UNITED STATES
DEPARTMENT OF THE INTERIOR
Stewart L. Udall, Secretary

BUREAU OF RECLAMATION
Floyd E. Dominy, Commissioner

SUPPLEMENTAL INFORMATION REPORT
ON
BRIDGE CANYON PROJECT

January 1964

Interior-Reclamation
Boulder City, Nevada

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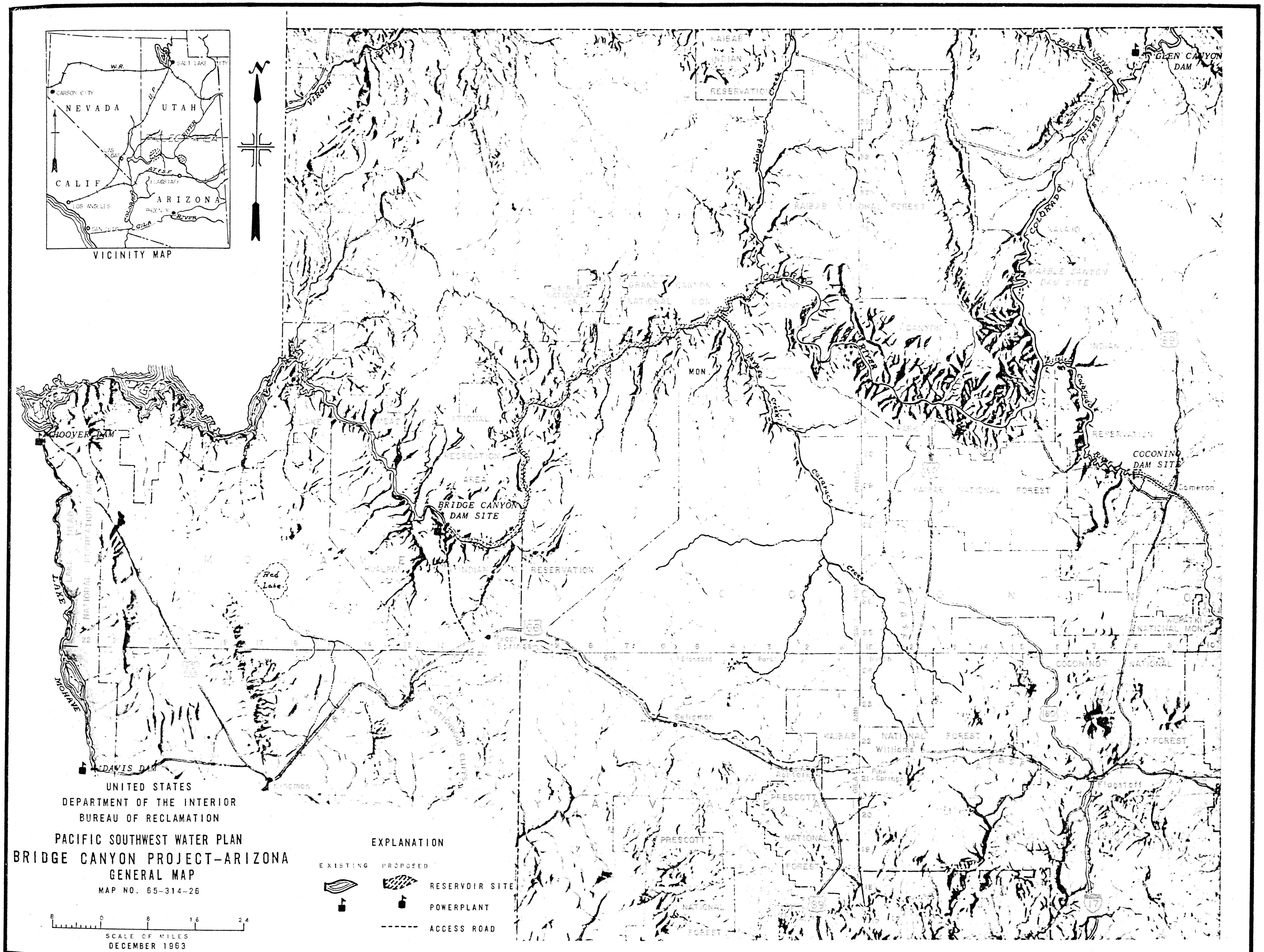


INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

INTRODUCTION

The Bridge Canyon Project, as shown on Drawing No. 65-314-26, is an integral part of the Pacific Southwest Water Plan. This comprehensive plan for the coordinated development and augmentation of the water resources of the Lower Colorado River Basin and southern California provides for the conservation of existing water supplies within the Lower Colorado River Basin, the importation of water from areas of surplus and the interchange of water between basins.

The electrical output of the Bridge Canyon Powerplant will be integrated with generation from other Federal hydroelectric powerplants on the Colorado River. It will be used to supply peaking power and energy to the commercial electrical load in the power market area and a portion of the water project pumping load in the Pacific Southwest Water Plan.

The Bridge Canyon Project is a feasible plan for the potential hydroelectric development of one of the two remaining undeveloped reaches of the Lower Colorado River. In addition to Bridge Canyon Dam and Powerplant, project features would include the power transmission system, the Coconino Dam and Reservoir, community and construction facilities incidental to the project, and recreation and fish and wildlife enhancement facilities.

SUMMARY

Project

Bridge Canyon, Lower Colorado River, Arizona.

Location

The Bridge Canyon Dam and Powerplant would be located in Mohave County in northwestern Arizona at Mile 237.5 on the Colorado River, 117.5 miles upstream from Hoover Dam. Under normal operating conditions, the reservoir would extend upstream to approximately River Mile 143.5, a total distance of some 94 river miles.

Need

The Bridge Canyon Project would:

Provide urgently needed peaking generation capacity for the electrical commercial load in Arizona, southern California, and southern Nevada;

Provide energy for a portion of the water project pumping load in the Pacific Southwest Water Plan;

Provide surplus revenues which, in combination with similar revenues from other existing and potential hydroelectric power-generating facilities, would be used for financial assistance in developing urgently needed additional water supplies for the water-deficient Pacific Southwest.

Principal Features

The principal features proposed for construction consist of Bridge Canyon Dam and Powerplant, the transmission system facilities, Coconino Dam and Reservoir and required access and operation facilities. Recreation and fish and wildlife enhancement facilities would be provided.

The Bridge Canyon designed dam is a conventional, variable-radius, concrete-arch dam 736 feet high above foundation, with a crest length of approximately 1,650 feet. The reservoir would have a capacity of 3,710,000 acre-feet at normal water surface elevation of 1866. Of this capacity, 2,490,000 acre-feet would be conservation, 730,000 acre-feet inactive, and 490,000 acre-feet dead storage.

The design and cost estimates of the powerplant are based on the concept of an underground plant located in a hall excavated in the left canyon wall downstream of the dam. The installed capacity of the powerplant is 1,500,000 kilowatts, comprised of six 250,000-kilowatt generators.

The transmission system would consist of transmission lines constructed from Bridge Canyon Powerplant to the load centers in the power market area and to other Bureau of Reclamation powerplants in the area. Switching stations and substations would be provided as required for the delivery of power and energy to the load centers of commercial power users and water project pumping plants.

Plan of Operation

The powerplant will utilize the Glen Canyon Reservoir cyclic regulation of the Colorado River flows to produce power and energy for commercial sale and a portion of the Pacific Southwest Water Plan pumping load. Coordinated with the seasonal releases from Glen Canyon Dam, the plant would be capable of operating at close to maximum elevation at all times. Under this plan of operation, a maximum of about 4 feet of drawdown would be required. The proposed Coconino Dam and Reservoir would retain the major portion of the sediment load of the Little Colorado River, thereby protecting the storage of Bridge Canyon Reservoir from serious depletion by sediment, particularly in the later years of project life.

Capital Costs

Bridge Canyon Dam and Reservoir (N.W.S. El. 1866)	$163,963,000
Bridge Canyon Powerplant (1,500,000 kw.)	140,530,000
Transmission System Facilities	187,500,000
Coconino Dam and Reservoir	11,960,000
Recreation and Fish and Wildlife Facilities	7,373,000
Total	$511,326,000

Power Production

Powerplant characteristics are as follows:

Average head	644 feet
Number of units (250,000 kw. each)	6
Installed capacity	1,500,000 kw.
Annual generation (100-year average)	5,362,000,000 kw.-hr.

Annual Benefits	
Power	$42,073,000
Recreation	658,000
Fish and Wildlife	1,305,000
Area Redevelopment	358,000
Total	$44,394,000
Annual Equivalent Federal Costs	
100-year period of analysis	$22,618,000
Benefit-Cost Ratio	
100-year period of analysis	2.0 to 1.0

C H A P T E R I

T H E P O W E R

M A R K E T

CHAPTER I - THE POWER MARKET

The potential market for Bridge Canyon Project power, as shown on Drawing No. 65-314-28, consists of the region designated by the Federal Power Commission as the "Lower Colorado River Basin Power Market Area." The power requirements of the area would include, in addition to domestic and industrial demands, a portion of the electrical energy for the operation of water conveyance facilities of the Pacific Southwest Water Plan.

Physiography

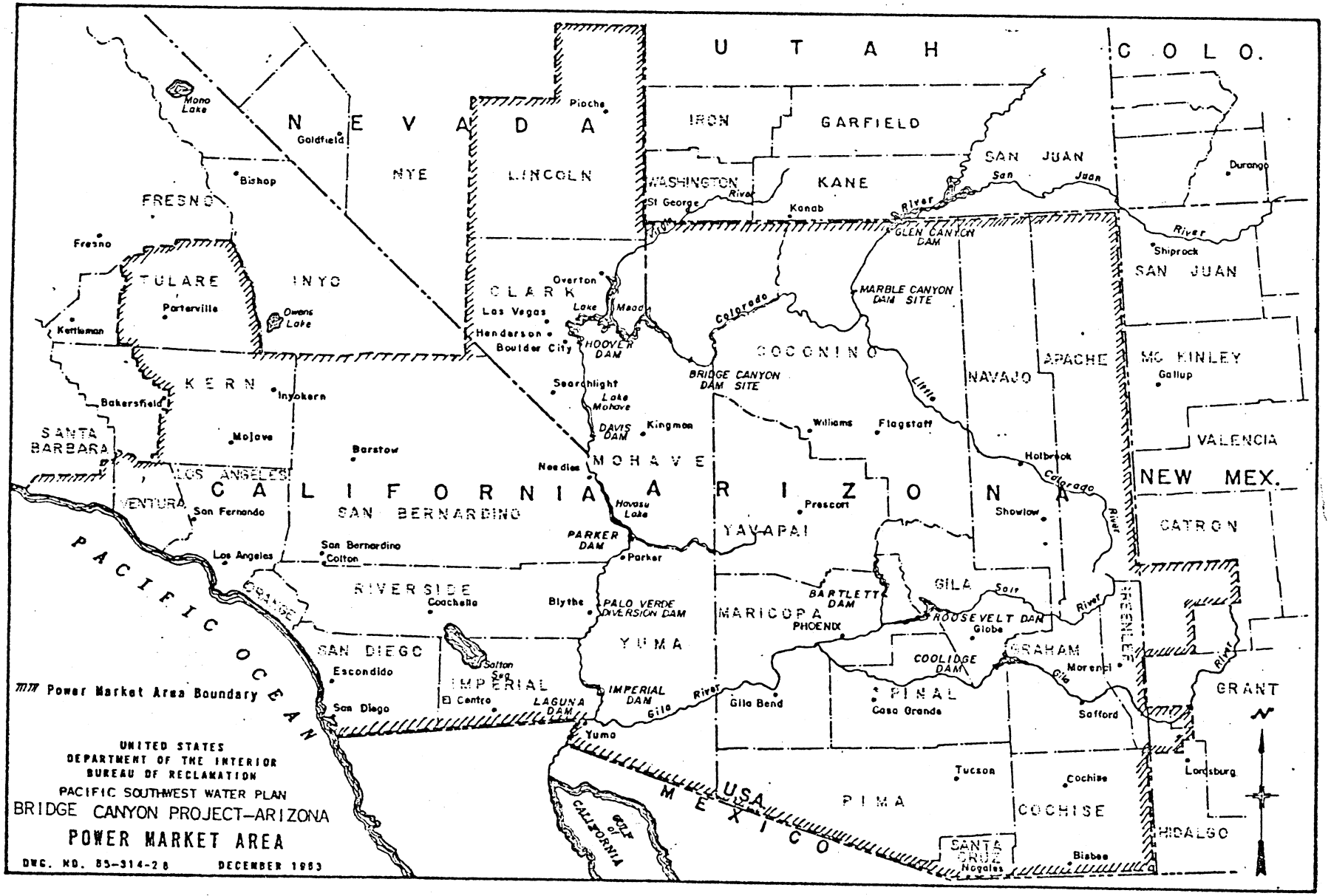
The entire area is drained by the Colorado River, with the exception of the coastal area of southern California, the inland basins of California and Nevada, and small basins in Arizona which drain into Mexico.

