HEADGATE ROCK HYDROELECTRIC PROJECT

ADVANCED PLANNING REPORT

PREPARED FOR THE
BUREAU OF INDIAN AFFAIRS

JUNE 1980

U.S. DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

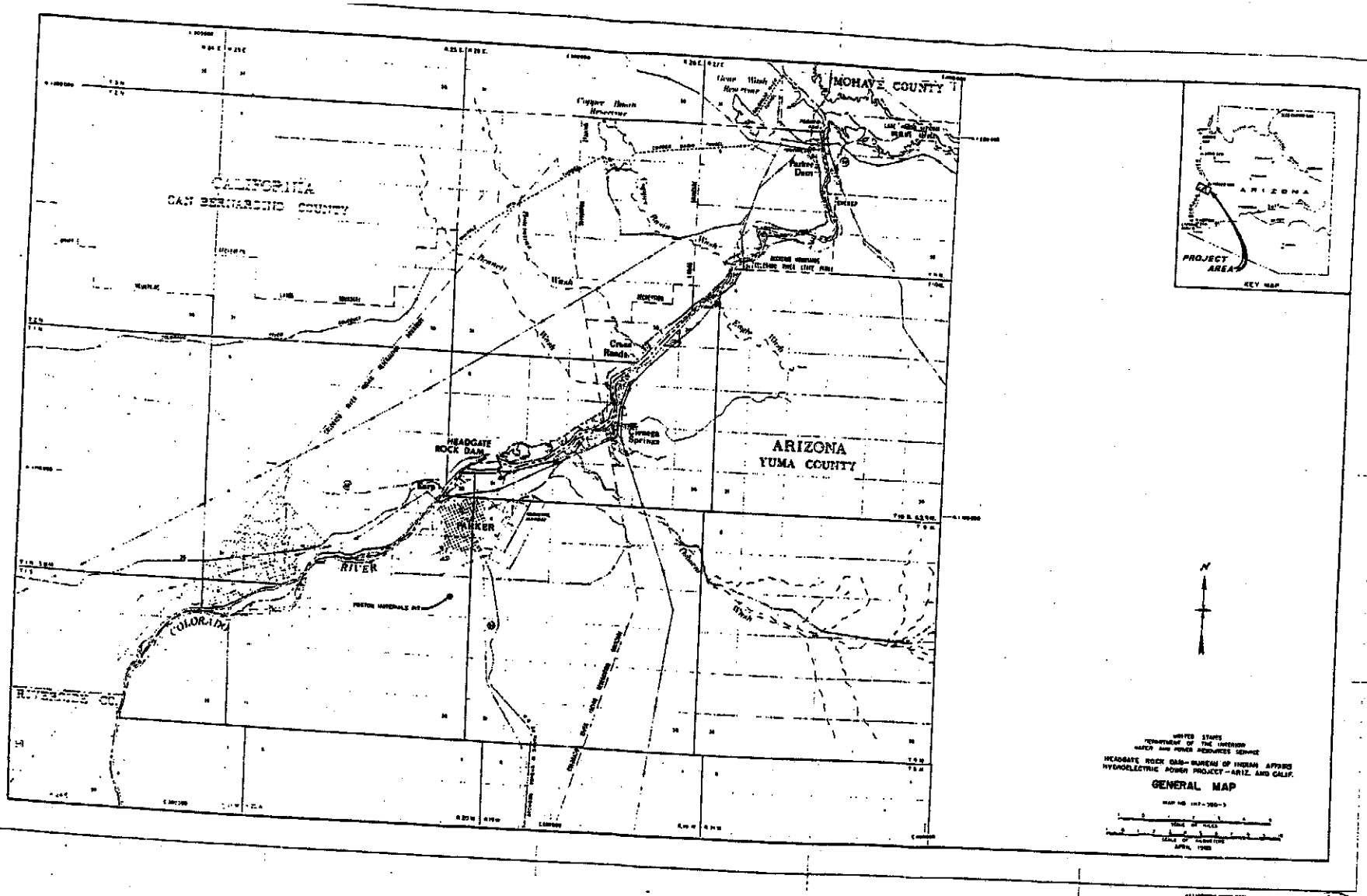
HEADGATE ROCK HYDROELECTRIC PROJECT

Advanced Planning Report
Prepared for the Bureau of Indian Affairs

U. S. Department of the Interior
Cecil Andrus, Secretary

Water and Power Resources Service
Lower Colorado Region
Eugene Hinds, Regional Director

June 1980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COLORADO
RIVERSIDE CO.
PROJECT AREA
KEY MAP
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UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
HEADGATE ROCK DAM-BUREAU OF INDIAN AFFAIRS
HYDROELECTRIC POWER PROJECT-ARIZ. AND CALIF.
GENERAL MAP
APRIL 1965

SUMMARY

PROJECT COST

Feature	Cost
Headgate Rock Powerplant	$34,513,000
Headgate Rock Switchyard, Transmission lines, Terminal Facilities	1,045,000
TOTAL PROJECT COST	$35,558,000

CONSTRUCTION PERIOD	Approximately 3-½ years
ANNUAL EQUIVALENT BENEFITS	$ 5,017,000
ANNUAL EQUIVALENT COSTS	3,090,000
PROJECT NET BENEFITS	1,927,000
BENEFIT-COST RATIO	1:6:1.0

ALLOCATION OF COSTS

Irrigation power	$ 9,352,000
Commercial power 1/	29,036,000
TOTAL	

1. Includes $2,830,000 interest during construction.

FINANCIAL SUMMARY

Following is the summary of project income and repayment for a 50-year payout period.

Income (50-year period)

Firm commercial energy (40.4 mills per kWh)	$ 129,535
Irrigation operations energy (11.4 mills per kWh)	13,150
TOTAL INCOME	$ 142,685

Repayment (50-year period)

Interest-bearing investment (commercial power)	$29,376,000
Interest-free investment (irrigation)	9,352,000
Interest on unpaid balance	89,782,000
Operation, maintenance, and replacement	14,000,000
TOTAL REPAYMENT	$142,510,000
SURPLUS	$ 175,000

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF PHOTOGRAPHS

APPENDED MATERIAL

I. TRANSMITTAL

I. TRANSMITTAL

A. Introduction

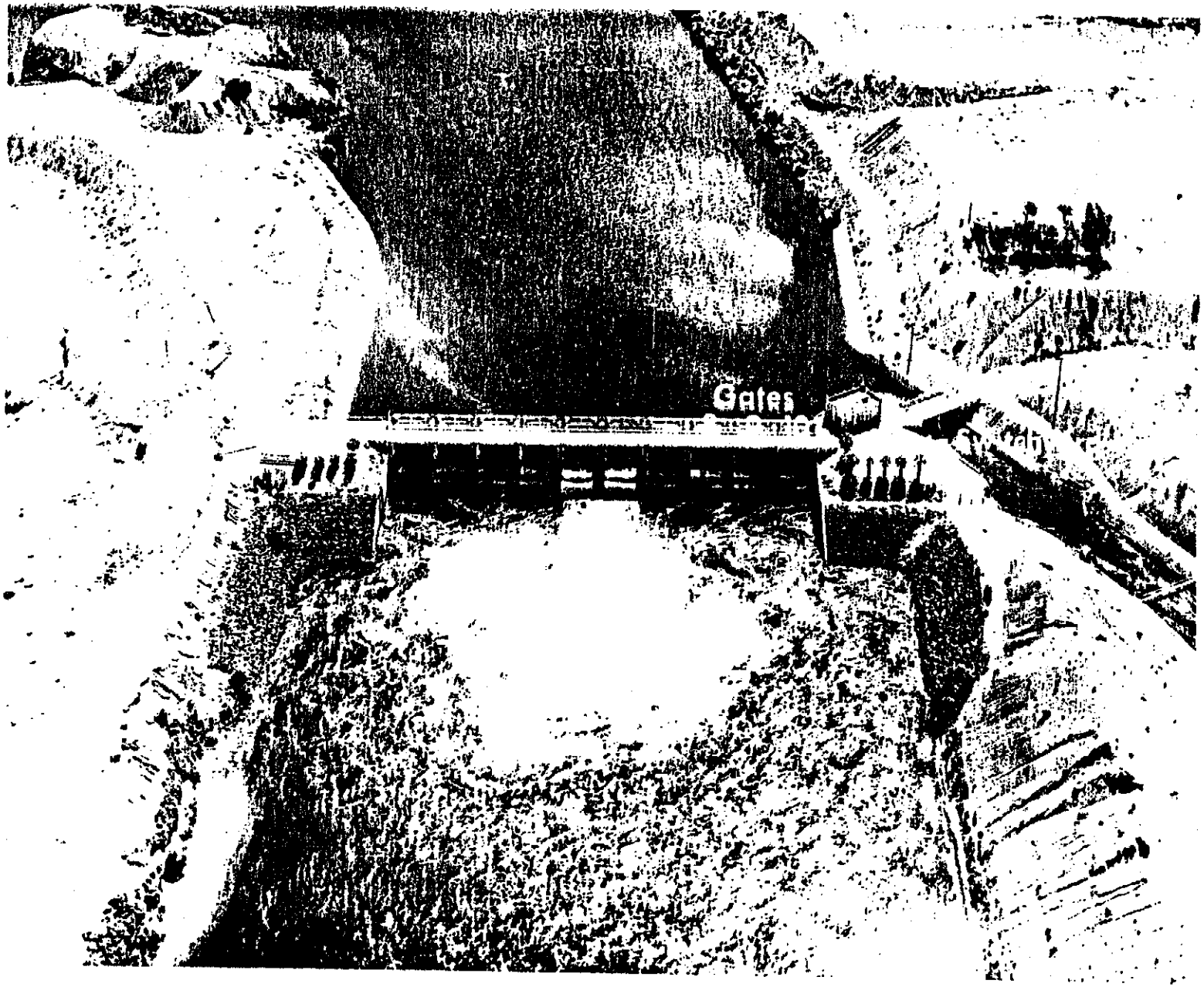
The Bureau of Indian Affairs (BIA) requested that the Water and Power Resources Service (Service) update the 1967 Feasibility Report for the construction of a low head power generation plant at Headgate Rock Dam, Arizona to supply additional power for the Colorado River Indian Reservation (Reservation). Marked photograph No. P423-300-12899 shows the spillway structure and the location for the three tube turbine generators. A 1967 report recommended that two 6,500 kW low head tube type turbine-generator units be constructed. With the rising energy costs, a new sizing study has indicated that three units at 6,500 kW each would produce the highest net benefits. The only present assured source of power to meet these needs is through private facilities. Even if additional Federal power facilities were established, it is probable that only a portion of the Reservation's power needs could be supplied from another Federal source. The most recent studies are a result of the Colorado River Indian Reservation Tribal Resolution 7-77, dated January 31, 1979, and the Memorandum of Understanding between the BIA and the Service dated May 7, 1980.

