Colorado River Basin Salinity Control Project
Title 1 Division
Desalting Complex Unit
Arizona

STATUS REPORT

April 1977

UNITED STATES
DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Basin Salinity Control Project
Title I Division
DESALTING COMPLEX UNIT
Arizona

STATUS REPORT

April 1977

BUREAU OF RECLAMATION

R. Keith Higginson, Commissioner

Manuel Lopez, Jr., Regional Director Lower Colorado Region

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources, and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Terrirories under U.S. Administration.

Colorado River Basin Salinity Control Project
Title I Division
Desalting Complex Unit

STATUS REPORT
April 1977
(Covering Activities Through June 1976)

FOREWORD

Authorization to construct, operate, and maintain the Desalting Complex Unit was approved June 24, 1974, in Section 101 of Public Law 93-320, the Colorado River Basin Salinity Control Act. The September 1973 Special Report, *Colorado River International Salinity Control Project*, prepared jointly by the Bureau of Reclamation and Office of Saline Water, is the basis for the project authorization.

This Status Report presents the findings of advance planning studies and project activities through June 1976. Some project construction activities were underway at that time, while other project activities, such as the design of the Yuma Desalting Plant, will undergo future modification prior to implementation. Because of the need for a document describing significant project activities since authorization, while simultaneously recognizing that some project features will not be finalized in plan until 1978 or 1979, available information is presented in this Status Report.

The most significant reason for preparation of this report is the need to describe a conceptional design of the Yuma Desalting Plant. This design, completed in December 1975, was prepared for the purpose of scoping performance, structures, and equipment requirements as a basis for requesting and evaluating proposals for furnishing membrane desalting equipment.

The results of advance planning studies presented in this Status Report are refinements and modifications of concepts of authorized project measures. Changes in general consist of refined hydrologic studies for desalting plant sizing; inclusion of desalting plant pretreatment and equipment performance characteristics as determined from information provided by manufacturers, and by testing with actual plant feed water; identification of specific fish and wildlife mitigation measures; and updating costs. The refinements and modifications do not add features to or delete features from the authorized plan, or change the objective results of the plan.

This report does not include conclusions of studies on reject stream replacement alternatives. These studies are ongoing and are scheduled to be completed in fiscal year 1980. This report also does not include the findings of advance planning studies on the Coachella Canal Unit and the Protective and Regulatory Pumping Unit, authorized by Sections 102 and 103, respectively, of Public Law 93-320. Definite Plan Reports will be prepared later for each of these units.

Primary refinements and modifications of authorized Desalting Complex Unit parameters presented in this Status Report, compared with those presented in the September 1973 Special Report, are:

1. The Desalting Complex Unit will be fully operational in 1981 instead of 1978.

2. The annual Wellton-Mohawk Division irrigation drainage is estimated to be 167,000 acre-feet with an average salinity of 3,200 parts per million total dissolved solids (p/m TDS) in 1981 as compared with 175,000 acre-feet at 3,100 p/m in 1978.

3. The salinity of water arriving at Imperial Dam in 1981 is estimated to be 865 p/m TDS, as compared with 910 p/m in 1978.

4. Pretreatment for the desalting plant will require partial lime softening and be more elaborate than originally conceived.

5. The membrane desalting plant will have the capacity to treat 144,700 acre-feet of pretreated feed water at 2,904 p/m. The result will be 102,700 acre-feet of product at 386 p/m and 42,000 acre-feet of reject at 9,056 p/m. This compares with 144,000 acre-feet of feed water at 3,100 p/m, 101,000 acre-feet of product at 240 p/m, and 43,000 acre-feet of brine at 9,600 p/m.