The area is characterized by a wide variation of land elevations ranging from over 12,000 feet in Arizona to sea level and below in southern California. East of the mountains which border the coastal area in California are closed drainage basins extending into Nevada, separated by low mountain ranges. The southwestern section of Arizona, at elevations generally less than 2,000 feet, is predominantly a desert while the north and east sections are mountainous with high plateaus.

Average temperatures vary generally with the precipitation pattern. The low precipitation areas, averaging as little as 2 inches annually, are primarily desert and have high temperatures which can range up to 115 degrees during the long summers. The higher precipitation areas, which receive up to 30 but average about 10 inches annually, are generally in the higher mountains where winter temperatures may be in the below-zero range. Southern California, influenced by the ocean winds, has the most moderate climate in the area throughout the year.

Population

The population of the area which could be served by the Bridge Canyon Project has increased overall by about 48 percent in the 1950 to 1960 period. In the period from April 1960 to July 1962, this trend continued, and projections of future population by many entities, both private and Government, indicate that this trend is expected to continue, if not increase. The number of seasonal visitors to the area is also increasing. The electrical energy consumption is not only expected to keep pace with the population growth, but to accelerate as additional electrical mechanisms are developed for domestic and industrial uses. The population of the area, based on official 1960 U.S. Bureau of Census data, was approximately 10,670,000, and is expected to approach 20,000,000 by 1980, by which time all of Bridge Canyon power would be absorbed.


U T A H
C O L O.
N E V A D A
IRON
GARFIELD
SAN JUAN
KANE
WASHINGTON
NYE
LINCOLN
FRESNO
TULARE
INYO
CLARK
KERN
COCONINO
APACHE
NAVAJO
MC KINLEY
SANTA BARBARA
LOS ANGELES
VENTURA
SAN BERNARDINO
MOHAVE
VALENCIA
NEW MEX.
CATRON
RIVERSIDE
YAVAPAI
ORANGE
GILA
MARICOPA
PHOENIX
GRAHAM
SAN DIEGO
YUMA
IMPERIAL
PINAL
GRANT
PIMA
COCHISE
HIDALGO
SANTA CRUZ
PACIFIC OCEAN
GULF OF CALIFORNIA
USA
MEXICO
Mono Lake
Goldfield
Pioche
Bishop
Fresno
Porterville
Owens Lake
Kettleman
Bakersfield
Inyokern
Mojave
Barstow
San Fernando
Los Angeles
San Bernardino
Colton
Coachella
Blythe
Escondido
San Diego
El Centro
Salton Sea
Overton
Las Vegas
Henderson
Boulder City
Searchlight
Lake Mead
Lake Mohave
Kingman
Needles
Havasu Lake
Parker
Williams
Flagstaff
Prescott
Holbrook
Showlow
Globe
Morenci
Safford
Gila Bend
Casa Grande
Tucson
Nogales
Bisbee
Douglas
Willcox
Lordsburg
St George
Kanab
Durango
Shiprock
Gallup
Yuma
HOOVER DAM
DAVIS DAM
PARKER DAM
PALO VERDE DIVERSION DAM
IMPERIAL DAM
LAGUNA DAM
BRIDGE CANYON DAM SITE
MARBLE CANYON DAM SITE
GLEN CANYON DAM
BARTLETT DAM
ROOSEVELT DAM
COOLIDGE DAM
Colorado River
Gila River
San Juan River
Little Colorado River
Salt River
Power Market Area Boundary
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PACIFIC SOUTHWEST WATER PLAN
BRIDGE CANYON PROJECT-ARIZONA
POWER MARKET AREA
DWG. NO. 85-314-28
DECEMBER 1983

Population distribution is extremely unbalanced, with a large majority being concentrated in a few metropolitan areas. The Los Angeles vicinity alone contained about 67 percent of the people in the area in 1960. Five metropolitan areas--Los Angeles, San Diego, and San Bernardino in California, and Phoenix and Tucson in Arizona--accounted for over 95 percent of the total population of the area.

The 1960 census, as presented in the following tabulation, indicates the unusual population increase that has occurred in the metropolitan areas since 1950.

Metropolitan Area	1950 Population	1960 Population	Increase
Los Angeles-Long Beach	4,367,911	6,742,696	56%
San Diego	556,808	1,033,011	85%
San Bernardino-Riverside-Ontario	451,688	809,782	80%
Phoenix	331,770	663,510	100%
Tucson	141,216	265,660	88%
Clark County, Nevada	48,289	127,016	165%

Economy

The region has experienced steadily increasing prosperity in recent years. Manufacturing and aero-space allied industries continue to flourish in Arizona and southern California, with the Los Angeles area now ranking third among the Nation's industrial areas. Agriculture and mining, the original economic bases, are next to manufacturing in income production. Military installations also contribute much to the general economic base. The influx of people to the area, both permament and transient, continues to increase, and providing the necessary services for these people is an increasingly important factor in the general economy.

Resources

The region has long been an important mineral-producing area, and there is a continuing development of reserves. Arizona leads the Nation in the production of copper, but lesser quantities of many other minerals are produced in the area. California's now declining oil production ranks third in the Nation, as exploration for new reserves continues throughout the region. In addition to lumber production, some of the large timber reserves in Arizona are used in the production of fiber for paper pulp. The desert soils of the area are highly productive, but adequate water supplies are not available even to permanently sustain the presently irrigated acreage.

Problems and Needs

The basic problem of this dynamic growth area is that of obtaining adequate supplemental water supplies to sustain the present economy and provide for future growth of population and industry. In the past, water was usually obtainable by simple gravity diversion or shallow pump lift in sufficient quantities to provide for the water needs of the area. This condition was relatively short lived, and long-term holdover storage reservoirs and high pump lift projects later became necessary to regulate and distribute waters to the farms and growing communities. The end of this era is now fast approaching, as the physical limits of local water supplies have been reached in many areas. No longer can a development request and receive water by merely demonstrating the need and the ability to pay.

Historically, most water development projects of the area were basically for agricultural consumption, with municipal, industrial, power, recreation, and other aspects being secondary or incidental participants. Today, this cycle is reversing as urban developments, demanding water supplies in areas of limited quantities, can only obtain water by condemning agricultural water rights. Coincident with the growing requirements for water are the demands for ever-increasing quantities of electrical energy for domestic and industrial use and for the pumping of water.

Peaking power and energy requirements now demand a high percentage of present installed capacity, especially for the areas that have been developed within desert regions. This demand arose with the now widespread use of air-conditioning equipment in home and industry. The irrigation pumping requirement in central Arizona adds to the summer load. It is probable that, as urbanization spreads over presently irrigated lands, the relatively constant summer irrigation pumping load will give way to more pronounced peaks as the pumps are converted to supply irregular municipal and industrial water requirements.

There is also a need for an adequate supply of peaking power and energy in the southern California area, as well as in the desert areas. Because of the larger total demand, peaking requirements are of greater magnitude than in the desert areas, although the daily duration is somewhat shorter at certain times of the year.

Present Development and Requirements

Present power developments in the Lower Basin market area range from large hydroelectric and fuel-burning plants, serving the metropolitan areas in southern California and south-central Arizona, to local powerplants serving the smaller towns and communities.

The principal suppliers of energy in the California portion of the market area are the cities of Los Angeles, Burbank, Glendale, and Pasadena; the Southern California Edison Company; the San Diego Gas and

Electric Company; the California Electric Power Company; Imperial Irrigation District; and the Bureau of Reclamation. The energy is produced at several hydroelectric plants within or near the market area, in addition to large steamplants located near the load centers. Hoover, Davis, and Parker Powerplants on the Colorado River form a major source of supply. Hoover Dam Powerplant is operated for the Bureau of Reclamation by the city of Los Angeles and the southern California Edison Company, and Parker Dam and Davis Dam Powerplants by the Bureau of Reclamation. The cities of Pasadena, Burbank, and Glendale operate municipally owned steam and hydroelectric plants, and the Imperial Irrigation District owns and operates steam and hydroelectric plants and distributes energy in the Imperial and Coachella Valleys. Most of the power systems of these agencies are interconnected, but integration of their operations is, in some cases, limited by existing facilities.

In Arizona, the principal agencies generating and distributing electric power are the Salt River Project Agricultural Improvement and Power District; the Arizona Public Service Company; the Tucson Gas, Electric Light and Power Company; Citizens Utilities Company; Arizona Electric Power Cooperative; the Bureau of Indian Affairs; and the Arizona Power Authority. In general, these agencies serve the more densely populated areas in the south-central part of the State. The Bureau of Reclamation, by virtue of the power delivered from Hoover, Davis, and Parker Powerplants, is a large producer of electric energy utilized in the State.

In southern Nevada, Clark and Lincoln Counties and the Atomic Commission's testing facilities in Nye County are supplied from the Nevada Power Company's Clark Steamplant, the Parker-Davis Project, and the Hoover Powerplant. The major operating agencies for this area are the Colorado River Commission of Nevada, the Amargosa Electric Cooperative, the Nevada Power Company, the Lincoln County Power District, the California-Pacific Utilities Company, the Bureau of Reclamation, and the city of Boulder City. Some of the foregoing utilities are purchasing electrical power from the Bureau of Reclamation as preference customers under the Reclamation Project Act of 1939, and it is anticipated that they would purchase additional power and energy to meet growing loads.

Transmission lines of sufficient capacity for present loads extend from Hoover, Davis, and Parker Powerplants to the load centers.

The installed generation capacity in the area was about 11,700,000 kilowatts as of December 31, 1962. Additional installed capacity of 3,700,000 kilowatts was planned for construction after 1962, some of which is now either in service or under construction. Planning since 1962 will have anticipated some of the additional capacity needed for the period beyond 1964.

The consumption of electric energy in the metropolitan areas of Los Angeles County, San Diego, and south-central Arizona continues to

increase tremendously as during World War II and the immediate postwar years. Continuous installation of power generation facilities has been required to meet population influx and "space-age" requirements. Additional large installations will be necessary to meet the ever-increasing demands.

The growth of industrial activity and increase in population during the 1950-1960 period was reflected by an increase in energy requirements of 27.4 billion kilowatt-hours, from 16.7 billion kilowatt-hours to 44.1 billion kilowatt-hours. During this period, the peakload of the market area increased from 3,100,000 kilowatts to 7,800,000 kilowatts. The 1961 increase was about $1\frac{1}{2}$ times the average annual increase of the 1950-1960 period. During this year, the energy requirements increased about 3 billion kilowatt-hours to 47 billion kilowatt-hours, and the peakload demand increased 600,000 kilowatts to about 8,400,000 kilowatts. To meet the 1950-1961 increased demand of 5,300,000 kilowatts and to provide reserve capacity, the principal energy-producing agencies increased their installed capacity by 6,131,000 kilowatts.

The Nevada powerload demand is characterized by a winter heating peak and the Arizona load by a summer air-conditioning peak. Their industrial demands are not of sufficient magnitude to materially flatten the peaks. California, with a large year-round industrial demand, has only a minor peak which occurs during the winter. The market area, as a whole, has a minor winter peak which is only 1 percent higher than the summer peak demand.

In the summer of 1961, only about 50 percent, or 4,200,000 kilowatts, of the maximum demand of 8,400,000 kilowatts was required throughout the 24-hour day. At this same time, 15 percent of the maximum demand, or 1,260,000 kilowatts, was required for only 57 hours during a week. About 10 percent, or 840,000 kilowatts, was required for only 41 hours a week. These periods of maximum demand occur in the 5 days, Monday through Friday, each week. Portions of the peakload demands of these periods are being provided by noncontinuous operating hydroelectric plants.

Future Power Requirements

According to Federal Power Commission estimates, the electrical requirements for 1970 and 1980, which do not include project pumping, and as presented in the following tabulation, will be 93 billions of kilowatt-hours and 172 billions of kilowatt-hours, respectively, with peakload demands of 17,000,000 kilowatts and 31,000,000 kilowatts.

	Estimated annual energy requirements (Millions of Kilowatt-Hours)		Estimated noncoincident peak demand (Thousands of Kilowatts)	Estimated 1/ required installed capacity (Thousands of Kilowatts)
	Load	Load Increase		
		Incremental Increase	Accumulative Total		
1950	16,713			3,085	
1960	44,135	27,422	27,422	7,790	
1970	93,009	48,874	76,296	17,000	19,500
1975	127,200	34,191	110,487	23,000	26,400
1980	171,534	44,334	154,821	31,000	35,700

1/ Includes 15 percent reserve capacity needed to meet peak demand.