B. Authority for the Advanced Planning Report

The revision and updating of the December 1967 report are pursuant to the act of May 21, 1920, (USC Title 31, Sec. 686) as amended by the Economy Act of June 30, 1932, and also as part of a request by the Bureau of Indian Affairs memorandum dated July 30, 1979, and Colorado River Indian Reservation Tribal Resolution R-7-77 dated January 1979, along with the Memorandum of Understanding dated May 7, 1980.

C. Previous Investigations

The Service's initial investigation culminated with the Reconnaissance report entitled "Memorandum on Reconnaissance Studies of Headgate Rock Dam Power Potential," dated July 1965. As a result of this report, the BIA recommended that a detailed feasibility


Gates

investigation be initiated. At the conclusion of these investigations, the feasibility report "Report on Headgate Rock Hydroelectric Power Project (Bureau of Indian Affairs), Project Development Report December 1967," was issued. A later report entitled "Reevaluation and Updating of the 1967 Feasibility Report, Headgate Rock Hydroelectric Power Project" was transmitted to the BIA, in June 1974.

A 1976 Bureau of Reclamation (Service) report, "The Western Energy Expansion Study," evaluated the Headgate Rock Hydroelectric Project and recommended it as the highest priority low head hydro project in the Lower Colorado Region.

D. Present Conditions

The Reservation contains 264,333 acres along the Colorado River, with 225,995 acres in Yuma County, Arizona and 38,338 acres in San Bernardino and Riverside Counties of California. Parker, Arizona, is the largest town within the reservation with an estimated population of 3,100 people in 1978. The permanent population in the Parker Valley is another 5,000 people, with an additional transient population of several thousand on weekends and holidays.

The Reservation has been making steady economic growth during the last several years. In 1965 there were 31,940 acres being irrigated while in 1978 there were 75,405 acres irrigated on the Reservation in Arizona. The March 9, 1964 Supreme Court Decree, Arizona vs. California, provides for the eventual irrigation of 107,588 acres, in Arizona and California. The Reservation's development of the remaining acreages will progress slower because of increased development costs and the required extension of the existing irrigation system.

The Reservation's electrical power requirements are allocated from two Federal sources, the Parker-Davis Project which supplies 8,900 kW during the summer and the Colorado River Storage Project which supplies 750 kW firm and 80 kW peaking during the summer. The Reservation also has a contract with the Arizona Public Service Company to supply up to 16,500 kW.

Headgate Rock Dam is located on the Colorado River 14.4 river miles downstream from Parker Dam. The dam was completed in 1941 and provides diversion facilities with sufficient capacity to serve about 100,000 acres of land in Arizona on the Reservation.

E. Plan of Development

All of the power that could be produced at Headgate Rock Dam Powerplant would be used on the Reservation to operate the irrigation and drainage facilities and to supply a portion of the residental and commercial power requirements on the Reservation land.

Three tube-turbine generator units, each with a rated capacity of 6,500 kilowatts, would be incorporated into and below the three left spillway gate sections 8, 9, and 10 of the existing Headgate Rock Dam. Draft tubes from these units would discharge into the existing spillway channel. The powerplant switchyard would be located next to the the left abutment of the spillway immediately adjacent and south of the spillway gate sections. A single 69-kilovolt transmission line would be constructed from the powerplant switchyard to the substation about 0.6 mile south of Headgate Rock Dam.

The generation from the 19,500 kilowatt powerplant would average 86,511,000 kilowatthours annually for the period 1985 through 2035 and have an average annual plant factor of 62 percent.

F. Economic and Financial Analysis

1. Benefits. Benefits are based on the production of electric power for irrigation and drainage use on the Reservation. The cost benefits are based on a cost comparison of a Federal share arrangement with a 800-MW coal fired powerplant. The value of this power is computed at the substation.

The value of power produced at Headgate Rock Dam Powerplant is estimated to be 57.3 mills per kilowatthour. The power benefits for this project are estimated at $152.74 per kilowatt per year and 23.06 mills per kilowatthour.

The annual equivalent benefits for the three tube turbine generator units at 6,500 kW each are $5,017,000. The net benefits are $1,927,000 annually.

2. Costs. The total estimated project cost including interest at 7.125 percent during construction for the 3 units is $39,398,000. This represents an annual equivalent cost of $2,810,000 based on a 100-year period of analysis. The estimated annual operation, maintenance, and replacement costs are $280,000 per year giving a total annual cost of $3,090,000.

3. Benefit-Cost Ratio. The construction of Headgate Rock Hydroelectric Project is economically justified with a benefit-cost ratio of 1.6:1.0 based on a 19,500-kW plant using three tube-turbine generators with a total design discharge of 18,390 ft^3/s.

4. Cost Allocation and Repayment. The project costs are divided into two segments, the costs for irrigation power and the costs for commercial power. Any costs that are related directly to irrigation are not interest bearing. The costs as related to commercial power are to be repaid with interest at the rate of 7.125 percent. Irrigation benefits are to include the increased use of power for both sprinkler irrigation and for drainage pumping. These benefits use about 26 percent of the power produced from the project.

G. Conclusions

1. Projections indicate that by 1985 the energy that can be generated by the Headgate Rock Powerplant could be used on the Reservation.

2. A 19,500-kW plant at a design head of 15.6 feet should be built using three tube turbine generator units at 6,500 kW each and producing a total of 86,511,000 kWh of energy annually.

3. The project plan is engineeringly feasible.

4. The project plan is economically justified, as indicated by the benefit-cost ratio of 1.6:1.0.

5. The project plan is feasible financially. All of the project costs can be repaid within 50 years after the project becomes operational.

6. The project would provide the most economical source of electric power that can be supplied to the Reservation.

II. GENERAL DESCRIPTION OF THE PROJECT AREA

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A. Project Area

The area that would be served by the Headgate Rock Hydroelectric Project is the Arizona portion of the Reservation. Some power could, of course, be used in California if the land were developed. The Reservation occupies about 264,333 acres of land with 99,375 irrigable acres of land in Arizona. There are 38,338 acres of Reservation land in California with 8,213 irrigable acres for a total of 107,588 irrigable acres with a Colorado River water allocation of 717,148 acre-feet as provided for in the March 9, 1964 Supreme Court Decree Arizona vs. California. The northern apex of the Reservation is about 10 miles north of the town of Parker, Yuma County, Arizona and 5 miles south of Parker Dam, Arizona-California. The Reservation is about 10 miles wide and extends for 44 miles south of the town of Parker through the Parker Valley.

B. History of Development

In 1865 Congress established the Colorado River Indian Reservation with the boundaries being changed many times since the present boundaries were established by Executive Order in 1916.

Congress appropriated $50,000 for the construction of the Grant-Dent Irrigation Canal in 1867. This canal was designed and constructed to divert water from the Colorado River and began operation in July 1870. The elevation of the Grant-Dent Canal headworks was so low that diversions could not be made during low riverflows. In 1874, appropriations were obtained to extend the canal upstream. The new selected diversion point was Headgate Rock which required that several tunnels be built. Since the tunnels were constructed in a rock that caved easily, excessive maintenance resulted, and the tunnels were abandoned in 1876.

Gravity diversions were made at a location just below the tunnels during the higher stages of riverflow. In 1899 a pumping plant was installed and gravity diversions were discontinued. This pumping plant was enlarged in 1918 to supply up to 125 ft^3/s. Headgate Rock

Dam was started in 1938 and was completed in 1941 providing permanent diversion facilities to irrigate by gravity up to 100,000 acres of land in Arizona.

In 1936 only 5,000 acres were irrigated, however, by 1965 the irrigated land had increased to 31,940 acres and by 1978 there was 75,405 acres under irrigation with over 8,000 acres being irrigated by sprinkler irrigation application methods. At this time there are still several miles of riverfront areas that could be developed for recreational uses.

To help encourage private investments within the Reservation, the Tribal Council sought and obtained Federal authority to grant long-term leases. In 1962, authority to grant 99-year nonagricultural leases was obtained. In 1963, a 25-year agricultural leasing authority was granted, and in 1965 a 40-year leasing authority was granted for citrus farming. During the past few years the BIA has not been exercising this leasing authority.

When the adjudication of the water rights for the Colorado River water use on the Reservation was settled by the March 9, 1964, U.S. Supreme Court decision in the Arizona vs. California (June 1963) positive development of these lands became a reality. The Decree allowed for 717,148 acre-feet of water to be diverted to irrigate a total of 107,588 acres of land on the Reservation.

C. Climate

The Reservation lies within the arid Sonoran Desert portion of the southwestern United States. The climate of this area is characterized by long hot summers and short mild winters, low annual rainfall, low relative humidity, high evaporation, and a high percentage of days of possible sunshine.

There are two distinct moisture sources. Winter precipitation is associated with moisture moving into the area from the Pacific Ocean, while the Gulf of Mexico supplies moist air for most of the regions summer rains. Winter rains, sometimes lasting for several days, usually occur as gentle showers over a large area. Local summer thunderstorms, which usually cover only small areas, are usually of high intensity and of short duration and produce many of the destructive flash floods that are well known in the Southwest.