6. During normal operation the desalting plant is designed to recover 70.9 percent of the feed water. The annual design plant product water volume will be 61.5 percent of the Wellton-Mohawk Division drainage, while the total combination of plant product and blend raw water returned to the Colorado River will be 74.0 percent of the drainage. We believe that from technical data provided to the Congress, the Special Report, and from the legislative history, that this is consistent with the intent of the Act (the second sentence of Section 101. (b) reads "The plant shall effect recovery initially of not less than 70 percentum of the drain water as product water. . . .").

7. The total desalting plant production capacity will be 108.5 million gallons per day (Mgal/d), composed of 20.5 Mgal/d capacity spiral wound reverse osmosis, 19.4 Mgal/d hollow fine fiber reverse osmosis, 22.9 Mgal/d electrodialysis, and 45.7 Mgal/d unspecified capacity segments. Including 90.7 percent plant factor, the plant will be capable of treating about 138.7 Mgal/d feed water and producing 98.4 Mgal/d product water, compared with 129 Mgal/d feed water and corresponding 90 Mgal/d product described in the Act.

8. The average annual plant product is projected to be 60,000 acre-feet from 1982 through 1993. Corresponding average annual reject will be 26,000 acre-feet. After this initial critical period plant product is projected to average 62,000 acre-feet annually, with 27,000 acre-feet of reject.

On a total annual basis 88.8 percent of the dissolved solids of the feed water will be removed by the plant. Correspondingly, 80.2 percent of the dissolved solids of the Division drainage will be restricted from being returned to the river (582,700 tons of the annual 656,000 tons).

9. During normal operation the desalting plant is designed to remove 91.5 percent by volume of the total dissolved solids of the feed water through the combination of pretreatment and the membrane plant. The Act requires a minimum of 90 percent.

10. The energy requirement of the desalting plant will be 278,700,000 kilowatthours (kWh) with a demand of 37,000 kilowatts (kW), compared to 276,000,000 kWh and 35,000 kW. The total net energy and demand requirements at the source (Navajo Project) are 296,400,000 kWh and 46,230 kW, respectively.