As previously stated, additional future installations will continue to be planned well in advance of need so construction can be completed in time to meet the ever-increasing demands.

Installed generation capacity as of 1962 and that planned for construction after that year amounts to 15,400,000 kilowatts. Generation to meet the projected 1975 domestic and industrial requirements is estimated to be 26,400,000 kilowatts. Disregarding the capacity that might be needed by project water supply pumping plants, the 1,500,000-kw. capacity of Bridge Canyon Powerplant could readily be absorbed in the market area as it would constitute only about 14 percent of the additional capacity installation of 11,000,000 kilowatts that will be needed to meet the projected 1975 domestic and industrial requirements.

C H A P T E R II

P L A N

O F

D E V E L O P M E N T

CHAPTER II - PLAN OF DEVELOPMENT

The Bridge Canyon Project would produce peaking power and energy which will be required by commercial loads in the Lower Colorado River Basin power market area, and would also supply a portion of the power and energy required by the water-pumping projects of the Pacific Southwest Water Plan. The powerplant would be interconnected with other hydroelectric plants on the Colorado River, and its output would be integrated with generation from these other installations.

The commercial peaking power and energy available from Bridge Canyon would be utilized to meet the expanding power demands of the area and to earn revenues for a Development Fund which would be used to provide financial assistance for development necessary to augment the area's inadequate water supply. The portion of the output of the 1,500,000-kilowatt Bridge Canyon Powerplant available for commercial sale would provide part of the capacity that will be needed to meet the projected 1975 peakload demand of 23,000,000 kilowatts.

In addition to the generation of power, the plan of development provides for silt control, recreation, fish and wildlife conservation, and benefits to area redevelopment.

The principal features of the plan would be: (1) Bridge Canyon Dam and Reservoir; (2) Bridge Canyon Powerplant with an installed capacity of 1,500,000 kilowatts; (3) an electrical transmission system; and (4) Coconino Dam and Reservoir. Owing to the inaccessibility of the inner gorge, the initial activity would be the construction of access roads and of community facilities for the workers and their families adjacent to Bridge Canyon Dam site. The construction of the dam and powerplant and the transmission system would follow in sequence. Drawing No. 65-314-26 shows the location of Bridge Canyon and Coconino Dams and Reservoirs.

Climatological Factors

Climate at the Bridge Canyon Dam site is characterized by dry, hot summers and mild, frost-free winters. The annual precipitation for the area is approximately 11 inches, most of which often comes in the form of torrential rains or cloudbursts during July, August, and September. May and June are normally extremely dry months. Snowfall is very rare in the canyon but occurs nearly every year on the plateau country.

Temperatures in the vicinity of the damsite range from a low of about 17 degrees to a high of 128 degrees Fahrenheit. The temperature at the townsite on the plateau would be approximately 19 degrees lower than in the canyon.

Settlement and Economy

The nearest sizable town to the Bridge Canyon Dam site is Kingman, Arizona, which is 50 miles southwest. The immediate vicinity is sparsely populated with Hualapai Indians. The tribe is very poor and their economy is based on grazing, timber sales, and selling merchandise to tourists traveling U.S. Route 66. The personnel required for construction activities would not be available from the permanent population of the area.

Bridge Canyon Facilities

Bridge Canyon Dam site is located in northwestern Arizona, approximately 20 airline miles north of the town of Peach Springs, Arizona, and 50 miles northeast of Kingman. It is on the Colorado River at River Mile 273.5, known as the "Lower Gneiss Site" 117.5 miles upstream from Hoover Dam, and is in unsurveyed section 22, Township 28 North, Range 12 West, in Mohave County. The reservoir would extend into Coconino County.

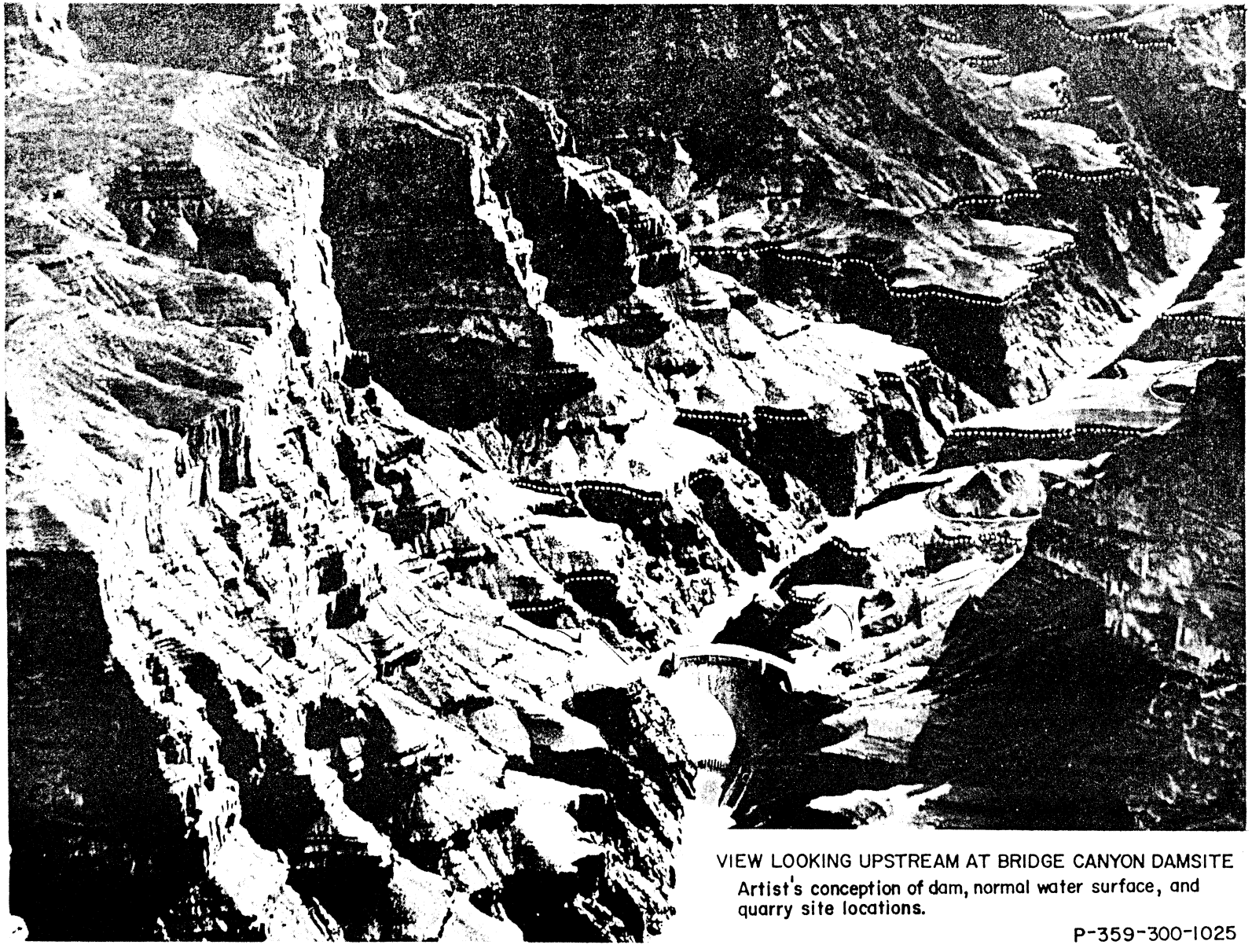
The eastern section of the Bridge Canyon Reservoir region is characterized by the extreme narrowness of the gorge and by very high sheer walls. Some of these nearly vertical walls rise in step fashion some 3,000 feet above the river. The canyon widens considerably as the river turns south, below Whitmore Wash, and in this section, between Granite Park and Diamond Creek, it reaches its greatest depth, over 5,500 feet. South of the river and extending from west of the Aubrey Cliffs to the Grand Wash Cliffs are vast colorful canyons, plateaus, and mountains. North of the river the region is divided into a series of canyons and plateaus.

Bridge Canyon Dam and Reservoir--The general plan and section for Bridge Canyon Dam are shown on Drawing Nos. 359-D-274 and 359-D-275. The dam would be a conventional variable-radius, concrete-arch structure 736 feet above foundation and with a crest length of approximately 1,650 feet. The designed crest elevation is 1,876 feet.

The river outlets would have a maximum capacity of 93,500 cubic feet per second and the powerplant turbines 39,160 cubic feet per second. A 45-foot-diameter spillway tunnel is designed to pass 212,000 c.f.s. at maximum water-surface elevation 1876.

Eight 8- by 12-foot river outlets at elevation 1,550 feet would discharge 52,000 cubic feet per second with a reservoir water-surface elevation 1,650 feet and 93,500 cubic feet per second at maximum reservoir water-surface elevation 1,876 feet.

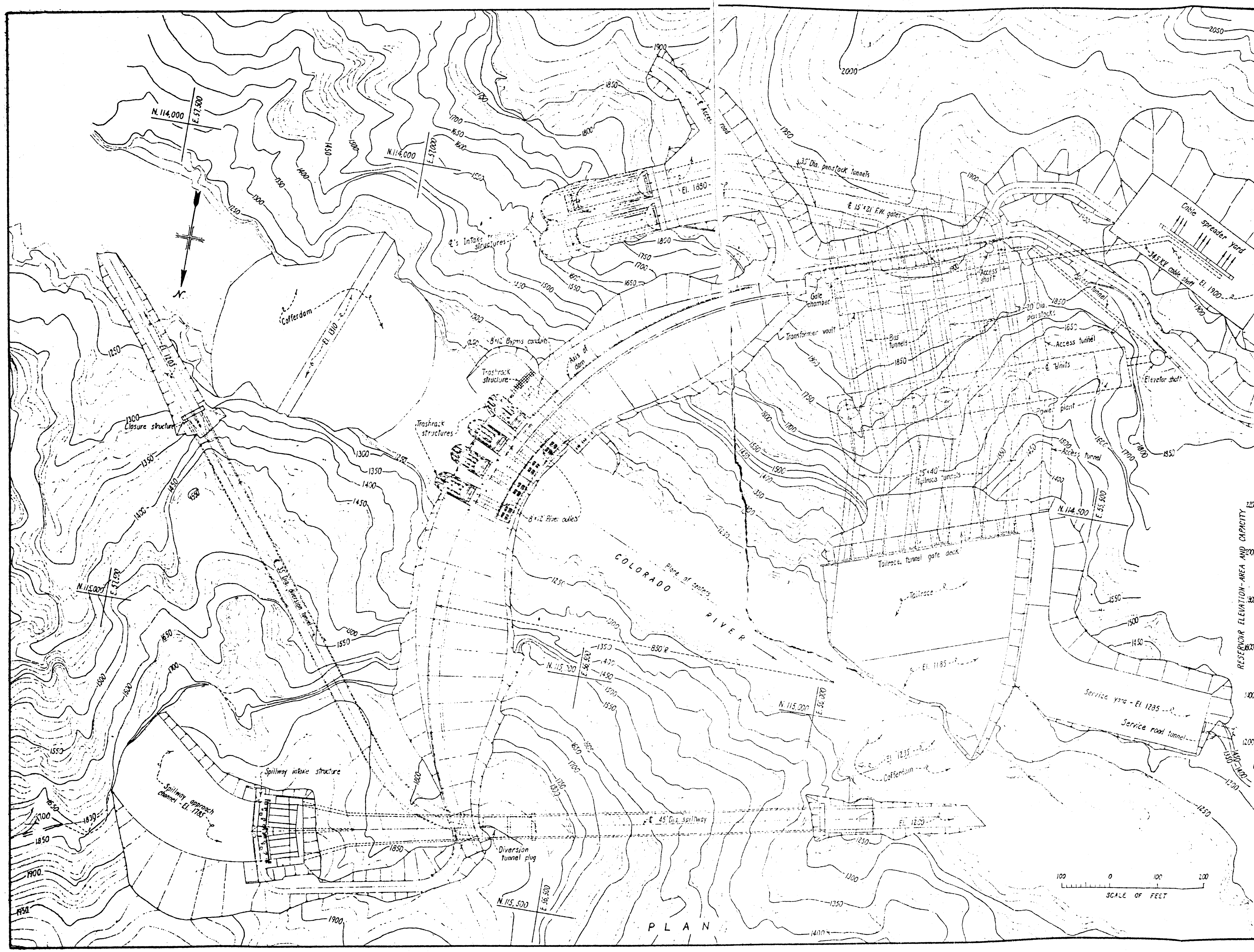
Three 8- by 12-foot conduits at elevation 1,225 feet would provide for bypassing water during the filling of the dead storage. These three conduits would discharge about 26,700 cubic feet per second with the reservoir water-surface at elevation 1,350 feet.