The annual precipitation in the Parker area averages about 5 inches. The average temperatures for the Parker area are shown in the following tabulation:

Average Annual	71.6°F
January Average	52.6°F
July Average	95.8°F

Summer temperatures are commonly in excess of 110°F and have reached a maximum of 127°F; while the minimum recorded winter temperature is 20°F. The summers are long and the winters are short and very mild with an almost complete absence of freezing temperatures. The average frost-free period is in excess of 300 days.

D. Geology

Headgate Rock Dam is located within the Basin and Range Physiographic Province which is generally characterized by nearly parallel fault block mountain ranges separated by deep alluvium-filled valleys. The area surrounding the dam, however, does not exhibit this typical physiography. The Whipple Mountains to the west and the Buckskin Mountains to the east owe their elevation to doming or arching (Davis and others, 1979) and are dominated by features resulting from low angle faulting and a conspicuous detachment surface.

The rocks in these mountains are complexly arranged crystalline and sedimentary units ranging in age from Precambrian to Recent. The Colorado River separates the two mountain ranges. The intervening lowland is filled with sedimentary deposits of Miocene to Recent age. The oldest of these is a steeply dipping gray to tan sandstone which contains a bed of tuff about 2 feet thick and is cut by andesitic dikes. According to Carr and Dickey (unpublished), the tuff is probably correlative with the Peach Springs Tuff which has been dated between 16.9± 0.4 and 18.3+ 0.6 million years before present (Young and Brennan, 1974). Earlier reports on the site refer to this unit which forms the right dam abutment as the Copper Basin Formation. Carr and Dickey's map (unpublished) classifies the unit as sedimentary rocks, unit 2 of Miocene age. Unconformably overlying this in the Osborne Wash Formation of the Pliocene-Micocene age, a variably

indurated fanglomerate containing beds of sandstone and basalt. The basalt capping this unit at Headgate Rock has been mapped by Carr and Dickey (unpublished) as basalt of Lake Moovalya and dated at 12.6± 1.1 million years before present. The Pliocene Bouse Formation deposited less than 10 million years ago (I. Lucchitta, 1972) is a sequence of variably indurated limestone, claystone, and cross-bedded sandstone. At the contact with the underlying Osborne Wash Formation is a deposit of tufa which was deposited against local topographic highs and forms a conspicuous white band along the low hill surrounding the Colorado River in this area. Quarternary alluvium makes up areas adjacent to and within the channel and in high terraces. In places, it forms thick deposits in abandoned channels.

The dam itself occupies the Colorado River channel and diverts the streamflow through a concrete spillway and canal. The spillway channel and canal were excavated through alluvial gravel and rock about 40 years ago to raise the water level to provide irrigation water to agricultural areas downstream.

E. Population

Parker, Arizona, is the largest town within the Reservation, it had a population of 1,937 in 1965. The estimated 1978 population was 3,100 people. In addition it is estimated that about 5,000 permanent residents reside in the Parker Valley. The recreational development along the river below Parker Dam normally generates a large influx of people during holidays and weekends.

F. Transportation

Parker, Arizona is connected to U.S. Highway 60-70 by Arizona State Highway 72. U.S. Highway 60-70 is a major east-west highway that provides access to both Los Angeles, California, and Phoenix, Arizona. A surfaced county highway connects Parker, Arizona with U.S. Highway 95 at Vidal, California, and in turn connects Blythe and Needles, California. Arizona State Highway 95 runs north to Parker Dam then crosses the Bill Williams arm of Lake Havasu and then goes north to Lake Havasu City, Arizona. This route provides direct access through Arizona to U.S. Highway 66 south of Kingman, Arizona. The Santa Fe Railroad provides rail service from the Los Angeles and

Phoenix areas. A municipal airport is on the north side of the town of Parker, Arizona, 0.8 of a mile from the spillway structure.

G. Economy

The economy of the area is based on two phases, the largest phase being the agricultural growth which has resulted due to the development of Reservation agriculture land since 1965 and the second phase being the recreational use of the lands along the Colorado River. Together agriculture and recreation make up the economic base within the project area.

H. Agriculture

In 1965, there was 31,940 net irrigated acres with practically no sprinkler irrigation. In 1978 there were 75,405 net irrigated acres with over 8,000 of these acres using sprinkler irrigation. The development of the remaining acreages will probably progress slower because of required expansion and improvements of the basic irrigation system, the clearing of lands, and the increased costs of development. Major construction programs have been underway since the mid-60's involving canals, laterals, drains, pumping plants, and dikes.

The crops that are grown on the Reservation include cotton, lettuce, corn, peanuts, alfalfa, wheat, barley, maize, and melons. Several thousand acres of mesa land have been developed to grow citrus crops.

I. Recreation

The increasing population in the Southwest, combined with the increased interest in water-oriented recreational opportunities, puts pressure on all of the areas that are suitable for this type of activity.

The Reservation tribes constructed the Blue Water Marine Park just upstream of Headgate Rock Dam, which is a waterfront facility having 2,500 feet of sandy beach, with two large cabanas, a parking lot, a restaurant, a racing judge's stand, restrooms, and a trailer park. There are several residential subdivisions which border on both sides of the Colorado River. Within a 1-mile area several commercial establishments and numerous homes have been constructed.

The tribes also made several recreation-oriented leases, the largest covering 9 miles of river frontage in California with 7,800 acres under lease. One consulting engineering firm estimated that this development would eventually have a permanent population of between 28,000 and 34,000 people.

J. Industry

Industrial firms have indicated interest in development on the Reservation for several years, but development has been slow.

There are three cotton gins and four large cattle feedlots plus several smaller feedlots on the Reservation. The only textile mill in the valley closed in 1965.

K. Future Electrical Power Requirements

The maximum power demand has been steadily increasing. In 1955 the peak monthly power demand was 1,214 kW, in 1965 this increased to 4,800 kW, and in 1979 the use was 26,500 kW.

The electrical load pattern on the Reservation is characterized by summer air-conditioning peak. The sprinkler irrigation requirements and the drainage well systems are normally operating steadily throughout the growing season. There is no appreciable variation in the electrical requirements for irrigation between the weekdays and the weekends.

The Reservation represents a small portion of the Southwest power market, in which the future growth is controlled by special localized conditions. The factors that were considered in deriving the future electrical requirement projections are: the rate of increase in electric power requirements for the period 1956 through 1979, the planned or anticipated recreation-oriented urban development, and the planned agricultural development. The industrial development is considered to be a minor factor and was therefore absorbed in other items.

The future residential and commercial power requirements are estimated to increase at an average annual rate of 6 percent. The estimated future power requirements for the Reservation are shown on Table 1. It is estimated that by 1985 the energy from a 19,500 kW powerplant at Headgate Rock would be completely utilized on the Reservation.

Table 1
PROJECTED POWER REQUIREMENTS
Headgate Rock Hydroelectric Project, Arizona

YEAR	AGRICULTURE		COMMERCIAL		TOTAL	
	Peak Month kW	MWH	Peak Month kW	MWH	Peak Month kW	MWH
1985	5,130	23,062	20,700	102,000	25,830	125,062
1990	5,130	23,062	27,700	136,400	32,830	159,462
1995	5,130	23,062	37,100	182,600	42,230	205,662
2000	5,130	23,062	49,600	244,400	54,730	267,462

L. Problems and Needs

The economy of the Reservation is sustained largely by the irrigated agriculture and the water-oriented recreational activities. Developments were encouraged on the Reservation because private investors could obtain long-term leases.

The accelerated development on the Reservation has created a large demand for ever-increasing quantities of electric power for domestic use and for the operation of both irrigation and drainage facilities.

Water conservation practices on the Reservation have also resulted in increased power requirements. At the present time over 8,000 acres are being sprinkler irrigated which requires energy to produce the necessary pressure for the sprinkler heads.

III. WATER SUPPLY

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A. Historic Water Supply

Historically the annual runoff as undepleted flow of the Colorado River has ranged between 5 and 24 million acre-feet. Prior to the construction of Hoover Dam, the waters passing the Headgate Rock Damsite ranged from rushing torrents to almost no flow at all during certain times of the year. After the completion of Hoover Dam the river below Hoover became a regulated stream. When Parker Dam was completed in 1936 more reregulation was added to the Colorado River.

Located about 10.4 miles upstream of Headgate Rock Dam is the U.S. Geological Survey's "Colorado River below Parker Dam" gage. As measured on this gage, the average annual historic discharge from Parker Dam for the 1941 to 1978 period was 8,981,000 acre-feet. The mean average summer flow below Headgate Rock Dam is 13,200 ft^3/s and the mean average winter flow is 5,400 ft^3/s. The average dissolved solids for the years 1941 through 1978 at the gage "Colorado River below Parker" is 702 mg/L.

B. Present Water Supply

The reservoir formed by the Headgate Rock Dam, Lake Moovalya, contains essentially no active storage capacity. The riverflow past Headgate Rock Dam is the releases Parker Dam minus the diversions to the Colorado River Indian Reservation Main Canal. The Parker Dam releases normally varies between 2,000 and 20,000 ft^3/s. The maximum releases can be expected during July and August, conversely the minimum releases can be expected during the winter months of January and February.

Downstream water orders are determined on a weekly basis throughout the year. Daily releases at Parker Dam are further governed by orders from the downstream irrigation and municipal industrial water users. These daily releases are further regulated according to Parker-Davis Project power system hourly generation demands. Diversions to the Reservation vary from zero in December and January to more than 900 ft^3/s during July and August.

C. Future Water Supply

It's projected that by the late 1980's, all normal flows of the Colorado River will be utilized. Water now available for use in the Lower Basin from the Upper Basin will decrease as new Upper Basin projects are constructed. The normal flow that is now passing Headgate Rock will remain relatively stable in the future due to downstream water right and the Mexican Water Treaty requirements. The minimum required annual flows passing Headgate Rock Dam without shortages would be 6,729,000 acre-feet.