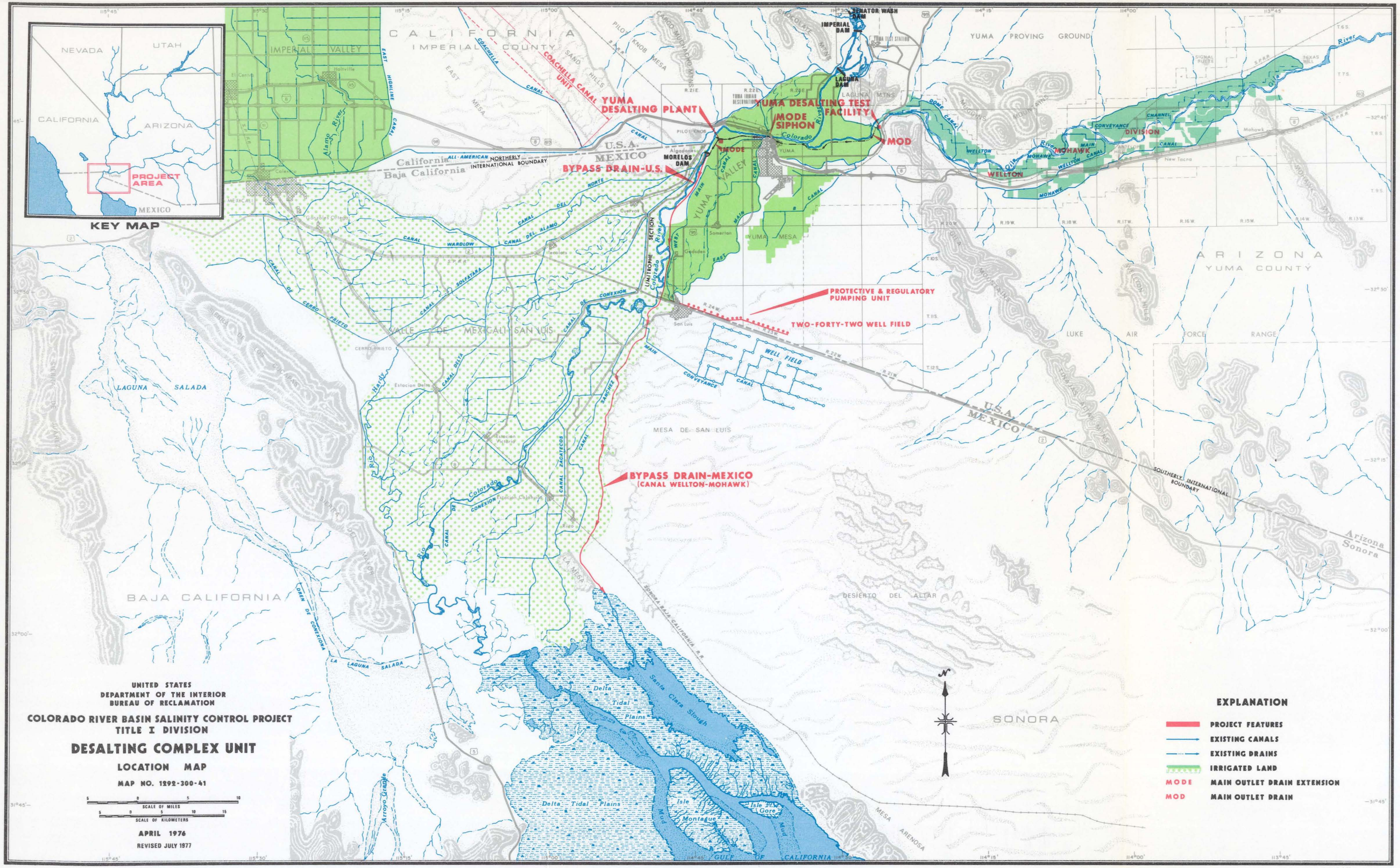
11. Annual costs (operation, maintenance, replacement sinking fund, and energy) are based on the desalting plant operating at design capacity even though it may be operated at reduced production in some years due to less-than-capacity output requirements.

12. Provision for fish and wildlife mitigation features were not adequately included in the Special Report, or in the Act.* An environmental statement (FES 75-57) was developed based on mitigation concepts and work has progressed cooperatively with Federal, State, and other interests to develop specific details. These will be presented when completed.

*($300,000 was included for fish and wildlife mitigation in the cost estimate for the Coachella Canal Unit in the Special Report. No costs were included in the cost estimates or the Act for the Protective and Regulatory Pumping Unit or Desalting Complex Unit.)

