	760,000
	SUBTOTAL				$17,618,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,642,700
	SUBTOTAL				$20,260,700
	UNLISTED ITEMS - ALLOWANCE (15%)				3,039,105
	SUBTOTAL				$23,299,805
	LAND ACQUISITION				113,100
	TOTAL ESTIMATED COST				$23,412,905

TABLE 5.2-32

CAPITAL COST ESTIMATE

EXISTING RESERVOIR - SPILLWAY AND OUTLET WORKS

DAM CREST ELEVATION 5,330 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	4,100	$ 1.75	$ 7,175
1-2	REINFORCED CONCRETE	CY	660	300.00	198,000
1-3	FILTER BEDDING	CY	230	5.00	1,150
1-4	RIP RAP	CY	250	20.00	5,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,200	1.75	2,100
2-2	REINFORCED CONCRETE	CY	730	300.00	219,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	440	15.00	22,000
2-6	PIPE (24" RCP)	LF	350	50.00	5,250
2-7	SLIDE GATE	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACK	LS	-	-	5,000
	SUBTOTAL				$ 470,775
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				70,616
	SUBTOTAL				$ 541,391
	UNLISTED ITEMS - ALLOWANCE (15%)				81,209
	TOTAL ESTIMATED COST				$ 622,600
	USE				$ 623,000

TABLE 5.2-33

CAPITAL COST ESTIMATE

EXISTING RESERVOIR - SPILLWAY AND OUTLET WORKS

DAM CREST ELEVATION 5,350 FEET

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	SPILLWAY				
1-1	EXCAVATION - COMMON	CY	6,700	$ 1.75	$ 11,725
1-2	REINFORCED CONCRETE	CY	620	300.00	186,000
1-3	FILTER BEDDING	CY	250	5.00	1,250
1-4	RIP RAP	CY	250	20.00	5,000
2	OUTLET WORKS				
2-1	EXCAVATION - COMMON	CY	1,300	1.75	2,275
2-2	REINFORCED CONCRETE	CY	970	300.00	291,000
2-3	FILTER BEDDING	CY	60	5.00	300
2-4	RIP RAP	CY	140	20.00	2,800
2-5	HANDRAILS	LF	540	15.00	27,000
2-6	PIPE (24" RCP)	LF	450	50.00	6,750
2-7	SLIDE GATE	EA	1	3,000.00	3,000
2-8	STOP LOG & TRASH RACK	LS	-	-	5,000
	SUBTOTAL				$ 542,100
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				81,315
	SUBTOTAL				$ 623,415
	UNLISTED ITEMS - ALLOWANCE (15%)				93,512
	TOTAL ESTIMATED COST				$ 716,927
	USE				$ 717,000

TABLE 5.2-34

CAPITAL COST ESTIMATE

NEW IMPOUNDMENT SOUTH OF BINGHAM CREEK

CELL 1

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 514,800
2	EMBANKMENT				
2-1	EMBANKMENT	CY	2,408,000	$ 1.50	3,612,000
2-2	SAND BEDDING	CY	32,000	6.75	216,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	215,000	1.40	301,000
3-3	FOUNDATION PREPARATION	SY	215,000	3.00	645,000
4	RESERVOIR				
4-2	SAND BEDDING	CY	142,000	6.50	923,000
4-4-1	HYPALON	SF	4,140,000	0.75	3,105,050
4-5	CLEAR	AC	88	1,100.00	96,800
4-6	STRIPPING	CY	142,000	1.00	142,000
6	MONITER WELLS	LF	800	35.00	28,000
7	STRUCTURE RELOCATION				
7-2	POWER LINES	FT	6,600	8.00	52,800
7-6	ACCESS ROAD (GRAVEL)	LF	4,700	20.00	94,000
8	FENCING	FT	8,000	10.00	80,000
9	PUMP STATION	LS	-	-	1,000,000
	SUBTOTAL				$10,810,400
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				1,621,560
	SUBTOTAL				$12,431,960
	UNLISTED ITEMS - ALLOWANCE (15%)				1,864,794
	TOTAL ESTIMATED COST				$14,296,754

TABLE 5.2-35

CAPITAL COST ESTIMATE

NEW IMPOUNDMENT SOUTH OF BINGHAM CREEK

CELL 2

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	-	-	$ 699,400
2	EMBANKMENT				
2-1	EMBANKMENT	CY	3,558,000	$ 1.50	5,337,000
2-2	SAND BEDDING	CY	40,000	6.75	270,000
3	FOUNDATION				
3-1	EXCAVATION (COMMON)	CY	279,000	1.40	390,600
3-3	FOUNDATION PREPARATION	SY	279,000	3.00	837,000
4	RESERVOIR				
4-2	SAND BEDDING	CY	229,000	6.50	1,488,500
4-4-1	HYPALON	SF	6,680,000	0.75	5,010,000
4-5	CLEAR	AC	142	1,100.00	156,200
4-6	STRIPPING	CY	229,000	1.00	229,000
6	MONITER WELLS	LF	1,800	35.00	35,000
7	STRUCTURE RELOCATION				
7-2	POWER LINES	FT	-	-	-
7-6	ACCESS ROAD (GRAVEL)	LF	4,700	20.00	94,000
8	FENCING	FT	8,000	10.00	80,000
	SUBTOTAL				$14,626,700
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				2,194,005
	SUBTOTAL				$16,820,705
	UNLISTED ITEMS - ALLOWANCE (15%)				2,523,106
	TOTAL ESTIMATED COST				$19,343,811