After the Central Arizona Project (CAP) is completed, the future annual flows of the Colorado River below Parker Dam will range between 6,307,000 and 15,336,000 acre-feet as based on the March 1978 Colorado River Storage Project (CRSP) computer program. The CRSP model assumed two conditions for the CAP; one for the project without regulatory storage and the other with regulatory storage. The CRSP computer program uses 13 sequences of values by months using 73 year intervals. Based on the average of the 13 sequences the long-term average flow at Parker Dam with CAP regulation is 7,259,000 acre-feet and without CAP regulation is 7,310,000 acre-feet.

For the purpose of this report, the typical 1964 release pattern was used. The historic release pattern, which reflects daily downstream water orders and the hourly electrical power production at Parker Dam, is assumed to remain the same in the future.

The water supply studies have included the larger than minimum required flows in the Lower Basin. With recent rapidly increasing value of energy, this report has considered a larger powerplant at Headgate Rock Dam in order to utilize the full range of normal releases at Parker Dam using the same criteria as established in the 1967 report. In order to utilize both the 2,000 ft^3/s minimum and the maximum normal flows at Headgate Rock dam, a third 6,500-kW turbine-generator unit would be most effective.

D. Floods

All of the riverflows which pass Parker Dam, minus the diversions to the Reservation Main Canal, arrive at and are immediately released from Headgate Rock Dam. Since the completion of the dams on the

Colorado River upstream of Parker Dam and of the Alamo Dam on the Bill Williams River, the possibility of large floodflows at both Parker Dam and Headgate Rock Dam has been greatly reduced.

The existing spillway structure at Headgate Rock Dam provides for a total capacity of 200,000 ft^3/s through the use of 10 gates, each with a capacity of 20,000 ft^3/s. The maximum 100-year design flood potential is 68,500 ft^3/s at Headgate Rock Dam of which 18,500 ft^3/s come from the 240 square mile area between Parker Dam and Headgate Rock Dam.

If three units are constructed within the spillway structure, 140,000 ft^3/s could still be passed through the remaining seven gates plus the 18,390 ft^3/s that could be passed through the turbines giving a total of 158,390 ft^3/s or an excess of 90,000 ft^3/s over the 100-year design flood.

E. Degradation

The channel elevation below Headgate Rock Dam has remained stable since 1955. The historic discharge since 1955 has varied between 1,770 $ft^3/sec.$ and 22,800 ft^3/s. The BIA also placed some additional riprap on the Arizona side of the river below Headgate Rock Dam during early 1979. Since the channel below the dam is considered to be a stable armored section, a future degraded condition was not studied.

IV. PRESENT FACILITIES

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A. Electric Power Supply

The Reservations present electric supply comes from three sources: (1) the Service's Parker and Davis Dams through Department of Energy's Parker-Davis Project, (2) the Colorado River Storage Project, consisting of Service dams and the transmission facilities operated by the Department of Energy, and (3) the Arizona Public Service Company which supplies requirements in excess of the allocations furnished by the two Government entities. The BIA's 34.5-kilovolt transmission system delivers all of the power to the Reservation.

1. Parker-Davis Project. A Memorandum of Understanding No. 14-06-300-2627 between the Bureau of Indian Affairs and the Department of Energy was initiated on April 1, 1976, with an expiration date of March 31, 1986. Provisions of this memorandum established contract rates of delivery separately for both the summer and winter seasons. The summer season is March through September with a contract rate of 8,900 kW and a winter season of October through February with a contract rate of 4,200 kW. The maximum quantity of energy delivered during the summer season is 29,386,368 kWh and 7,172,352 kWh during the winter season for an annual total of 36,558,720 kWh. If it is available, additional energy may be purchased from this source.

The present demand charge per kilowatt is $1.39 while the energy charge is 3.5 mills per kilowatthour, an additional transmission line charge of $5.30 per kilowatt is charged annually for an annual southern diversion composite rate of 6.67 mills per kWh. The Parker-Davis Project will have new power rate adjustments taking effect July 1, 1980. The new power rates are $1.82 per kilowatt per month and 4.15 mills per kWh for an annual composite rate of 8.3 mills per kWh.

2. Colorado River Storage Project. A Memorandum of Understanding, No. DE-MS65-80-WP39025 was made between the Department of Energy and the Bureau of Indian Affairs on March 26, 1980 to supply electric service for use of the Colorado River Indian Reservation. The memorandum remains in effect until September 30, 1989.

The summer season under this memorandum is from April through September and the winter season is from October through March. The contract rates of delivery is 750 kW firm plus 80 kW peaking power during the summer season and 400 kW firm plus 40 kW peaking during the winter season.

An adjustment of 7 percent for losses is applied to storage project power deliveries, as measured at the Parker-Davis Project points of delivery.

The cost of Colorado River Storage Project power is determined at the rate of $1.34 per kW per month of the greater of the contract rate of delivery, or the maximum 30-minute integrated demand. The energy charge is 3.4 mills per kWh. In addition, there is a wheeling charge of $3.67 per kW for each of the summer and winter seasons.

The average composite rate is 6.55 mills per kWh per month. A rate increase is proposed to take effect October 1, 1980 that would result in $1.76 per kW per month and 4.1 mills per kWh for an annual composite rate of 8.25 mills per kWh.

3. Arizona Public Service Company. The additional required electrical service for the Reservation is furnished by the Arizona Public Service Company. The demand charge is $5.70 per kilowatt per month with an additional energy charge of $0.0144 per kilowatthour. Present contract is for 16,850 kW from this source.

B. Substation and Transmission Facilities

Electrical power is delivered to the Reservation's 34.5-kilovolt transmission system through the Parker Powerplant switchyard. The first 3 miles of transmission lines from Parker Dam are owned by the Metropolitan Water District of Southern California, with the remaining 6.5 miles owned by the Colorado River Indian Reservation. The distribution facilities are all owned by the irrigation project.

C. Headgate Rock Dam

Headgate Rock Dam is located on the Colorado River 14.4 river miles downstream from Parker Dam and 1 mile northeast of the town of Parker, Arizona as shown on the frontispiece map.

Headgate Rock Dam was constructed by the BIA and was completed in 1941 to provide diversion facilities for up to 100,000 acres of land

in Arizona on the Colorado River Indian Reservation. The dam is an earthfill structure which rises 77 feet above the lowest point in the foundation and about 38 feet above the original streambed. It is 2,800 feet long with a crest elevation of 390 feet. The spillway and canal headworks are located on the Arizona side of the river channel. The present spillway is where the proposed powerplant would be constructed. It is a reinforced concrete structure with 10 automatic gates and a capacity of 200,000 ft^3/s. The normal forebay water surface elevation is maintained at 364.4 feet. The maximum surface elevation is a result of the limitation of possible backwater encroachment on the Parker Powerplant tailwater. Other items that have effected the normal fluctuation in reservoir level behind this diversion dam include homesite and recreational development along the shoreline, and the diversion requirements for the Colorado River Indian Reservation Project's canal. As a result of these imposed physical limitations, the reservoir formed, Lake Moovalya, by Headgate Rock Dam has no active capacity.

The dam and spillway are in excellent condition, showing no indications of settlement, cracking, or alkali reaction in the concrete.

V. PLAN OF DEVELOPMENT

V. PLAN OF DEVELOPMENT

The plan of development as presented in this section includes the engineering plan and cost estimates for the construction of the hydroelectric generating facilities at the Colorado River Indian Reservation.

The Headgate Rock Hydroelectric Project would supply the electric power requirements for the operation of the Reservation's irrigation and drainage facilities and a portion of the residential and commercial power requirements.

The features included in this project are the powerplant with a rated capacity of 19,500 kilowatts using 3 tube-turbine generator units rated at 6,500 kW each, a switchyard, and transformer facilities, 0.6 mile of transmission line, and terminal facilities at the Headgate Rock Substation. The power and energy from the proposed hydroelectric powerplant would be transmitted at 69 kilovolts to the BIA 161/69/34.5 kV substation. The BIA will distribute the power to the Indian Reservation over its own facilities.

The annual generation for the three unit 19,500-kilowatt powerplant would average 86,511,000 kilowatthours annually for the period 1985 through 2035 and have an annual plant factor of 62 percent. The third 6,500-kW unit would be for peaking and have an average annual plant factor of 21 percent.

A. Headgate Rock Hydroelectric Facilities

Three tube-turbine generator units, each with a rated capacity of 6,500 kilowatts, would be incorporated into the three left spillway gate sections 8, 9, and 10 of the existing Headgate Rock Dam and the power would be integrated into the power grid network through the addition of a 69-kV forebay at the BIA substation. The powerplant would discharge directly into the existing spillway channel, which would be used in its present condition with no changes. The channel is considered to be an armored section.

A powerplant switchyard, a completely new facility, would be used to step the voltage up to 69 kilovolts and would be located in the area adjacent to the left abutment of the spillway. A single 69-kV

transmission line would be constructed from the powerplant switchyard to the Headgate Rock substation, about 0.6 mile south of the powerplant site. The route is shown on Drawing No. 1117-300-5. The line would begin at the powerplant switchyard and then proceed along the east side of the paved road running to Headgate Rock substation, turn 90° and enter the substation. Consideration should be given to underbuilding on the existing 12.4-kV line running to the dam on the 69-kV poles. It does not appear to be possible to underbuild under the Parker-Blythe 161-kV line, but from this point on to the dam, underbuilding should be feasible. This substation also receives electric power from the Parker-Blythe 161-kV transmission line and provides additional capacity for the present system. The 161/69-kV substation was constructed as a separate project by the BIA. Space is available within these terminal facilities to be able to interconnect the system with the proposed Headgate Rock Powerplant.

The locations of the various project features are shown on the Site Map, Drawing No. 1117-300-5.