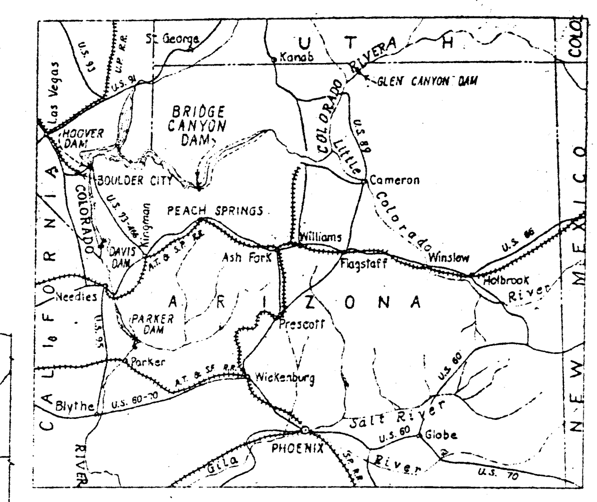


VIEW LOOKING UPSTREAM AT BRIDGE CANYON DAMSITE

Artist's conception of dam, normal water surface, and quarry site locations.

P-359-300-1025





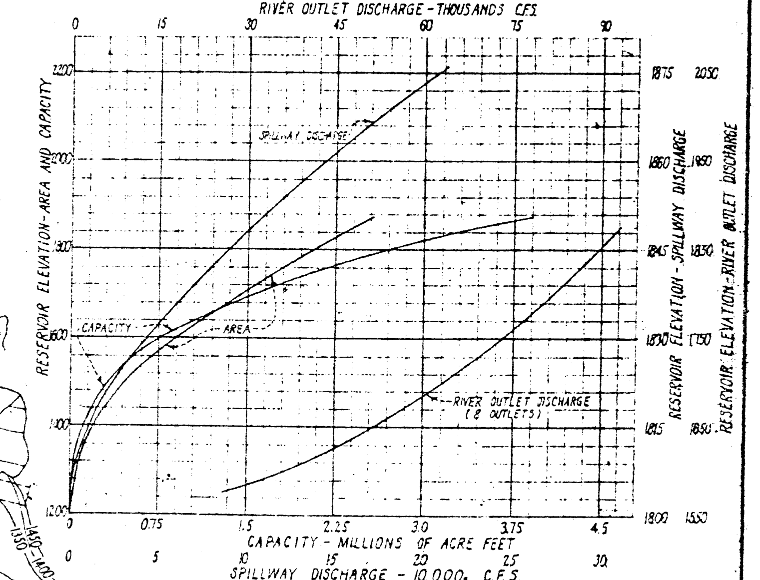
LOCATION MAP

RESERVOIR STORAGE ALLOCATIONS

Purpose	Elevation	Storage - A.F.
Surcharge	1866 - 1876 (Max. W.S.)	180,000
Active conservation	1666 - 1866	2,490,000
Inactive	1550 - 1666	730,000
Dead	Streambed (El.1202±) to El.1550	490,000
		3,890,000

Max. spillway capacity .... 212,000 C.F.S.
Max. outlet capacity .... 93,500 C.F.S.
½ Power plant capacity (3 units @ 6,360 C.F.S.) .... 19,080 C.F.S.
324,580 C.F.S.

Inflow Design Flood:
4 Day volume .... 1,972,000 A.F.
Peak discharge .... 420,000 C.F.S.



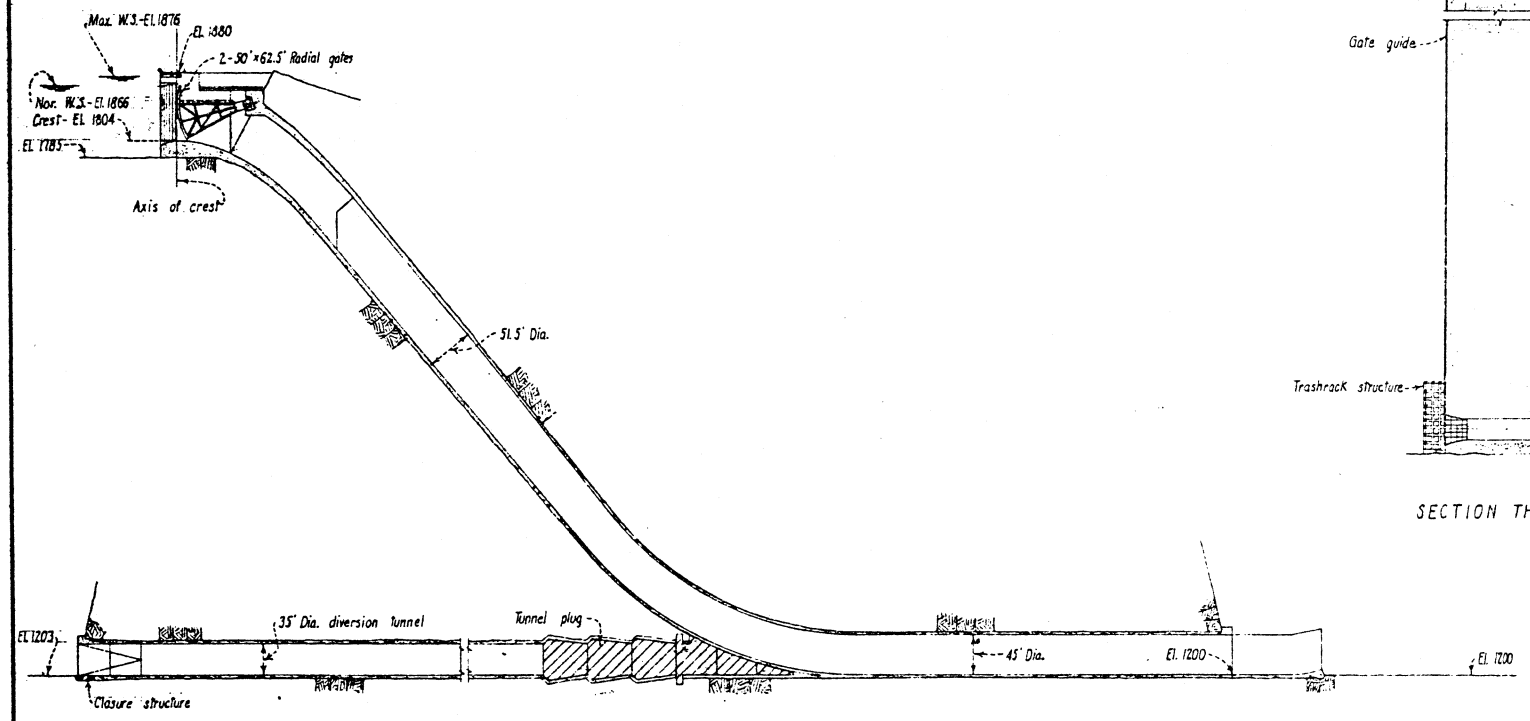
AREA, CAPACITY, SPILLWAY DISCHARGE, AND RIVER OUTLET DISCHARGE CURVES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BRIDGE CANYON PROJECT - ARIZONA

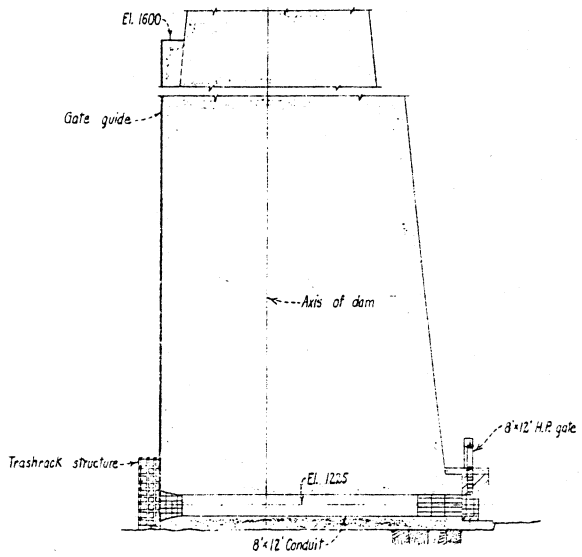
BRIDGE CANYON DAM AND POWER PLANT
FEASIBILITY ESTIMATE DRAWING

DRAWN .... SUBMITTED Fred L. Wyllis
TRACED .... RECOMMENDED E. V. Lindseth
CHECKED .... APPROVED .... ASST. COMM. AND CHIEF ENGINEER
DENVER, COLORADO, OCTOBER 12, 1961 SHEET 1 OF 2 359-D-274

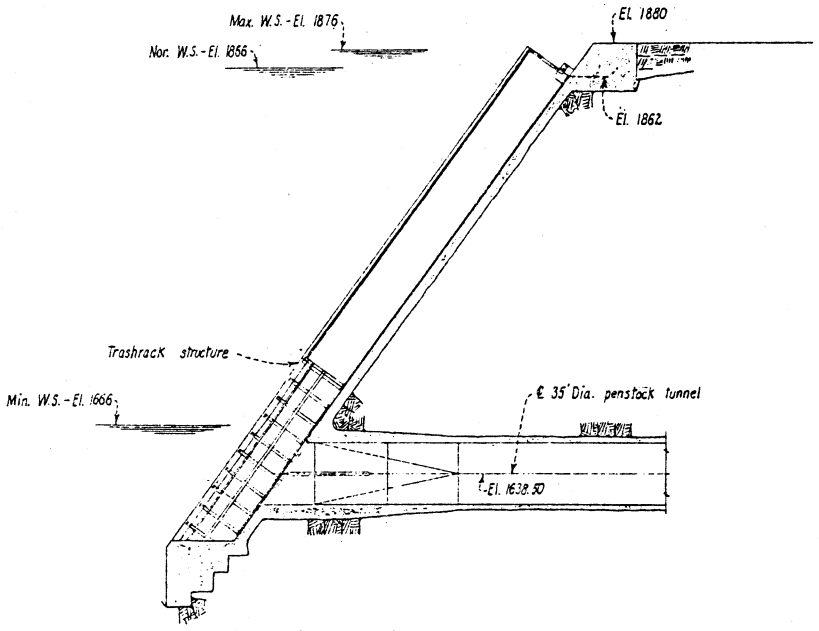
INTERIOR-RECLAMATION, BOULDER CITY, NEVADA