TABLE 5.2-36

CAPITAL COST ESTIMATE

TREATMENT PLANT

CASE Ia

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	PIPELINE - 10" Ø DRISCO	FT	92,000	$ 21.83	$2,008,000
2	TREATMENT PLANT W/LIME RECEIVING, STORAGE, SLAKING	LS	-	-	1,174,000
3	TWO SETTLING PONDS LINED	EA	2	334,000.00	668,000
4	MUCKOUT SLUDGE; RECLAIM TO TAILINGS	LS	-	-	153,000
	SUBTOTAL				$4,003,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				600,450
	SUBTOTAL				$4,603,450
	UNLISTED ITEMS - ALLOWANCE (15%)				690,518
	TOTAL ESTIMATED COST				$5,293,968
	USE				$5,294,000

NOTE: TREATMENT PLANT COSTS ARE FACTORED COSTS.

TABLE 5.2-37

CAPITAL COST ESTIMATE

TREATMENT PLANT

CASE Ib

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	PIPELINE - 14" Ø DRISCO	FT	92,000	$ 27.47	$2,527,000
2	TREATMENT PLANT W/LIME RECEIVING, STORAGE, SLAKING	LS	-	-	1,538,000
3	TWO SETTLING PONDS LINED	EA	2	334,000.00	668,000
4	MUCKOUT SLUDGE; RECLAIM TO TAILINGS	LS	-	-	153,000
	SUBTOTAL				$4,886,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				732,900
	SUBTOTAL				$5,618,900
	UNLISTED ITEMS - ALLOWANCE (15%)				842,835
	TOTAL ESTIMATED COST				$6,641,735
	USE				$6,462,000

NOTE: TREATMENT PLANT COSTS ARE FACTORED COSTS.

TABLE 5.2-38

CAPITAL COST ESTIMATE

TREATMENT PLANT

CASE II

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	CARR FORK UNDERGROUND MINE PUMPS, PIPELINE	LS	-	-	$1,120,000
2	LINING OF EXISTING 20MG RES				
2-1	EXCAVATION	CY	14,519	$ 6.00	87,000
2-2	LINER	SF	196,000	.75	147,000
2-3	COVER	CY	7,259	5.00	36,000
3	TREATMENT PLANT	LS	-	-	1,675,000
4	LINING OF EXISTING CEMETERY RESERVOIR				
4-1	EXCAVATION	CY	17,259	6.00	104,000
4-2	LINER	SF	233,000	.75	175,000
4-3	COVER	CY	8,629	5.00	43,000
	SUBTOTAL				$3,387,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				508,050
	SUBTOTAL				$3,895,050
	UNLISTED ITEMS - ALLOWANCE (15%)				584,258
	TOTAL ESTIMATED COST				$4,479,308
	USE				$4,479,000

NOTE: TREATMENT PLANT COSTS ARE FACTORED COSTS.

TABLE 5.2-39

CAPITAL COST ESTIMATE

TREATMENT PLANT

CASE III

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
1	NEW LINED RESERVOIR (FEED)				
1-1	EXCAVATION/BERMS	CY	50,000	$ 2.00	$ 100,000
1-2	LINER	SF	250,000	.75	188,000
1-3	COVER	CY	9,259	5.00	46,000
2	TREATMENT PLANT	LS	-	-	1,675,000
3	NEW LINED RESERVOIR (DISCHARGE)				
3-1	EXCAVATION/BERMS	CY	50,000	2.00	100,000
3-2	LINER	SF	250,000	.75	188,000
3-3	COVER	CY	9,259	5.00	46,000
4	BINGHAM TUNNEL PIPELINE	LS	-	-	585,000
5	BUTTERFIELD TUNNEL PIPELINE	LS	-	-	687,000
	SUBTOTAL				$3,615,000
	ENGINEERING & CONSTRUCTION MANAGEMENT (15%)				542,250
	SUBTOTAL				$4,157,250
	UNLISTED ITEMS - ALLOWANCE (15%)				623,588
	TOTAL ESTIMATED COST				$4,780,838
	USE				$4,781,000

NOTE: TREATMENT PLANT COSTS ARE FACTORED COSTS.

TABLE 5.2-40

CAPITAL COST ESTIMATE

PIPELINE CONVEYANCES

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT[1] PRICE	AMOUNT
1	6,250 GPM TO JORDAN RIVER	FT	46,700	$ 52.25	$2,440,000
2	6,250 GPM TO NEW CONCENTRATOR	FT	12,400	141.37	1,753,000
3	6,250 GPM TO C-7 CANAL	FT	84,000	74.69	6,274,000
4	12,500 GPM TO JORDAN RIVER	FT	46,700	124.97	5,836,000
5	12,500 GPM TO NEW CONCENTRATOR	FT	12,400	181.53	2,251,000
6	BUTTERFIELD TUNNEL PIPELINE	FT	84,000	126.26	10,606,000

NOTE 1: ABOVE UNIT COSTS INCLUDE 15% ALLOWANCE FOR ENGINEERING AND CONSTRUCTION MANAGEMENT, AND 15% ALLOWANCE FOR UNLISTED ITEMS.

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