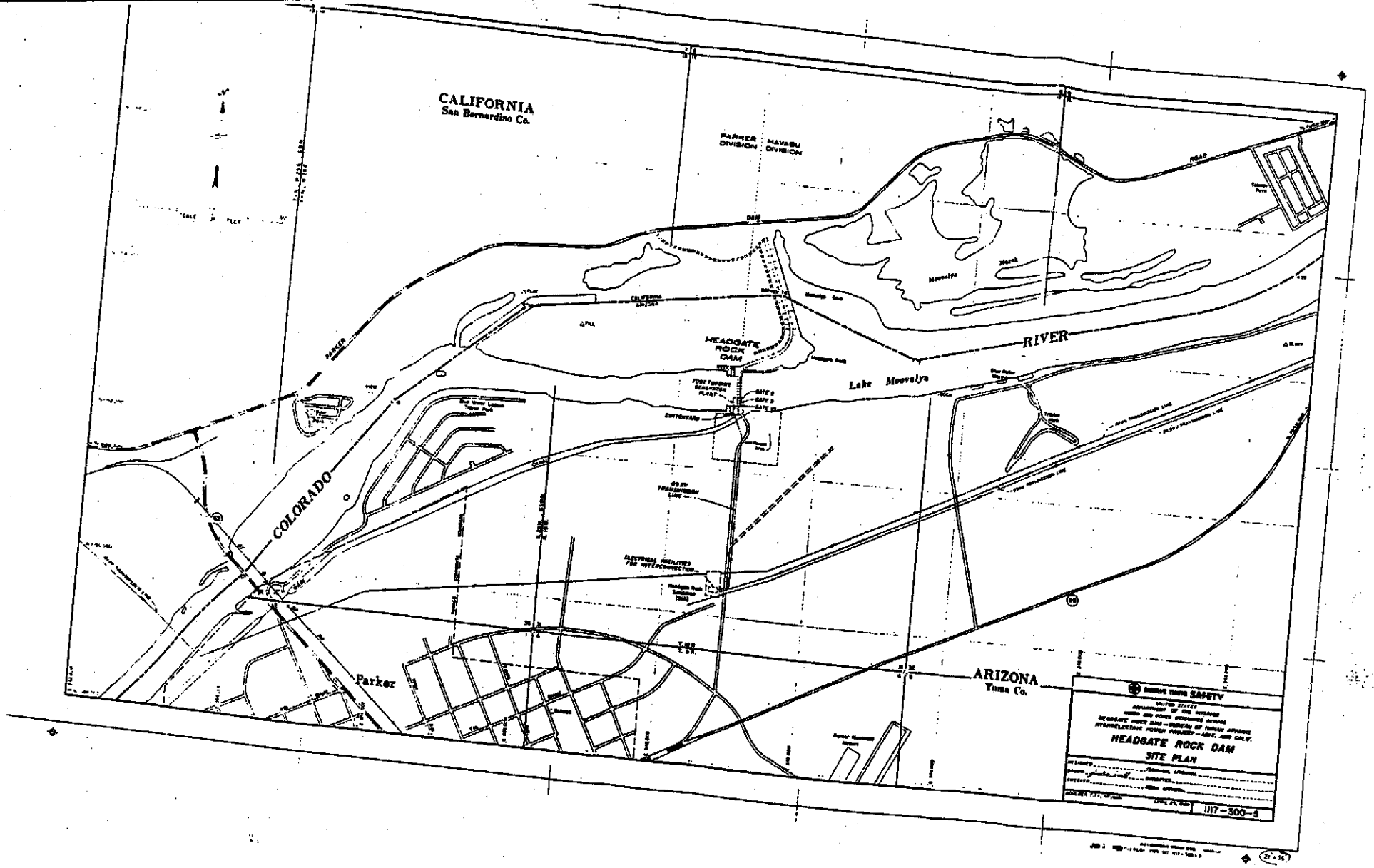
B. Engineering Geology

The proposed Headgate Rock Powerplant would be constructed within the three left gate sections of the existing spillway of the Headgate Rock Dam. This site is considered to be geologically favorable for the proposed plant.

The Colorado River Valley is a sequence of sedimentary formations consisting of alluvial fan, delta, and lake origin deposits with occasional interbedded lava flows. Deposits of unconsolidated sand and gravel are found in both the present and abandoned river channels and adjacent terraces.

The left side of the spillway is mostly andesite interbedding and the right side is mostly conglomerate. The andesite tends to dip about 5 degrees in a downstream direction and is lower on the left side than on the right side. Although conditions are not ideal, this andesite interbedding appears to be adequate for use as the foundation for the powerplant.

Differential settlement or other weaknesses in the foundation have not been found under the presently imposed static structural


CALIFORNIA
San Bernardino Co.
PARKER DIVISION
HAVASU DIVISION
HEADGATE ROCK DAM
RIVER
Lake Moovalya
COLORADO
Parker
ARIZONA
Yuma Co.
HEADGATE ROCK DAM
SITE PLAN
1117-300-5

loads. The final designs will have to consider the andesite and conglomerate for foundation stability for static and dynamic loads which would be imposed by the machinery in the proposed powerplant. Additional anchor support structures may be required below the contact zone.

C. Earth and Rockfill Materials

Pervious or impervious materials, like those used in the construction of Headgate Rock Dam, are within a short haul distance from the proposed construction site. During the initial construction of the dam, the excess material from required excavation was hauled to waste areas adjacent to and downstream from the existing dam. Material from the waste areas would have to be transported across the top of the existing dam. The material would either be deposited in place or stockpiled for use at a later date. BIA officials do not object to the use of the materials, as long as the present structure is not damaged in any way from hauling material across it. Riprap and rockfill are also available from the waste dumps or from natural outcrops within about 1 mile of the site.

1. Noncommercial Concrete Aggregate

There are two undeveloped and one developed concrete aggregate sources in the general area of the Headgate Rock Dam. They are known as Rock Drop pit, Poston pit, and Bill Williams River aggregate sources.

The Rock Drop pit is located on Reservation land. The pit is a portion of an alluvial fan at the edge of a mesa deeply cut with washes. Vegetation is of a sparse variety. The volume of the pit is about 250,000 cubic yards with no overburden and varies in depth from 0 to 25 feet.

The Poston pit is located on Reservation land. The pit site is located in an active wash area with very sparse desert vegetation. The volume is over 500,000 cubic yards with no overburden.

The Bill Williams River pit is located on Federal land administered by the Bureau of Land Management and withdrawn by the Water and Power Resources Service. The material deposited appears to be

localized terrace remnants. Vegetation consists of a slight to moderate cover of paloverde trees, greasewood bushes, and cacti. The volume is in excess of 400,000 cubic yards and the overburden varies from 0 to 4 feet in depth.

2. Commerical Concrete Aggregate

The Poston materials pit shown on Drawing 1117-300-3 is a privately owned pit, which could supply the necessary amounts of concrete for the project.

D. Powerplant Operation

The water supply available for operation of the Headgate Rock Powerplant would consist of controlled releases from Parker Dam, less diversions to the Colorado River Indian Irrigation Project's canal. Water is released from Lake Havasu at Parker Dam to supply irrigation requirements downstream and for delivery of water to Mexico. The daily quantity of water released is governed by orders from downstream water users. These releases are utilized for electric power production at the Parker Powerplant. The hourly pattern of releases for electric power production is regulated according to the load pattern of the Parker-Davis Project system. Maximum normal releases of 20,000 ft^3/s can be expected during July and August, and minimum releases of 2,000 ft^3/s during winter months.

The Headgate Rock Dam's present normal forebay water-surface elevation of 364.4 feet would be maintained through the use of the automatically controlled spillway gates. A portion of the water released from Lake Havasu would be diverted to the Colorado River Indian Irrigation Project's canal, and the remainder would either pass through the 19,500-kilowatt powerplant or be released over the spillway. There would be no reregulation of riverflows at Headgate Rock Dam for electric power production.

The water supply available for electric power production at Headgate Rock Dam would closely follow the seasonal electric power requirements on the reservation. The peak demand occurs in July and August, coinciding the maximum irrigation releases.

Since the hourly pattern of water releases at Parker Dam is regulated according to the power market area load pattern, the generation at Headgate Rock Powerplant would benefit from this same regulation. The generation rate of 19,500-kilowatt Headgate Rock Powerplant

would closely parallel the hourly load pattern on the Reservation. Approximately 1 hour is required for releases from Lake Havasu to be reflected at Headgate Rock Dam which results in a slight lag between the peak generation rate and peak demand. However, a mutual exchange of energy through the interconnection with the Department of Energy's system could eliminate any problems.

E. Electric Power Production

The annual generation of a Headgate Rock Powerplant with a rated capacity of 19,500 kilowatts for the period 1985 through 2024 would average 86,511,000 kilowatthours annually. The average annual plant factor would be about 62 percent. The estimated water available for electric power production at Headgate Rock Dam for this period averages 6,729,000 acre-feet, of which a 19,500-kilowatt powerplant could utilize 6,638,000 acre-feet for the generation of electrical energy.

A summary of the estimated Headgate Rock power and energy generation by months is contained in Table 2.

F. Electric Power Utilization

The output of Headgate Rock Powerplant would assist in supplying the increasing electric power requirements on the Colorado River Indian Reservation. Other sources of electric power which would be utilized are the Parker-Davis Project, Colorado River Storage Project, and Arizona Public Service Company.

1. Parker-Davis Project--It is assumed that electric service would continue to be provided to the Reservation in accordance with Memorandum of Understanding No. 14-06-300-2627, and that the present rates of delivery would be maintained. The present contract rate of delivery is 8,900 kilowatts for the months of March through September, and 4,200 kilowatts for the months of October through February.