GUIDE TO

STATUS REPORT


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
TITLE I DIVISION
DESALTING COMPLEX UNIT
LOCATION MAP
MAP NO. 1292-300-41
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WELL FIELD
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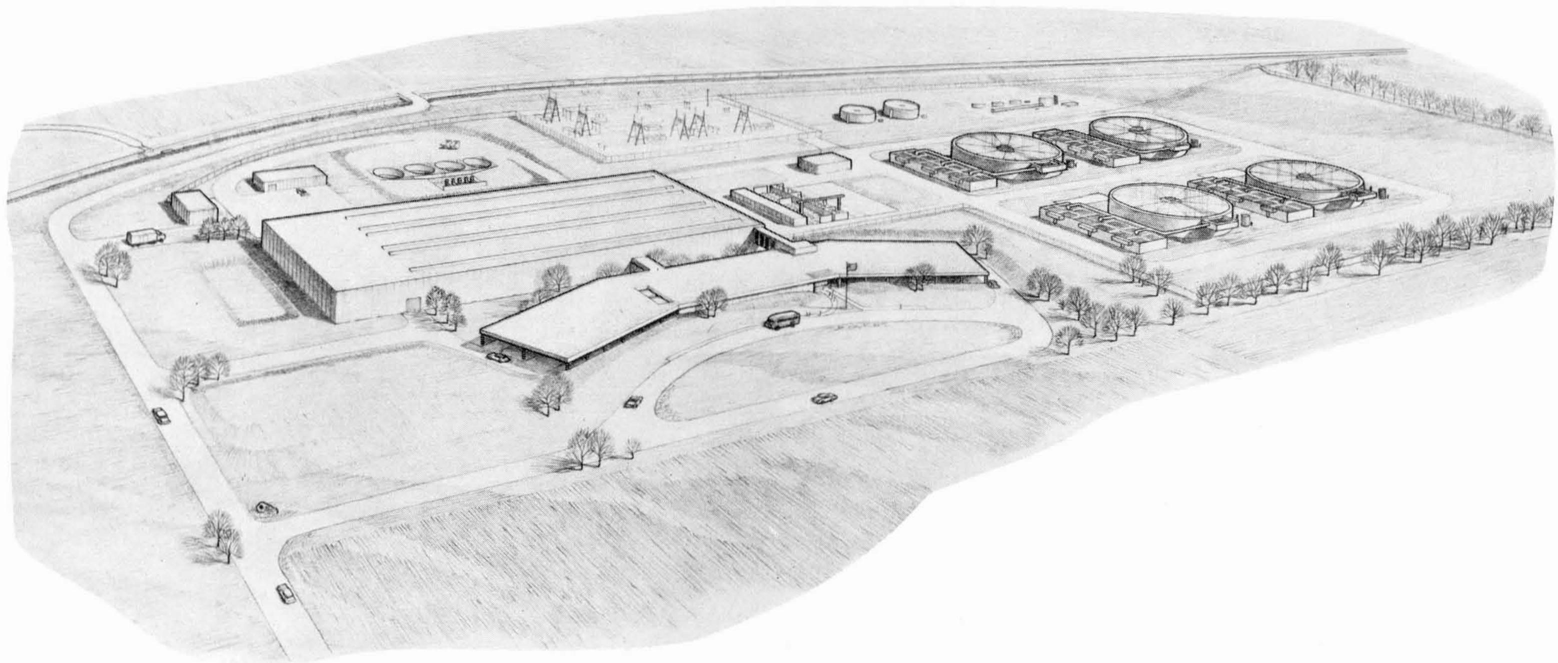
SOUTHERLY INTERNATIONAL BOUNDARY
Arizona
Sonora
BAJA CALIFORNIA
DESIERTO DEL ALTAR
SONORA
Delta Tidal Plains
Santa Clara Slough
Isle Montague
Isle Gore
GULF OF CALIFORNIA
MESA ARENOSA



YUMA DESALTING PLANT
Artist's Conception

Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

S T A T I S T I C A L   S U M M A R Y

Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

LOCATION:

The project area is located in valleys adjacent to the Gila and Colorado Rivers in southwestern Yuma County, Arizona, and northwestern Sonora, Mexico.

AUTHORIZATION:

The project was authorized for construction by Act of June 24, 1974, (88 Stat. 266), Public Law 93-320, Title I - Programs Downstream from Imperial Dam (specifically Section 101).

EXISTING DEVELOPMENT:

The project will reduce the quantity of irrigation drainage pumped from the shallow aquifer beneath fields of the Wellton-Mohawk Division of the Gila Project, and improve its quality so that it can be utilized as part of the deliveries to Mexico in accordance with the Treaty of February 3, 1944 (Treaty Series 994). Pumped drainage from the 65,000 developed acres is currently transported to the Colorado River channel on the downstream side of Mexico's Morelos Dam via the continuous Wellton-Mohawk Main Conveyance Channel (WMMCC) and Main OUtlet Drain Extension (MODE), without credit toward Treaty deliveries, in order to comply with obligations of the Agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Bouldary and Water Commission). The primary objective of the Minute is to limit the average annual salinity of the approximately 1,360,000 acre-feet of water delivered to Mexico upstream of Morelos Dam to no more than 115 parts per million (p/m) $\pm$ 30 p/m over the annual average salinity of Colorado River waters which arrive at Imperial Dam; these waters presently average 823 p/m.