SECTION THRU SPILLWAY AND DIVERSION TUNNEL



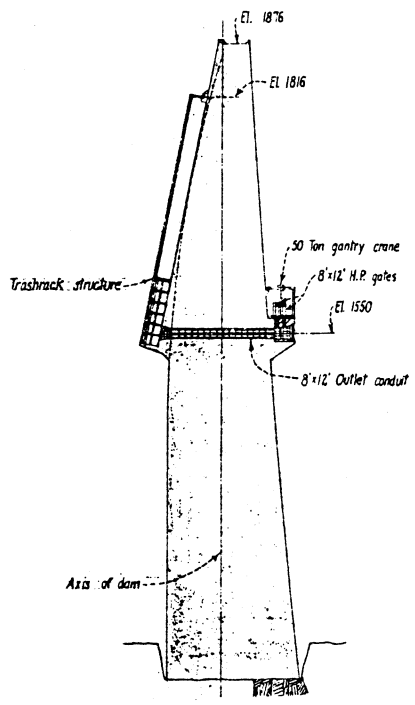
SECTION THRU BYPASS CONDUIT



SECTION THRU INTAKE STRUCTURE

50 0 50 100
SCALE OF FEET

100 0 100 200
SCALE OF FEET



SECTION THRU OUTLET WORKS

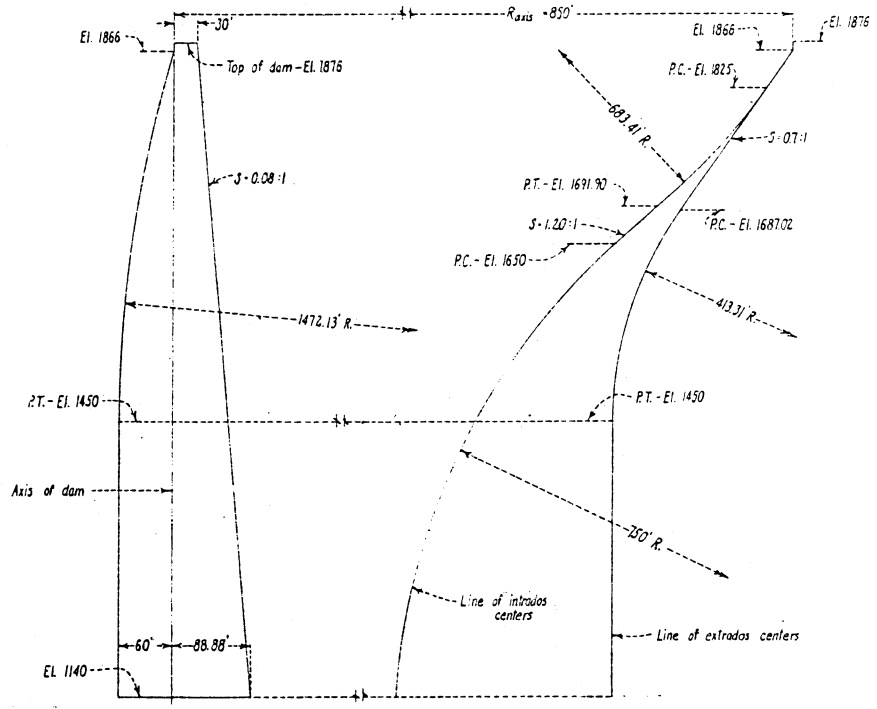
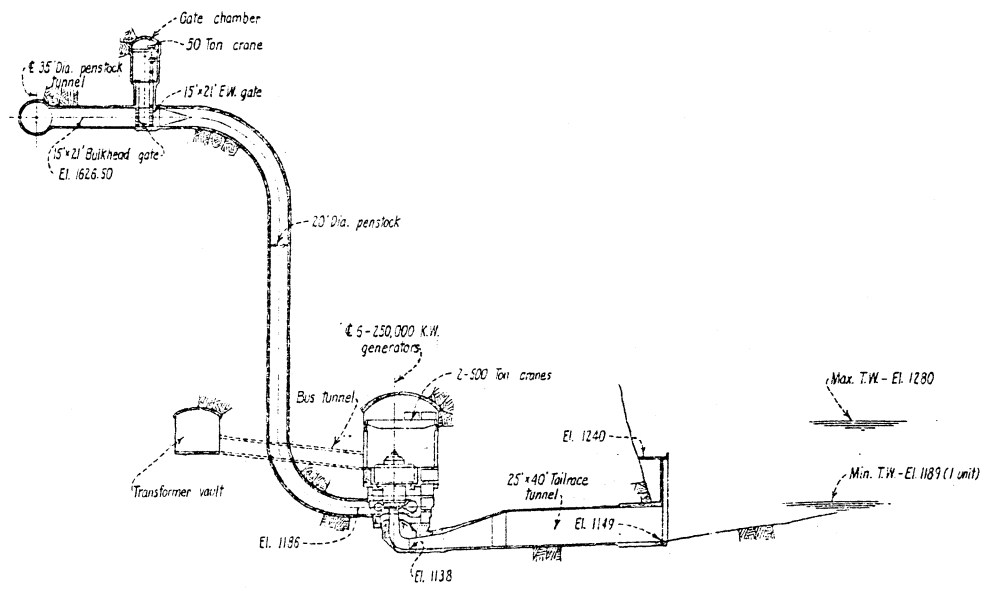


DIAGRAM ALONG PLANE OF CENTERS



SECTION THRU PENSTOCK AND POWER PLANT

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BRIDGE CANYON PROJECT-ARIZONA

BRIDGE CANYON DAM AND POWER PLANT
FEASIBILITY ESTIMATE DRAWING

DRAWN: J. SUBMITTED: Fred C. Witkop
TRACED: RECOMMENDED: E. O. Grindrod
CHECKED: Geo. A. F. K. APPROVED: [illegible]
DENVER, COLORADO, OCTOBER 10, 1944. 359-D-275.
SHEET 2 OF 2

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

The reservoir formed by the dam would have a capacity of 3,710,000 acre-feet at normal water-surface elevation 1,866 feet. This would consist of 2,490,000 acre-feet for emergency conservation storage; 730,000 acre-feet of inactive storage; and 490,000 acre-feet of dead storage. Under normal operating conditions the reservoir water-surface elevation will only vary about 4 feet.

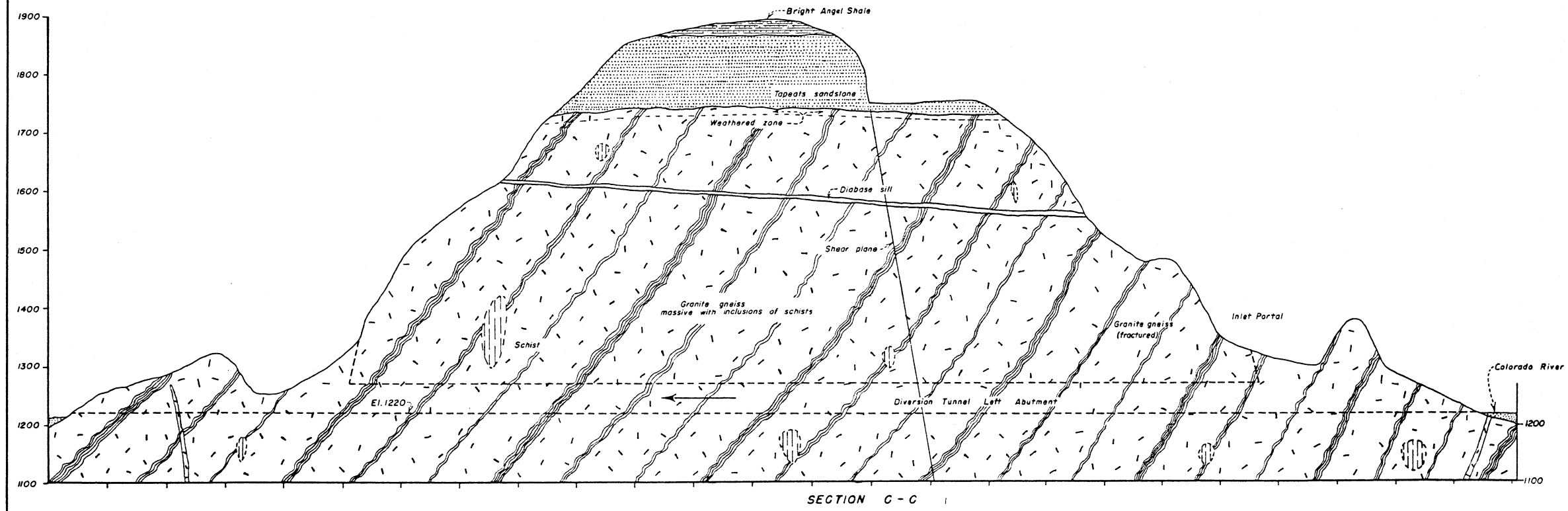
Powerplant--An underground powerplant with an installed capacity of 1,500,000 kilowatts is planned for location in a hall excavated in the left canyon wall downstream from the dam. A separate vault for the main transformers would be provided upstream from the generator hall with connecting adits for generator voltage bus structures. Present plans include six 250,000-kilowatt generators to be driven at a speed of 150 revolutions per minute by six 400,000-horsepower Francis-type turbines. The turbine design head is 650 feet. Three single-phase transformers would be furnished for each two units. Two 500-ton overhead traveling cranes are also included in the plant plans for handling generator rotors and other parts. A machine shop equipped to handle routine maintenance is also included.

Geology--Geologic conditions at the damsite are very favorable for the construction of a thin-arch, concrete dam. The lower three-quarters of the dam would rest on sound, massive granite gneiss which is overlain in the upper abutment by the hard, quartzitic Tapeats sandstone. The extreme top of the dam would contact the weak Bright Angel shale formation, but a small thrust block in the right abutment and grouted concrete construction joints would be expected to relieve the shale of most of the load from the dam.

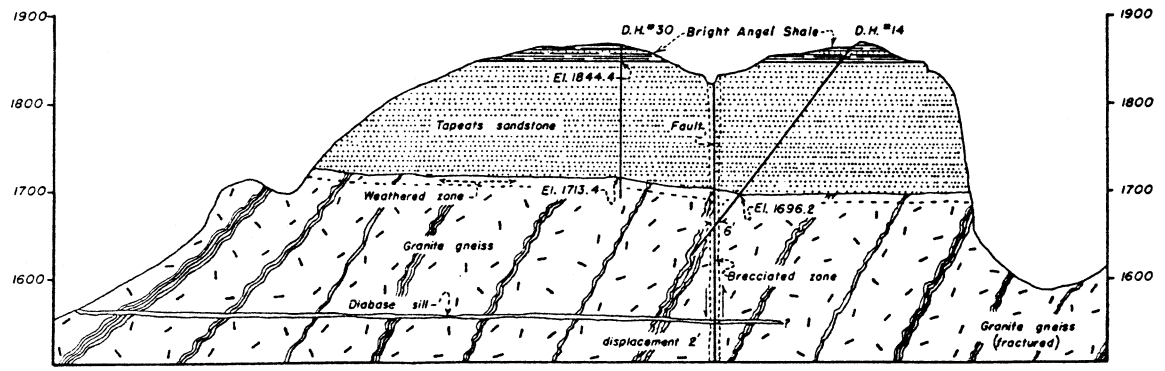
Exploration of the site disclosed no important structural defects. Percolation tests show the gneiss to be impermeable and free from extensive joints. As sound rock is exposed over most of the area, stripping would be confined principally to keyways and other critical areas. The river channel deposits are silt and sand with some large boulders near the bedrock surface. Bedrock was encountered at a depth of 64 feet (elevation 1154) in the deepest portion of the channel. The diversion tunnel would be in generally hard, sound, granite gneiss which is exposed at both portals.

Exploration of the damsite consisted of 27 diamond drill holes totaling 5,325 lineal feet, and 5 test drifts totaling 263.5 lineal feet. Drawing No. 359-D-255 shows the location of the geologic sections, the diamond drill holes, and the test drifts, and Drawing Nos. 359-D-201 and 359-D-202 show the geologic sections.

Construction materials--As no satisfactory natural aggregate deposits occur within a reasonable distance of the damsite, the utilization of crushed Redwall limestone would be made. The Redwall limestone forms the upper part of the rim of the outer gorge above the damsite. Two quarry sites slightly downstream from the damsite have been selected to provide continuous operations.



SECTION C - C



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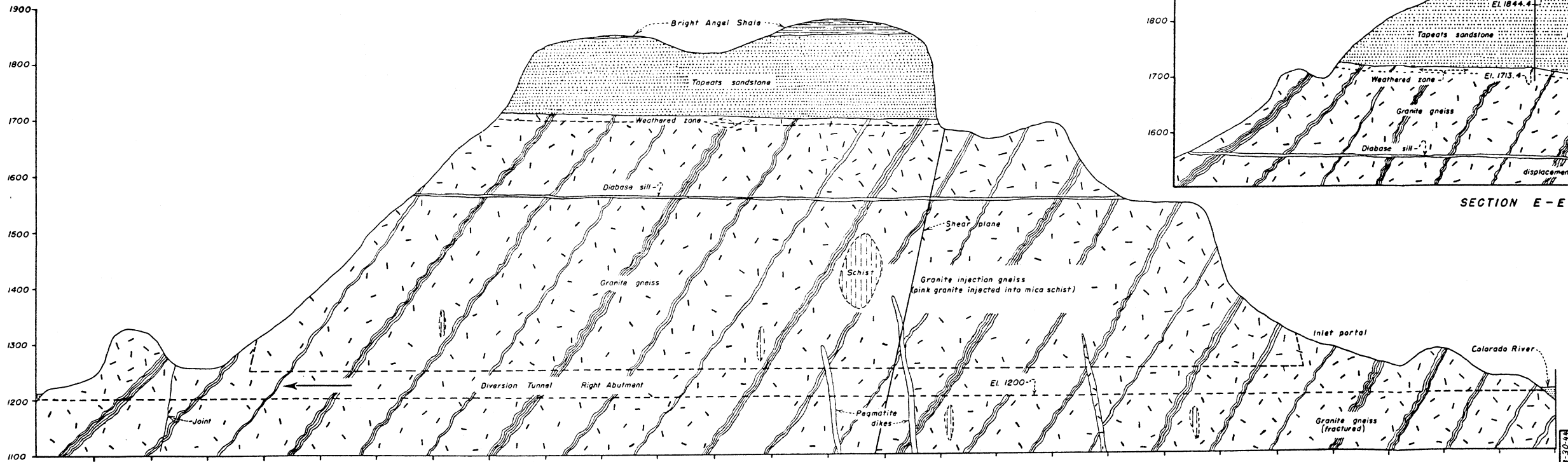


SECTION D - D

VERT. 1"=100'