Table 2
POWER AND ENERGY GENERATION BY MONTHS
Headgate Rock Hydroelectric Project
Arizona

	1985		1990		2000		2030	
	Power kW	Energy MWH	Power kW	Energy MWH	Power kW	Energy MWH	Power kW	Energy MWH
January	10,100	4,890	10,100	4,745	10,100	4,706	10,100	4,627
February	15,200	6,395	15,200	6,369	15,200	6,315	15,200	6,207
March	15,000	8,647	15,000	8,397	15,000	8,312	15,000	8,169
April	15,000	8,720	15,000	8,449	15,000	8,375	15,000	8,229
May	15,000	8,149	15,000	7,896	15,000	7,828	15,000	7,691
June	19,700	9,623	19,700	9,327	19,700	9,246	19,700	9,085
July	19,700	11,297	19,700	10,947	19,700	10,851	19,700	10,661
August	19,700	10,240	19,700	9,920	19,700	9,834	19,700	9,661
September	15,200	7,864	15,200	7,629	15,200	7,684	15,200	7,428
October	15,200	5,903	15,200	5,718	15,200	5,668	15,200	5,568
November	10,100	4,415	10,100	4,275	10,100	4,237	10,100	4,161
December	10,100	4,083	10,100	3,955	10,100	3,921	10,100	3,838
		90,226		87,626		86,977		85,325

Note: Average annual generation 1985-2035 = 86,511
Average annual plant capacity factor - 62%

2. Colorado River Storage Project--It is assumed that electric service would be provided at the minimum contract rate of delivery, as contained in Memorandum of Understanding No. DE-MS65-80-WP39025. This provides for a rate of delivery of 750 kilowatts firm plus 80 kW peaking power for the months of April through September and 500 kilowatts form plus 40 kW peaking during the months of October through March.

3. Arizona Public Service Company--The power requirements, in excess of those provided from the previous sources, could be supplied by the Arizona Public Service Company.

4. Headgate Rock Powerplant--The 86,511,000 kilowatts of energy produced at Headgate Rock Powerplant would be utilized in conjunction with the preceding sources. It was assumed that the Parker-Davis Project and Colorado River Storage Project allocations would be fully utilized to supply the commercial load and that Headgate Rock energy would supply the entire irrigation load. The remaining energy would be available for residential and commercial use. It is assumed that as additional electric power is required it would be purchased from the Arizona Public Service Company.

The estimated utilization of Headgate Rock generation, when combined with Federal purchases, is summarized in Table 3. The additional electric power needed to supply the estimated demands on the Reservation for the years, and assumed to be purchased from private sources, is also summarized in this table.

G. Project Costs

The total estimated project cost includes a 19,500-kilowatt hydroelectric powerplant incorporated with the existing Headgate Rock Dam, a switchyard, 0.6 mile of 69-kilovolt transmission line, terminal facilities to be incorporated within a proposed substation, and all temporary facilities required during construction.

The project cost is estimated to be $35,558,000 based on January 1980 price levels.

Operation and maintenance facilities were not provided, as these functions would be performed through the facilities and personnel of the Bureau of Reclamation's Parker-Davis Project at Parker Dam.

Table 3
ELECTRIC ENERGY REQUIREMENTS & SUPPLY
Headgate Rock Hydroelectric Project, Arizona

Year	Headgate Rock Power Utilization		Available Federal Energy P-D&CRSP MWH	Federal Energy plus HGR MWH	Private Energy Purchases MWH	Total Energy Supply
	Agriculture MWH	Commercial MWH				
1985	23,062	65,864	39,878	128,804	—	128,804
1990	23,062	64,564	39,878	127,504	31,958	159,462
1995	23,062	64,239	39,878	127,179	78,483	205,662
2000	23,062	63,915	39,878	126,855	140,607	267,462

P-D - Parker-Davis Project
CRPS - Colorado River Storage Project

All facilities would be located within the Colorado River Indian Reservation, where adequate land has been reserved for rights-of-way.

The Basic Estimate, DC-1 Summary, provides a summary of project costs and is appended to this report.

H. Construction Schedule

The estimated construction time for the Headgate Rock Hydroelectric Project is about 3½ years from the time funds are made available. During the first year, work would include preconstruction investigations and the preparation of the designs and specifications. At the beginning of the second year, bids would be advertised and the construction contract awarded. It is estimated that 630 days would be required to complete the prime contract and the supply contracts after they have been awarded. The installation and testing of equipment would require an additional 250 days. All construction would be completed in the fourth year. The Control Schedule, PF-2, shows the construction order and fund requirements and is appended.

I. Operation, Maintenance, and Replacement Costs

The operation, maintenance, and replacement cost of the 19,500-kilowatt powerplant, switchyard, 0.6-mile transmission line and terminal facilities is estimated to total $280,000 annually.

The estimated cost of operating and maintaining the Headgate Rock power facilities is based on semiautomatic operation of the powerplant and integrating the operation and maintenance with that of the Service's power facilities at Parker Dam. The operation and maintenance cost that would be attributed to Headgate Rock is estimated to be $199,000 annually.

The estimated annual provision for replacements is $81,000.

VI - ECONOMICS

A. Introduction

The Headgate Rock Hydroelectric Project as evaluated is economically justified. The cost of power electric production would be less than obtaining similar electric power from other sources. Revenues from the sale of electric power for irrigation and residential-commercial purposes would repay all reimbursable costs within a 50-year repayment period.

B. Economic Analysis

Economic justification is based on comparison of annual benefits and annual project cost. Benefits anticipated from project development would result from the production of electric power for use primarily on the Reservation.

1. Project Benefits. Benefits from the construction of the hydroelectric power facilities at Headgate Rock Dam are measured by the amount of cost that would be required to obtain the same quantity of electric power from least cost alternative facility. The Arizona Public Service Company was considered the most likely alternative source of comparable power if the project were not constructed. It is estimated that firm energy could be obtained for an average rate of 57.31 mills per kilowatthour.

Estimated production of energy for selected dates and estimated sales of energy for different purposes are shown in the following tabulation:

Estimated Energy Sales

Unit: Million

Year	Commercial	Irrigation	Total
1985	65,864	23,062	88,926
1990	64,564	23,062	87,626
2000	63,915	23,062	86,977

To derive a benefit value for the Headgate Rock Powerplant, which has a varying amount of production over the life of the project, the annual output for the plant is reduced to an annual equivalent production for 100-year period, as shown in Table 4.

The average annual energy production so derived is designated as annual equivalent values.

Table 4
COMMON TIME VALUE OF COMMERCIAL
ENERGY SALES @ 7-1/8 PERCENT
Headgate Rock Hydroelectric Project, Arizona

Year	Energy 1,000 kWh	7-1/8% Factor	Common Time Value 1,000 kWh
1985	65,864	.93349	61,483
1986	65,604	.87140	57,167
1987	65,344	.81344	53,153
1988	65,084	.75934	49,421
1989	64,824	.70884	45,950
1990	64,564	.66169	42,721
1991	64,499	.61768	39,840
1992	64,434	.57660	37,153
1993	64,369	.53825	34,647
1994	64,304	.50245	32,310
1995	64,239	.46903	30,130
1996	64,174	.43783	28,097
1997	64,109	.40871	26,202
1998	64,044	.38153	24,435
1999	63,979	.35615	22,786
2000	63,915	.33247	21,250
Total 16 years			606,745
84 years (13.99180 X .33247) 4.65185 X 63,915 =			297,323
Total 100 years			904,068
Annual Equivalent kWh (100 years @ 7-1/8 % .07132)			64,478

Application of the 57.31 mills per kWh to the annual equivalent quantity of firm energy (commercial and irrigation energy) results in an annual equivalent benefit of $5,017,000.

2. Project Costs. Annual equivalent project costs over the 100-year period of analysis were estimated to be $3,090,000. The conversion of project costs to annual costs was based upon an interest

interest rate of 7.125 percent. The following tabulation shows the derivation of the annual equivalent costs:

Project Costs	$35,558,000
Interest During Construction	3,840,000
Investment Cost	$39,398,000
Annual Equivalent Costs (100-years @ 7.125%)	2,810,000
Annual Equivalent OM&R Cost	280,000
Total Annual Equivalent Costs	$ 3,090,000

3. Benefit-Cost Ratio. The benefit-cost ratio is derived by dividing annual equivalent benefits by annual equivalent costs.

The annual equivalent project benefits of $5,017,000 divided by the annual equivalent costs of $3,090,000 gives a benefit-cost ratio of 1.6 to 1.0. Project net benefits are $1,927,000 annually.

C. Financial Analysis

1. Cost Allocation. Costs were allocated between commercial power and irrigation proportional to the common time value of the energy used for each. The allocation percentage to irrigation is 26.3 percent computed as follows:

$$\frac{\text{Irrigation kWh, annual}}{\text{Total project kWh, annual}} = \frac{23,062,000}{87,540,000} = 26.3 \text{ percent}$$

The allocation percentage to commercial power is 73.7 percent. The cost allocation is presented in Table 5.

Table 5
COST ALLOCATION
Headgate Rock Hydroelectric Project, Arizona

	Irrigation	Commercial Power	Total Project Cost
Cost Allocation			
Allocation Percentages	26.3	73.7	100.0
Investment Cost			
Construction Cost	$9,352,000	$26,206,000	$35,558,000
Interest During Construction	1,010,000	2,830,000	3,840,000
Total			
OM&R Cost, Annual	74,000	206,000	280,000
Reimbursable Costs			
Investment Cost			
Construction Cost	9,352,000	26,206,000	35,558,000
Interest During Construction	1/	2,830,000 2/	2,830,000
Total	9,352,000	29,036,000	38,388,000
OM&R Cost, Annual	74,000	206,000	280,000

1/ Interest during construction is nonreimbursable for irrigation.

2/ Power's interest during construction is increased for repayment to $3,170,000. This occurs because the 8.0 percent interest rate is used for repayment and the 7-1/8 percent interest rate is used for economic analysis.