PLAN:

In executing the plan to reduce the quantity and improve the quality of Wellton-Mohawk Division drainage so that the majority of it can be credited toward Treaty deliveries, seven measures will be implemented:

1. Construction of the 108.5 million gallons per day (Mgal/d) equivalent product capacity membrane Yuma Desalting Plant to treat drainage water from the Division;

2. Construction of the Bypass Drain from the terminus of the existing MODE at Morelos Dam to the Santa Clara Slough in Mexico to carry plant reject;

3. Replacement of a temporary flume section of the MODE in Yuma with a buried concrete siphon;

4. Commencement of an Irrigation Efficiency Improvement Program in the Division;

5. Acquisition of 10,000 acres of irrigable land in the Division;

6. Control of Gila River floodwaters into the Division aquifer by acquisition of rights-of-way for flood storage in, and modifying operating criteria of, the Corps of Engineers' Painted Rock Reservoir; and

7. Fish and wildlife mitigation measures.

In addition, authorized feasibility studies of reject replacement source alternatives will continue until June 20, 1980. Also, development testing of pretreatment processes and membrane desalting equipment will contine at the Yuma Desalting Test Facility through module proof testing in FY 1978 and high recovery pretreatment and module testing in FY 1978-1979.

INVESTMENT COST:

Construction Cost (October 1975 prices)		$ 229,870,000
Yuma Desalting Plant	$ 151,900,000	
Bypass Drain-United States	8,300,000	
Bypass Drain-Mexico	24,825,000	
MODE Siphon	3,600,000	
Wellton-Mohawk Irrigation Efficiency Improvement Program	9,848,000	
Wellton-Mohawk Acreage Reduction	15,000,000	
Painted Rock Reservoir Land Acquisition and Operation Schedule Modification	5,000,000	
Fish and Wildlife Mitigation Measures	2,357,000	
Yuma Desalting Test Facility	6,600,000	
Reject Stream Replacement Studies	2,440,000	
Interest During Construction	(5-5/8 percent)	$ 23,330,000
Total Federal Investment		$ 253,200,000

ANNUAL EQUIVALENT COST:

(50-Year Period of Analysis at 5-5/8 Percent)

Annual Equivalent of Investment	$15,214,000	
Annual Costs (O.M.R.&E.)	11,745,000	
Total Annual Cost		$ 26,959,000

IMPLEMENTATION PERIOD:

Irrigation Efficiency Improvement Measures	7 years
Desalting Complex Unit Construction	6 years
Yuma Desalting Plant Construction	4 years

FEDERAL BENEFITS:

Economic benefits have not been determined. Social and political benefits accrue that are outside the normal realm of economic quantification; however, in addition to meeting the salinity provisions of Minute No. 242, the project will reclaim about 123,700 acre-feet of water per year that is presently being bypassed and, therefore, lost for further use.

BENEFIT-COST RATIO:

Not computed.

ALLOCATION OF COSTS:

All costs are allocated to Mexican Treaty.

REPAYMENT:

Project expenditures are nonreimbursable.

HYDROLOGY:

The 21-mile long Gila Gravity Main Canal, with headworks at Imperial Dam, supplies water to the Gila Project in accordance with the Gila Project Reauthorization Act of 1947 (61 Stat. 628). Approximately 15 miles southeast of Imperial Dam the Wellton-Mohawk Canal diverts from the Gila Gravity Main Canal. The Wellton-Mohawk Canal and its branches convey irrigation water to the Wellton-Mohawk Division, Gila Project. Three pumping plants along the canal lift water a total of 170 feet. Smaller relift pumps are located throughout the Division on 227 miles of laterals.