100 0 100 200
Scale of feet

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

BRIDGE CANYON INVESTIGATIONS, ARIZONA

LOWER GNEISS DAM SITE

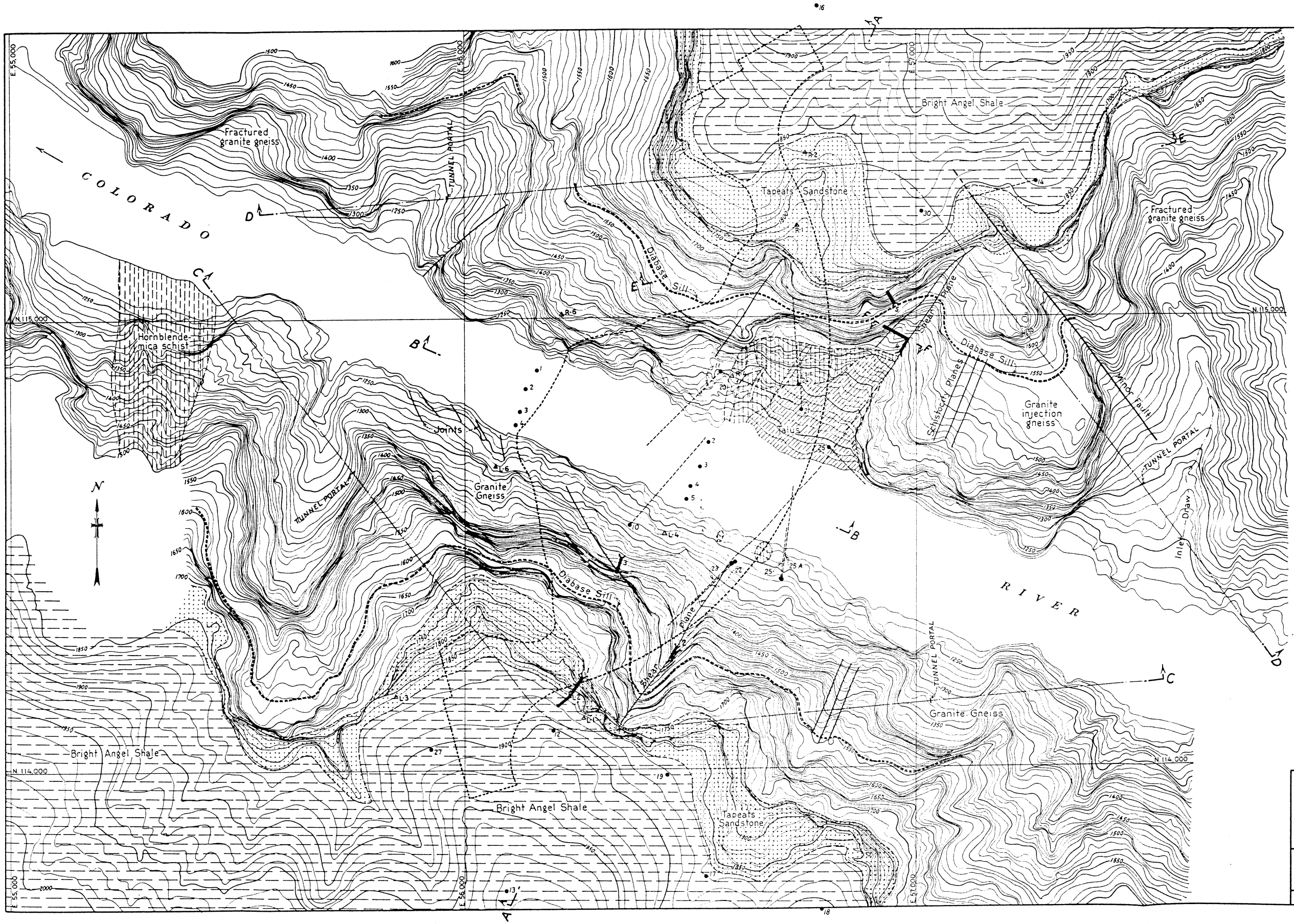
GEOLOGIC SECTIONS

DRAWN: J.N.M. SUBMITTED: W. E. Warren
TRACED: J.N.M. RECOMMENDED:
CHECKED: APPROVED:

PHOENIX, ARIZONA, JAN. 1943
SHEET 2 OF 2

359-D-202

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA



EXPLANATION

- Talus
- Bright Angel Shale
- Tapeats Sandstone
- Granite Gneiss
- Hornblende-mica schist
- Diamond drill hole
- Exploratory drifts
- Joints or shear planes
- Triangulation station

100 0 100 200
SCALE OF FEET

SUPERSEDES DWG. 359-D-203 FIELD TOPOGRAPHY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BRIDGE CANYON PROJECT - ARIZONA

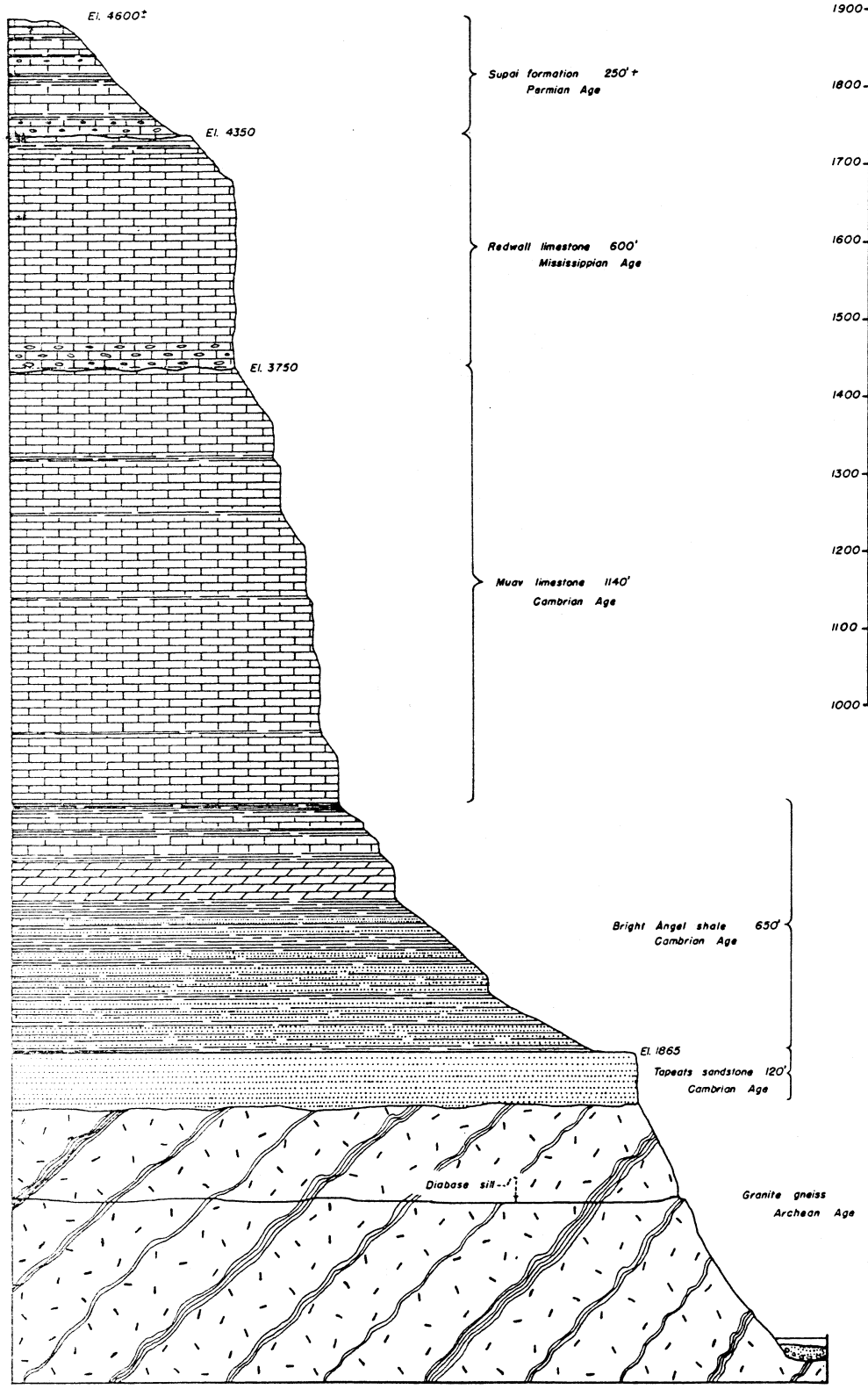
LOWER GNEISS DAM SITE
GEOLOGY MAP

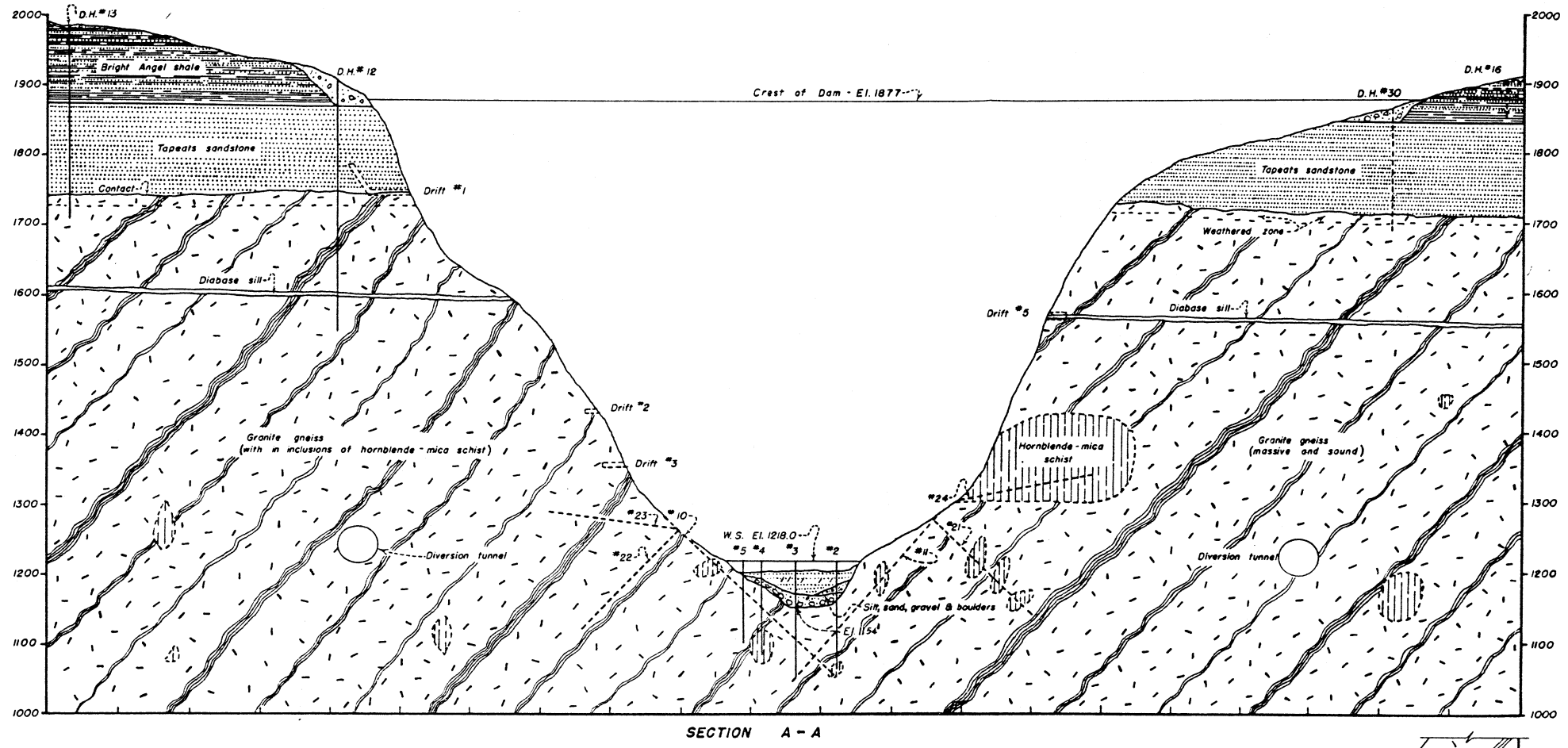
DRAWN	J.N.M. V.E.L.	SUBMITTED	V.E. Larson
TRACED	C.J.A.	RECOMMENDED	
CHECKED		APPROVED	

DENVER, COLORADO MARCH 24, 1944 | 359-D-255

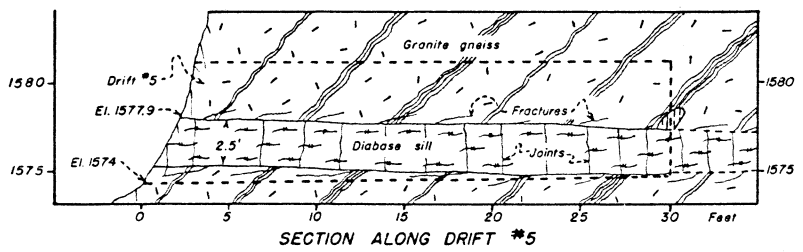
INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