2. Repayment. The repayment analysis included in this study follows standard Service procedures. Since all benefits are attributed to electric power production, all project costs are considered reimbursable. The reimbursable costs of $38,388,000 include $9,352,000 allocated to irrigation designated to be interest free, and $26,206,000 including $2,830,000 interest during construction allocated to commercial power. The costs allocated to commercial power would be repaid with interest on the unpaid balance at a rate of 8.0 percent. Annual operation, maintenance, and replacement costs

were calculated on the basis of having an operating agreement with the Parker-Davis Project, and were estimated to be $280,000.

All project costs could be repaid by power revenues within 50 years after the project becomes operational. The repayment of project costs would require an average rate of return at the plant bus bar of 40.4 mills per kilowatthour for firm commercial energy and 11.4 mills per kilowatthour for energy utilized for irrigation purposes. Commercial power costs would be repaid in 50 years with 8.0 percent interest on the unpaid balance with revenue from commercial power. Irrigation power costs would be repaid in 50 years without interest using irrigation power revenue. Revenues resulting from the average rate of return for energy at the plant bus bar would be sufficient to pay annual operation, maintenance, and replacement costs and return the obligation within a 50-year period. The payout schedule for the Headgate Rock Hydroelectric Project is presented in Table 6. Summary of the project payout study is presented in the following tabulation:

Income (50-year period)	
Firm commercial energy (40.4 mills per kWh)	$129,535
Irrigation operations energy (11.4 mills per kWh)	13,150
Total Income	$142,685
Repayment (50-year period)	
Interest-bearing investment (commercial power)	$29,376,000
Interest-free investment (irrigation)	9,352,000
Interest on unpaid balance	89,782,000
Operation, maintenance, and replacement	14,000,000
Total Repayment	$142,510,000
Surplus	175,000

If all project costs had been considered interest bearing, without a suballocation to irrigation, repayment within the 50-year period would require an average rate of return of 40.4 mills per kilowatthour for commercial energy.

Table 6
Payout Schedule
Colorado River Indian Reservation
Headgate Rock Hydroelectric Project, Arizona

	Commercial Power							Irrigation				
	Power Energy							Irrigation Energy				
Year	1,000 kWh	Value at 40.4 Mills Per kWh	OM&R Cost $1,000	Net Power Revenue $1,000	Interest on Unpaid Bal. at 8.0% $1,000	Principal Payment $1,000	Unpaid Balance $1,000	1,000 kWh	Value at 11.4 Mills Per kWh	OM&R Cost $1,000	Net Revenue and Principal Payment $1,000	Unpaid Balance $1,000
							29,376					9,352
1985	65,864	2,661	206	2,455	2,350	105	29,271	23,062	263	74	189	9,163
86	65,604	2,650		2,444	2,342	102	29,169					8,974
87	65,344	2,640		2,434	2,334	100	29,069					8,785
88	65,084	2,629		2,423	2,326	97	28,972					8,596
89	64,824	2,619		2,413	2,318	95	28,877					8,407
1990	64,564	2,608		2,402	2,310	92	28,785					8,218
91	64,499	2,606		2,400	2,303	97	28,688					8,029
92	64,434	2,603		2,397	2,295	102	28,586					7,840
93	64,369	2,601		2,395	2,287	108	28,478					7,651
94	64,304	2,598		2,392	2,278	114	28,364					7,462
95	64,239	2,595		2,389	2,269	120	28,244					7,273
96	64,174	2,593		2,387	2,260	127	28,117					7,084
97	64,109	2,590		2,384	2,249	135	27,982					6,895
98	64,044	2,587		2,381	2,239	142	27,840					6,706
99	63,979	2,585		2,379	2,227	152	27,688					6,517
2000	63,915	2,582		2,376	2,215	161	27,527					6,328
01					2,202	174	27,353					6,139
02					2,188	188	27,165					5,950
03					2,173	203	26,962					5,761
04					2,157	219	26,743					5,572
05					2,139	237	26,506					5,383
06					2,120	256	26,250					5,194
07					2,100	276	25,974					5,005
08					2,078	298	25,676					4,816
09					2,054	322	25,354					4,627
2010					2,028	348	25,006					4,438
11					2,000	376	24,630					4,249
12					1,970	406	24,224					4,060
13					1,937	439	23,785					3,871
14					1,902	474	23,311					3,682
15					1,865	511	22,800					3,493
16					1,824	552	22,248					3,304
17					1,780	596	21,652					3,115
18					1,732	644	21,008					2,926
19					1,681	695	20,313					2,737
2020					1,625	751	19,562					2,548
21					1,565	811	18,751					2,359
22					1,500	876	17,875					2,170
23					1,430	946	16,929					1,981
24					1,354	1,022	15,907					1,792
25					1,273	1,103	14,804					1,603
26					1,184	1,192	13,612					1,414
27					1,089	1,287	12,325					1,225
28					986	1,390	10,935					1,036
29					875	1,501	9,434					847
2030					755	1,621	7,813					658
31					625	1,751	6,062					469
32					485	1,891	4,171					280
33					334	2,042	2,129					91
34	63,915	2,582	206	2,376	170	2,206	0 1/	23,062	263	74	189	0 2/
total	3,706,460	129,535	10,300	119,235	89,782	29,453	29,376	1,153,100	13,150	3,700	9,450	9,352

VII. ENVIRONMENTAL CONSIDERATION

VII. ENVIRONMENTAL CONSIDERATIONS

As part of the study to evaluate the Headgate Rock Hydroelectric Project an environmental assessment was conducted. The existing environmental conditions within the proposed project area were evaluated, along with possible enivronmental effects if the project is built. The following is a summary of both existing and possible environmental conditions. Detailed environmental data are presented in a finding of no significant impact that is being prepared.

A. Current Environmental Conditions

1. Vegetation. Headgate Rock Dam is located within the Desert Shrub Community of the Mohave Desert. Creosote and burro bush is the predominant plant community. Other plants such as snakeweed, desert trumpet, lupine, and scorpion weed are found in the area.

The woody riparian community dominates the steeper banks of the river. Salt cedar, arrowweed, and catclaw are abundant within a few feet of the shoreline. Vegetation is scarce in most areas and the most extensive growth is located on the California side of the river along the reach above Headgate Rock. Willows, cottonwood, and introduced salt cedar, plus a number of other native and introduced (ornamental) riparian plants are present. Marsh habitat is dominated by cattail and sedges. Salt grass, salt cedar, and other halophytes are locally abundant where desiccation of backwaters resulted in accumulations of salt.

In waters isolated from the river, high total dissolved solids preclude growth of other than the halophytic spiny maid. That species, sago pondweed, coontail, some hornwort, parrots-feather, and chara form extensive beds in protected areas. Changes in discharge detach some masses of vegetation that drift downstream.

Under authority of Section 12 of the Endangered Species Act of 1973 (Public Law 93-205, 87 Stat. 884) the Federal Government has been developing a list of proposed endangered plants. A tentative listing of such plants was published in the Federal Register of June 16, 1976. No proposed endangered plants are found in the project area.

2. Fish and Wildlife

a. Fish. Sampling of the Colorado River channel in the Headgate Rock Dam has not produced satisfactory quantitative data. Problems of water depth, current velocity, snags, drifting debris, and vandalism have plagued the investigations. What fish data available have been collected by nets, electrofishing in shallower areas, and information from anglers.

Sport fish reported above the dam include mostly largemouth bass, redear sunfish, bluegills, and black crappie. In lesser numbers are channel catfish, striped bass, yellow bullheads, and carp.

Anglers reported fish downstream from the dam are similar to those found upstream and include largemouth bass, bluegill, black crappie, redear sunfish, yellow bullhead, channel catfish, and rainbow trout. Channel catfish and rainbow trout populations are replenished by periodic stocking by the U.S. Fish and Wildlife Service.

b. Benthos. Bottom types range from rock and gravel found in the river channel to salt in bays and eddies.

Benthos samples taken with a Ekman dredge below Headgate Rock Dam indicated that Asiatic clams comprised 68.3 percent by numbers and 99.0 percent by total weight. Other groups such as simuliid dipterans and bactid ephemeropterans were relatively abundant making up 12.0 percent in total numbers.

Groups characteristic of flowing waters and coarse bottoms such as similiid and tabanid dipterans, hydrophlid beetles, and an introduced snail contributed significantly to biomass, as did the more typical chironomid dipteran larvae and oligochaete worms.

Dredge samples from flowing water between Headgate Rock and Parker Dams also contained Asiatic clams these are the most abundant organism, constituting 95 percent of the total animals present and 96 percent of the estimated biomass of 2.29 kg/ha.

Dredge samples from Moovalya Pond yielded large numbers of chironomids and oligiochactes with a few culicid dipteran larvae.

All of the above samples were taken at depths of less than 10 feet. With the Ekeman dredge used it was not possible to sample benthos on harder, more stable substrates such as boulder and gravel found in the main river channel.

c. Amphibians and Reptiles. Numerous species of lizards, snakes, and amphibians inhabit the area. Most common in the area are the desert turtle, spiny soft-shelled turtle, western banded gecko, desert spring lizard, chuckawally, Mohave rattlesnake, western diamondback rattlesnake, coachwhip, and common whip snake. Some bullfrogs are harvested from the marsh area.

d. Birds. There is a great diversity in the bird community for the Lower Colorado Region. The more commonly seen birds in the immediate Headgate Rock Dam site include: great blue heron, long-billed marsh wren, mourning doves, red-winged blackbird, common coot, black-crowned night heron, brown-headed cowbird, western grebe, cormorants, teal species, and domestic pigeons.

The highest concentration of birds observed were morning doves located along the canal, and domestic pigeons that were nesting in the supporting structures of the dam. Other birds that may be found in the area include the turkey vulture, lesser nighthawk, white-winged dove, killdeer, Gambel's quail, roadrunner, common raven, cactus wren, and ash-throated fly catcher.

e. Mammals. Several species of small mammals are sparsely distributed throughout the creosote bush habitat including the coyote, badger, skunk, jackrabbit, fox, various ground squirrels, bats, shrews, mice, and rats. Larger species would rarely be seen because of the close proximity to town and the amount of activity in the area. Mammals located in the riparian habitat include the muskrat, racoon, and beaver.

3. Special Status Species. There are three species that have or may frequent the area near Headgate Rock Dam.

a. Razorback Sucker. The razorback sucker (Xyrarchen texanus), although no longer a special status species, is being included because of the possibility that it will be proposed in the near future.

The razorback sucker is endemic to the Colorado River drainage. It once ranged from Wyoming and Colorado southward to Mexico. At the present time this once-abundant species has been extirpated from much of its original range. The species is now scarce

along the Grand Canyon and has been completely eliminated from the Green River and its tributaries above Flaming Gorge Dam in Utah and Wyoming. The fish appears to be nearing extinction in portions of the Lower Colorado River. Razorback suckers are commonly seen in Lakes Mead and Mohave. Spawning observations have been made in both lakes and recruitment is thought to be very limited. Razorbacks spawn in shallow areas (1 to 20 feet) with a substrate composition of gravel. Eggs and milt are deposited in the substrate. As with other suckers, these fish show no parental care behavior.

In early 1980, two small (12.9, 14.6-inch) razorback suckers were taken from the Colorado River Indian Reservation Irrigation Project. The canal was located 15 miles below Headgate Rock Dam. These fish may represent the first documented recruitment in many years.

b. Bonytail Chub. The bonytail chub (Gila elegans) was once found throughout the Colorado River Basin in large turbid rivers. In these rivers it was most frequently associated with eddies adjacent to swift water. The bonytail has declined in the watershed due to manmade changes in the river system. The most recent surveys of streams and reservoirs in the Colorado River Basin indicate that it is presently found only in Lake Mohave. The bonytail has not been collected below Parker Dam for a number of years. At present, no known habitat fulfills all the requirements necessary for the chub to successfully reproduce.

c. Yuma Clapper Rail. The original range of the Yuma clapper rail (Rallus longinostus yumanensis) was confined to the Colorado River delta but the range has been extending northward during the past 60 years (Ohmart and Smith, 1973).

There is no evidence that the Yuma clapper rail existed north of the Colorado River delta prior to 1921. From descriptions of the Lower Colorado River made by Grinnell in 1914, suitable habitat for this rail was not available along the river. Construction of dams and subsequent river management and control have created suitable Yuma clapper rail habitat to the north of the original range. The first specimens taken north of the Colorado River delta were secured in 1921 by Huey and Canfield in the vicinity of Laguna Dam. The first

recorded presence of clapper rails north of Laguna Dam follows a few years after the beginning of operation of Parker, Imperial, and Headgate Rock Dams which were 1938, 1939, and 1942, respectively. In 1966, Yuma clapper rails were first recorded in Topock marsh. This is the northernmost record of the Yuma clapper rail to date.

Bennett and Ohmart studied the habitat requirements of the Yuma clapper rail in the Imperial Valley of California. Rails used fresh water marsh areas containing mature stands of cattail and bulrush. Territory size ranged from 0.32 to 0.70 acres in unpaired birds to 0.27 to 0.71 acres in paired birds. Water level variation was found to influence the permanence of territories and the breeding effort. Marsh areas with permanent shallow water through the breeding season contained the highest rail densities. Crayfish (Procambarus sp. and Orcopectes sp.) formed a major portion of the clapper rail diet.

4. Archeological and Historical Sites. A survey was completed in compliance with Executive Order 11593, 36 Code of Federal Regulations Part 800, and Water and Power Resources Services, 43 CFR 422 regarding the proposed powerplant and 69-kV transmission line. This line extends from Headgate Rock Dam to Headgate Rock Substation and is located in T. 10 N., R. 26 E., sec. 31, in the W½. The area has been heavily disturbed by offroad vehicles and some construction activity. Several parallel transects were conducted over the area and no signs of prehistoric or historic activity were noted. A copy of the archeologists report is included in the finding of no significant impact

B. Environmental Consequences

If a project is built with three 6,500-kW generators built into the existing spillway structure, and proposed, the following environmental effects could be felt:

1. Vegetation. No vegetative change would be experienced at the dam site since the turbine units would be placed in the tailrace. The proposed switchyard would be constructed on an existing fill. A limited amount of creosote burrobush community would be needed to construct a transmission line .6 mile to an existing switchyard. The

line would parallel the existing access road to Headgate Rock Dam on the Arizona side. This is a disturbed area that was used during the construction of the main dam facility in the 1930's. No endangered or threatened plants are known to exist in the area.

2. Fish and Wildlife.

a. Fish. No significant impact is expected on the fish community at Headgate Rock Dam. Reservoir levels will be maintained at an elevation of 364.4 feet probably by the continual use of automatic discharge facilities through the turbines. There would be no degradation of fish habitat or spawning areas as a result of the construction of the project.

b. Benthos. No significant change is expected in the quality or quantity of benthic organism above the dam due to water being discharged through turbines 8, 9, and 10 instead of a rotation through all 10 gates.

Under present conditions, water is usually discharged through gates 5 and 6 with maintenance discharges rotated through all 10 gates. The placement of turbines in gates 8, 9, and 10 would establish the main flow regime on the Arizona side instead of the main channel. The water velocity below gates 1 through 7 would decrease and form an eddy. This action would create a more stable condition on the California side. The maximum usable flow through the three units would be in excess of 18,000 ft^3/s. With the potential diversion of 1,000 ft^3/s to the Colorado River Indian Reservation main irrigation canal, expected releases through the remaining seven gates would be minimal. Also, maximum discharges would be accomplished through three turbines instead of two gates. The dispersion of the discharge and the buffering affect of the tailwaters may decrease turbulence and water velocities in the immediate area of the tailrace. It is speculated that these factors, although small, may slightly increase benthic productivity.

Centrarchids make up a large part of the areas sport fishery. These fish are territorial and their movements are expected to be minimal. Ideal centrarchid habitat is located along the Moovalya marsh area which is a considerable distance from the project area.

Fish migration is restricted by Headgate Rock Dam. The chances of fish migrating through the extreme velocities at the gates to swim upstream past the dam would be extremely remote. There is the possibility that a few fish do move downstream through the dams gates. The success rate of this movement is not known. The placement of the hydroelectrical facility would restrict downstream movement to smaller fish. It is estimated from studies done by the Corps of Engineers that impingement mortalities would be 15 percent for small fish and increase proportionately with the size of fish. Although some mortalities are expected their numbers would be insignificant.

Fish do migrate from Lake Moovalya into the main irrigation canal. Although the turbine units would be located in close proximity to the canal intake, water velocities are not expected to have any significant effect on fish movements into the canal system.

Operation and management of the completed facility would not interfere or detract from the present sport fishery in the area. The present condition of aquatic habitat and cover would be maintained.

c. Wildlife. The project would have little effect on wildlife habitat. The proposed construction, storage, and transmission line sites are located in a disturbed creosote burrobush community that affords rather poor habitat. The area under consideration has already been disrupted by past construction activities. The hydroelectric plant and switchyard would be built near the present dam system and no apparent wildlife species would be affected.

In recent years pigeons have used protected areas of the dam as nesting sites. Although these sites on gates 8, 9, and 10 would be disturbed during construction these birds are expected to reestablish their nest elsewhere. The pigeon is extremely tolerant of man's activities and probably would continue to nest at the remaining gates during the construction.

The riparian community would not be impacted by the project. The elevation of Lake Moovalya and the dams discharges would be maintained under current conditions.

3. Special Status Species

a. Razorback Sucker. Although the razorback has not been collected in the immediate vicinity of Headgate Rock, it is expected to be represented in limited numbers. The collection of the two small suckers 15 miles downstream suggests the possibility that the canal system may be suitable habitat for spawning. This cannot be documented and there is the possibility that the fish migrated into the system from the river. In either case, the Headgate Rock Hydroelectric Project is not expected to adversely affect the sucker. As stated before, no change in the aquatic habitat is expected and discharges and diversions into the canal system will remain under current management policies.

b. Bonytail Chub. The bonytail is thought to be extirpated from the Headgate Rock Dam area. Since little is known on the required habitat needed for successful spawning, it can only be speculated that if it existed in the area the species would still be represented.

The construction and maintenance of the facility would have no significant impact on the aquatic habitat of the area. It is, therefore, determined that the Headgate Rock Hydroelectric Project would have no impact on the bonytail chub.

c. Yuma Clapper Rail. Observations of the endangered Yuma clapper rail have been made in the Moovalya Swamp. This area is located upstream approximately 1 mile from the dam and provides quality habitat for rails, large wading birds, and waterfowl. The last sighting was made during the summer of 1972. This area is on the opposite and upstream side of the proposed construction. Access to this area can only be made by boat or by foot. There are no areas in the immediate construction site that would be suitable habitat for the rail.

C. Summary for Finding of No Significant Impact (FONSI)

For the following reasons it was determined that a FONSI would be prepared:

1. There are no significant environmental, social, or economic impacts related to the project.

APPENDED MATERIAL

LEGEND: Types of Activity

Preconstruction and Other Work | Construction

LINE NO	PROGRAM ITEM	QUANTITY	ESTIMATED TOTAL	TOTAL TO SEPT. 30, 19	FISCAL YEARS 1981	1982	1983	1984	19	19	BALANCE TO COMPLETE
	1	2	3	4	5	6	7	8	9	10	11
1								19.5 mW			
2	Power Development - Hydro	19.5 mW									
3											
4	Construction Program										
5	Headgate Rock Powerplant		35,558,000	500,000	2,352,000	16,415,000	13,256,000	3,035,000			
6											
7											
8	Total Cost		35,558,000	500,000	2,352,000	16,415,000	13,256,000	3,035,000			
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NOTES: Definite Plan Report June 1980
Repayment Contract - Not Required
Land Certification - Not Required

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

RECOMMENDED: _____ (Regional Director) _____ (Date)

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

CONTROL SCHEDULE

Headgate Rock Hydroelectric Project, Arizon