COLUMNAR SECTION SOUTH FROM DAM SITE

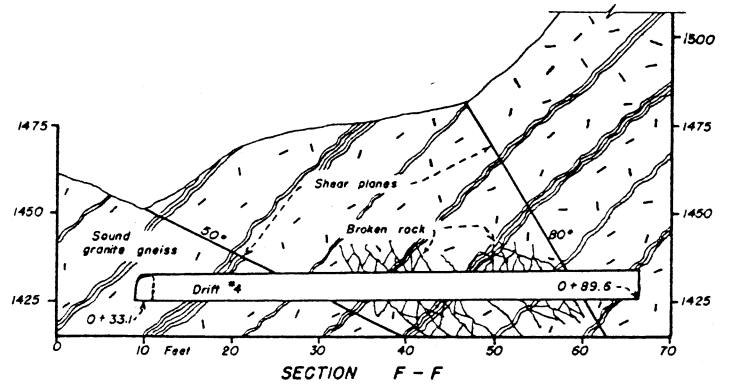




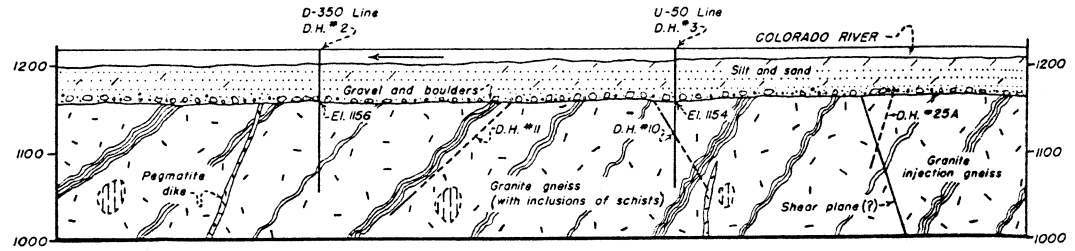
SECTION A - A



SECTION ALONG DRIFT #5



SECTION F - F



SECTION B - B

100 0 100 200
Scale of feet

Note: Drill holes shown as a dashed line were projected.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

BRIDGE CANYON INVESTIGATIONS, ARIZONA

LOWER GNEISS DAM SITE

GEOLOGIC SECTIONS

REV. 3-30-43 V.E.L.

DRAWN: J.N.M. SUBMITTED: W.C. Lowdermilk
TRACED: J.N.M. RECOMMENDED:
CHECKED: APPROVED:

PHOENIX, ARIZONA, JAN. 1943
SHEET 1 OF 2

359-D-201

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

Water supply and powerplant operation--Water supply for Bridge Canyon Powerplant operation is based upon studies of future average annual depletions of streamflow made in 1957 for the "Financial and Economic Analysis" of the Colorado River Storage Project, which were published in 1958 as Senate Document No. 101, 85th Congress, 2d Session, and upon the February 1960 Colorado River Storage Project operation studies.

Glen Canyon Reservoir, the principal storage feature of the Colorado River Storage Project, will provide cyclic regulation of the flows of the Colorado River. Based upon the recurrence of Colorado River flow corresponding to the 1906-1959 period after making appropriate deductions for future water uses within the Upper Colorado River Basin, it is estimated that power releases from the Bridge Canyon Powerplant would produce an average of 5,362,000,000 kilowatt-hours of energy each year, based on a 100-year period of analysis. After supplying transmission losses, 1,350,000 kilowatts of capacity and 4,933,000,000 kilowatt-hours of energy would be available for supplying commercial loads and pumping requirements of the Pacific Southwest Water Plan. Under normal operation, the reservoir would fluctuate between elevations 1866 and 1862.

Operation of the powerplant would be fully integrated with both Glen Canyon and Marble Canyon hydraulically and electrically to provide optimum daily and seasonal operation.

Access--The potential damsite access highway from its junction with U.S. Highway 66, at a point 3.6 miles west of Peach Springs, to the damsite, would be a two-lane surfaced road with a total length of 24.5 miles (see Drawing No. 65-314-26). From the junction with Highway 66, the road would run in a northerly direction across the flat plateau country to the rim of Hindu Canyon, a distance of about 12.5 miles. Grades would not exceed 3.5 percent and only three slight curves would be required. Construction would be relatively easy with very little clearing required. The 12-mile descent from the rim to the inner gorge at the damsite, by way of Hindu Canyon and Bridge Canyon, would require considerable heavy and difficult construction involving sharp curves, steep grades varying from 3 to 8 percent, and a tunnel 4,100 feet long.

The present unimproved road from Peach Springs to the saddle on the divide between Hindu and Bridge Canyons could be made serviceable as a temporary construction road. From the saddle, the damsite is presently reached by means of a difficult 12-mile pack trail. A temporary road would be constructed to replace the pack trail until the main highway to the damsite could be completed. This temporary road would not only be needed for the highway construction but would also facilitate the construction of other features such as the town water supply. The total length of the proposed pioneer road from the Hindu-Bridge Canyon saddle to the damsite would be approximately 10 miles.

Townsite--A large temporary construction camp would be required during the period that work is in progress and a smaller permanent camp would be needed for project operations after completion of construction. The camp facilities would be located on a plateau south of the canyon rim in an area designated as Cedar Town Site. The area is about 12 miles south of the damsite, by way of the potential access road, and about the same distance north of the junction with U.S. Highway 66 near the town of Peach Springs, Arizona. Facilities required include housing, administration buildings, business activities, and public facilities such as schools, parks, churches, and other community services. Water supplies would be pumped from the Colorado River and treated for domestic use. Sewage treatment facilities would also be included.

Transmission system--Transmission lines would be constructed from the Bridge Canyon Powerplant to the load centers in Arizona, southern California, and southern Nevada, and to other plants on the Colorado River for maximum utilization of the hydroelectric power potential. The transmission lines would interconnect Bridge Canyon Powerplant with the load centers, the Parker-Davis and Colorado River Storage Project transmission systems, and the Havasu Pumping Plants. Switching stations and substations would also be built to provide for line sectionalizing, interconnection with existing Bureau transmission systems, and delivery of power and energy at the load centers.

Rights-of-way--Lands required for the dam, powerplant, and reservoir are in the Hualapai Indian Reservation, Lake Mead Recreational Area, Grand Canyon National Park, Grand Canyon National Monument, Kaibab National Forest, land withdrawn for reclamation purposes, and possibly a few private ownerships. Five powersite reserves and two waterpower designations covering the damsite and part of the reservoir area were made during the period between 1914 and 1941.

Indian lands--All the features required for the construction of the project except the dam and a portion of the reservoir area will be located within the boundaries of the Hualapai Indian Reservation. It is estimated that approximately 20,132 acres of Hualapai Indian Reservation land would be required for rights-of-way.

National park encroachment--Storage of water in the reservoir to its normal water-surface elevation 1866 would raise the water surface through the Grand Canyon National Monument for a distance of 39 miles, approximately 13 miles of which would border on the Grand Canyon National Park along the common boundary upstream from the mouth of Havasu Canyon. At the lower or western end of the park, near the mouth of Havasu Canyon, the water surface would be raised about 89 feet above natural conditions at normal riverflow. In the event of infrequent flood conditions, the surface of the river would be somewhat higher for periods of short duration. This depth would gradually lessen going upstream from Havasu Canyon until the effect would become imperceptible at about 17 miles under all conditions of the riverflow.

Havasu Canyon encroachment--The Bridge Canyon Reservoir would inundate the present mouth and the extreme lower end of the canyon bottom of Havasu Creek. This would provide a comparatively easy access route into this scenic area while detracting but very little, if any, from its natural beauty. With an easy route available, more tourists would visit the canyon than at present, resulting in an excellent opportunity for the Havasupai Indians to increase their income from their established tourist enterprise.

Exchange lands--The Indian lands required for rights-of-way for Bridge Canyon Dam and Reservoir are tribal lands held in trust for the benefit of all members of the tribe, and these lands constitute, to all intents and purposes, the only source of their livelihood.

The Hualapai Indians are increasing in number and consequently the available resources per individual are shrinking. The acquisition of the lands for the Bridge Canyon Project further reduces these resources. Adequate compensation would be provided either by cash payment or exchange of lands for acquisition of right-of-way prior to start of construction.

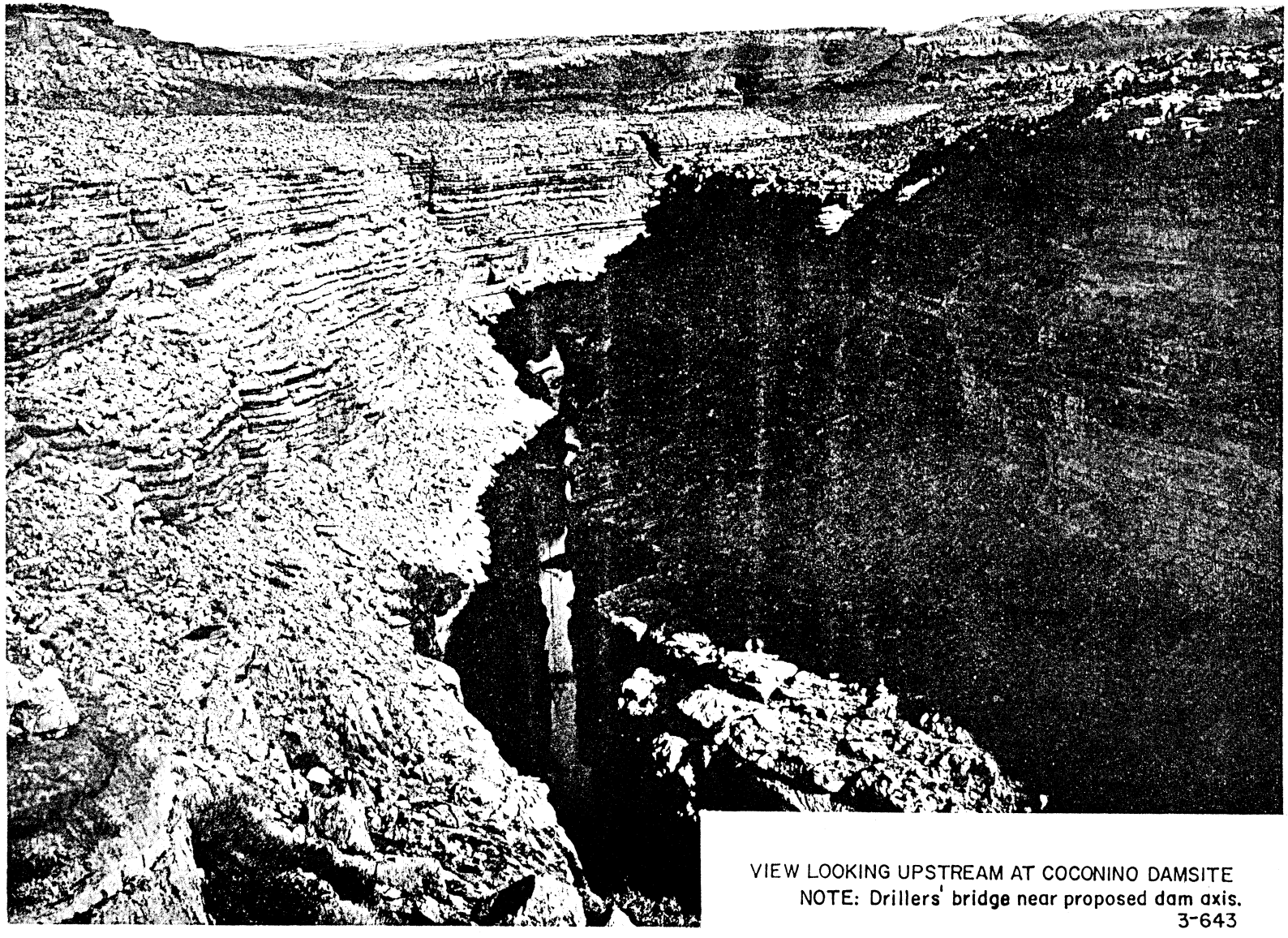
Coconino Dam and Reservoir

This development on the Little Colorado River is proposed to provide sediment and debris control for the Grand Canyon National Park and to protect storage of Bridge Canyon Reservoir from serious depletion by sediment. The dam would be located about 9 miles downstream from the town of Cameron, Arizona.

Dam--The dam as presently planned would be a concrete gravity-type composite structure 480 feet long between abutments at the top elevation 4300. Its total height above streambed would be about 250 feet. The dam would be composite in that it would consist of barriers for the inner and outer gorges of the canyon.

Reservoir--The reservoir would be operated for the single purpose of sediment retention by the use of stoplog placement to maintain a 40,000 to 80,000 acre-foot detention pool. Sufficient reservoir capacity would be available to provide for 100 years of sediment storage.

Rights-of-way--At reservoir elevation 4300, the area required for rights-of-way would be approximately 76,000 acres. Approximately 45,000 acres lie within the present boundaries of the Navajo Indian Reservation which are also included in Powersite Withdrawals Nos. 450 and 451. Most of the remaining lands are privately-owned, State-owned, or are public domain outside an organized grazing district. A small part of Wupatki National Monument would also be inundated, but the flowage would not affect any of the known archeological attractions.



VIEW LOOKING UPSTREAM AT COCONINO DAMSITE
NOTE: Drillers' bridge near proposed dam axis.
3-643

Relocation of a portion of U.S. Highway 89, which crosses the Little Colorado River, would be required and improvements at Cameron, Arizona, valued at $700,000, would have to be acquired.

Estimated Costs

Construction costs--The estimated capital cost of Bridge Canyon Project, on the basis of October 1961 prices, is presented in the following tabulation. This total includes contingencies, engineering, general expenses, lands and rights, relocation of existing property, and construction and recreational facilities. A detailed summary of costs is presented in table 1.

Bridge Canyon Dam and Reservoir (N.W.S. El. 1866)	$134,690,000
Bridge Canyon Access Road	14,750,000
Bridge Canyon Powerplant (1,500,000 kw.)	140,530,000
Bridge Canyon Transmission System	187,500,000
Coconino Dam and Reservoir	11,960,000
Bridge Canyon Construction Camp	14,523,000
Recreation Facilities	6,173,000
Fish and Wildlife Facilities	1,200,000
Total	$511,326,000

Construction program and schedule--The construction of the Bridge Canyon Project, as proposed in table 2, is estimated to require a preconstruction period of 6 months and a construction period of 9 years.

Access facilities construction schedule--In order to accomplish access to the damsite in the least time possible, it will be necessary to award contracts simultaneously on several schedules of the access facilities at the start of construction.

The pioneer road could be constructed to provide early access for work on the main access highway and water supply facilities. It is estimated that approximately 5 months would be required for its completion. It would accelerate the construction of the main highway to the damsite and would permit the necessary work prior to the actual construction of the dam to proceed at a more rapid pace and with greater economy. Construction of the main access highway is estimated to take 18 months.

7-1720
(6-62)
Bureau of Reclamation

BASIC ESTIMATE DC-1 SUMMARY

PROJECT BRIDGE CANYON
Date of Estimate October 17, 1961
Prices as of October 1961
Sheet 1 of 1 sheets

Prepared by Phoenix Development Office

Previous Estimate Prices as of

PROPERTY CLASS	PROPERTY IDENTIFICATION	PROPERTY ACCOUNT	PROPERTY DESCRIPTION	LABOR AND MATERIALS BY CONTRACTOR COST	MATERIALS AND EQUIPMENT BY GOVERNMENT COST	LABOR BY GOVERNMENT FORCES COST	FIELD COST PROPERTY ACCOUNT	TOTAL FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	INVEST'GNS ENGR'G. AND OTHER COST IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY	TOTAL COST PROPERTY CLASS	TOTAL COST IDENTIFIED PROPERTY
1			2	3	4	5	6	7	8	9	10	11	12
01			RESERVOIRS AND DAMS									161,260,000	
	01		BRIDGE CANYON DAM--Crest Elevation 1876					134,135,000		15,305,000	149,440,000		
		30	Lands and Rights				10,115,000						
		35	Dam				82,220,000						
		50	Roads, Railroads, and Bridges				41,800,000						
	02		COCONINO DAM					11,820,000			11,820,000		
		30	Lands and Rights				1,000,000						
		31	Relocation of Existing Facilities (Highway U.S. 89)				3,000,000						
		35	Dam				7,500,000						
		50	Roads, Railroads, and Bridges				320,000						
11			POWERPLANTS - HYDRO										
	01		BRIDGE CANYON POWERPLANT--6 - 250,000-kw. Units	650' Head				117,110,000		23,420,000	140,530,000	140,530,000	
		33	Structures and Improvements				19,470,000						
		36	Waterways				35,500,000						
		41	Turbines and Generators				51,530,000						
		48	Accessory Electric Equipment				5,850,000						
		49	Miscellaneous Equipment				1,300,000						
		50	Roads, Railroads, and Bridges				3,460,000						
13			TRANSMISSION LINES, SWITCHYARDS, AND SUBSTATIONS										
	01		TRANSMISSION SYSTEM				155,500,000	155,500,000		32,000,000	187,500,000	1/ 187,500,000	
15			GENERAL PROPERTY										
	01		PERMANENT OPERATING FACILITIES (Bridge Canyon Town and Camp)				11,618,000	18,200,000		3,696,000	21,896,000	21,896,000	
	02		FISH AND WILDLIFE FACILITIES				1,000,000						
	03		RECREATION FACILITIES				5,582,000						
GL	130		SERVICE FACILITIES					116,000		24,000	140,000	140,000	
	01		COCONINO DAM CONSTRUCTION CAMP				116,000						
			TOTAL CONSTRUCTION COST					436,881,000		74,445,000		511,326,000	

1/ Total cost Transmission Lines based on 1,500,000-kw. Powerplant at $125 per kw.

TABLE 1

LEGEND: Types of Activity

Preconstruction — Construction

LINE NO.	CLASS AND ACCOUNT	PROGRAM ITEM	QUANTITY	UNIT	ESTIMATED TOTAL	TOTAL TO JUNE 30, 65	FISCAL YEARS 1	2	3	4	5	6	7	8	9	10	BALANCE TO COMPLETE	ESTIMATED COMPLETION DATE	LINE NO.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		BRIDGE CANYON DAM AND RESERVOIR Normal Water Surface El. 1866																	1
2		IMMEDIATE CONSTRUCTION PROGRAM																	2
3																			3
4		Bridge Canyon Access Road			14,750,000	0	8,000,000	6,750,000											4
5		Bridge Canyon Construction Camp			14,523,000	42,000	50,000	6,301,000	8,130,000										5
6		Bridge Canyon Dam and Reservoir	3,710,000	A.F.	134,690,000	387,000	1,386,000	11,397,000	19,399,000	26,908,000	26,908,000	26,908,000	21,397,000						6
7		Bridge Canyon Power Plant	1,500,000	K.W.	140,530,000	403,000	2,000,000	2,000,000	10,002,000	30,005,000	30,005,000	30,005,000	18,503,000	11,001,000	6,606,000				7
8		Transmission System			187,500,000	538,000	900,000	11,002,000	500,000	2,700,000	25,984,000	40,349,000	47,988,000	32,985,000	24,554,000				8
9		Fish and Wildlife Facilities			1,200,000	0				200,000	320,000	620,000	20,000	20,000	20,000				9
10		Recreation Facilities			6,173,000	0	1,235,000				309,000	555,000	1,111,000	1,667,000	1,296,000				10
11		Coconino Dam and Reservoir	2,100,000	A.F.	11,960,000	295,000							2,000,000	5,000,000	4,665,000				11
12																			12
13		TOTAL CONSTRUCTION COST			511,326,000	1,665,000	13,571,000	37,450,000	38,031,000	59,813,000	83,526,000	98,437,000	91,019,000	50,673,000	37,141,000				13
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Notes:

Recommended: _____ (Operating Office Head) _____ (Date)

Recommended _____ (Regional Director) _____ (Date)

Recommended: _____ (Chief, Div. of P.C. & P.) _____ (Date)

Approved: _____ (Commissioner) _____ (Date)

Revised: _____ (Date) SHEET ___ OF ___ SHEETS

Form PF-3 — UNITED STATES — DEPARTMENT OF THE INTERIOR — BUREAU OF RECLAMATION — AUG. 1961

CONTROL SCHEDULE

BRIDGE CANYON PROJECT

PHOENIX, ARIZONA (OFFICE) — JAN. 8, 1964 (DATE) — 2 (REVISION)

☐ GENERAL INVESTIGATIONS ☐ LOAN PROGRAM
☐ CONSTRUCTION ☐ OTHER

SHEET 2

Municipal water supply construction schedule--The full use of the town would be limited until a water supply was made available, and it is therefore considered a major controlling factor in the preconstruction schedule for the dam. The pioneer road would be extremely useful in initiating early construction of the pumping plants, treatment plants, and conduits required for securing water from the river.

Dam structure construction schedule--It is possible that a contract for the construction of the dam might be awarded 2 or 3 months prior to completion of the main highway. If this were to happen, it would be possible, by means of the pioneer road, to start construction immediately on the necessary primary plant facilities such as the compressor house, powerlines, shop, and warehouses.

Operation, maintenance, and replacement costs--The following tabulation presents the annual costs of the principal features of the project. They include operation and maintenance, including administrative and general expenses, and payments to reserve for replacement of equipment.

Feature	Operation & Maintenance	Replacement	Total
Bridge Canyon Dam and Reservoir	$ 84,900	$ 13,800	$ 98,700
Bridge Canyon Powerplant	1,500,000	323,200	1,823,200
Coconino Dam and Reservoir	13,000	-	13,000
Transmission System	-	-	2,112,000
Recreation	275,000	169,000	444,000
Subtotal			$4,490,900
Purchase Energy			$ 913,000
Total Annual Cost			$5,403,900
Rounded to			$5,404,000

C H A P T E R I I I

E C O N O M I C

A N A L Y S I S

CHAPTER III - ECONOMIC ANALYSIS

Economic Justification

The Bridge Canyon Project would provide several different types of benefits to the economy of the Southwest area. The nature of these benefits and the methods by which they were derived are described in the following paragraphs. Derivation of the project cost, the other major element required in showing economic justification, has been described in the preceding chapter.

Power Benefits

Benefits accruing from the production of power were determined as costs of producing similar-type power at the lowest-cost alternative source. It was assumed this would be steam-electric plants located near load centers in the Lower Colorado River power market area. The cost of energy produced at such plants was supplied by the Federal Power Commission, San Francisco, California, and was used as the basis for an estimate of alternative costs at the load centers. On this basis the average annual equivalent cost was estimated to be $42,073,000, which was used as annual benefits for the power produced at Bridge Canyon Powerplant.

Irrigation and Municipal and Industrial Water Supply Benefits

Irrigation water supplies would not be developed by the Bridge Canyon Project, as the Bridge Canyon Reservoir is operated primarily for power production and the Coconino Reservoir for sediment retention. Seasonal regulation of the Colorado River flows is provided by Glen Canyon Reservoir.

Recreation Benefits

The National Park Service estimates annual benefits accruing to recreation from the development of Bridge Canyon Project to be $658,000.

Fish and Wildlife Benefits

The Bureau of Sport Fisheries and Wildlife estimates the annual benefits accruing to fish and wildlife from project development to be $1,305,000.

Area Redevelopment Benefits

The Bridge Canyon Project would be constructed in part on the Hualapai Indian Reservation, and in Mohave County, Arizona, both

designated redevelopment areas. It is assumed that unemployed area labor would be utilized, wherever possible, in the construction, operation, and maintenance of the project.

Estimates of this type labor that might be utilized were based on employment records of the Glen Canyon Unit of the Colorado River Storage Project. The annual area redevelopment benefits accruing from the construction and operation of Bridge Canyon Project are estimated as follows:

Construction	$271,000
Operation	87,000
Total Annual	$358,000

Benefit and Cost Summaries

The following tabulation presents the annual benefits derived for the 100-year period of analysis, using an interest rate of 3 percent:

Purpose	Annual Benefits
Power	$42,073,000
Recreation	658,000
Fish and Wildlife	1,305,000
Area Redevelopment	358,000
Total	$44,394,000

The average annual project costs are summarized in table 3.

Benefit-Cost Ratio

The total annual benefits of $44,394,000 accruing from development of the project exceed the total annual costs of $22,618,000 for the 100-year period of analysis, at a ratio of 2.0 to 1.0.

Table 3

Derivation of Average Annual Project Costs

Bridge Canyon Project

	100-year Period of Analysis
Construction Costs 1/	$509,661,000
Interest During Construction 2/	34,291,000
Total Federal Cost	$543,952,000
Average Annual Equivalent Costs 3 percent interest 100-year period	$ 17,214,000
Annual Operation, Maintenance, and Replacement Costs 3/	5,404,000
Total Annual Equivalent Project Costs	$ 22,618,000

1/ Excludes $334,000 of nonreimbursable and $1,331,000 of reimbursable investigation costs.

2/ Interest during construction computed at 3 percent.

3/ Includes annual operation, maintenance, and replacement cost of recreation facilities, and $913,000 for purchase energy.