Irrigation return flows are selectively pumped from 106 drainage wells located throughout the Division. All drainage is discharged to the WMMCC, which runs westerly the full length of the Division; the MODE extends from the terminus of the WMMCC to Morelos Dam. Drainage flows can either be delivered to the Colorado River for diversion by Mexico, or bypassed below Morelos Dam to the river channel. All drainage is presently being bypassed. In recent years, annual drainage has ranged from 210,000 to 220,000 acre-feet.

The Yuma Desalting Plant will annually treat most of the MODE flow in order that it may be utilized for deliveries to Mexico, which are subsequently diverted by Mexico at Morelos Dam. Operational reject from the plant will be discharged to the Santa Clara Slough via the Bypass Drain. Flows in the MODE are expected to increase from the current level of 203,000 acre-feet per year to 167,000 acre-feet per year by 1981, as a result of the Wellton-Mohawk Irrigation Efficiency Improvement Program and the Wellton-Mohawk Acreage Reduction Program (6,200 acres of low-efficiency irrigated land will be taken out of production and 3,800 acres of undeveloped Federal land will be restricted from development). Other hydrologic and hydraulic parameters are presented in Table S-1 and Figure S-1, following this summary.

PROJECT MEASURES:

The seven project measures, as previously mentioned, are the 1) Yuma Desalting Plant, 2) Bypass Drain, 3) MODE Siphon, 4) Wellton-Mohawk Irrigation Efficiency Improvement Program, 5) Wellton-Mohawk acreage reduction, 6) Painted Rock Reservoir land acquisition and operation schedule modification, and 7) Fish and wildlife mitigation measures.

Yuma Desalting Plant:

The Yuma Desalting Plant will be a membrane desalting plant that will reduce the salinity of Wellton-Mohawk pumped drainage before it is returned to the Colorado River. The plant will be located about four miles west of Yuma, near the Arizona Public Service Yucca-Axis Powerplant. The plant capacity will be 108.5 Mgal/d of product. Wellton-Mohawk drainage is expected to total 167,000 acre-feet per year at 3,200 p/m, of which the plant will desalt up to 102,700 acre-feet to 386 p/m and produce up to 43,300 acre-feet of reject at 8,874 p/m; approximately 100 additional acre-feet will be consumed in the pretreatment process. When the plant product is blended with the remaining 20,900 acre-feet from the MODE, 123,600 acre-feet of total blend water at 854 p/m will be returned to the Colorado River annually.

The average annual plant product is projected to be 60,000 acre-feet from 1982 through 1993, the period of hydrologic operation studies. The corresponding average reject will be 26,000 acre-feet.

The final desalting plant performance characteristics will be determined during final design after membrane equipment contracts are awarded in 1977. The actual parameters will probably vary somewhat from those presented herein. Specifically, the product salinity will probably differ from 386 p/m and, consequently, the plant size will differ from 108.5 Mgal/d.

Bypass Drain:

A bypass drain will be constructed to cary reject from the desalting plant to the Santa Clara Slough in Mexico. The concrete-lined drain will be 50.7 miles long and have a capacity of 353 cubic feet per second (ft^3/s), and will begin at the end of the MODE at Morelos Dam. The bypass drain will be the same capacity as the MODE so that it can carry the total MODE flow during desalting plant outages, startups, and shutdowns.

MODE Siphon:

A buried circular concrete siphon has been constructed to replace an existing 12-foot, 6-inch diameter semicircular metal flume section of the MODE adjacent to the Colorado River in Yuma at the foot of Prison Hill. The 3,491-foot-long siphon is 10 feet in diameter and was completed in 1976.

Wellton-Mohawk Irrigation Efficiency Improvement Program:

An irrigation efficiency improvement program is in progress, in conjunction with an acreage reduction program, to reduce drainage flows in the Wellton-Mohawk Division to 167,000 acre-feet by 1981, and ultimately to 136,000 acre-feet. Separate subprograms of the overall program include 1) Irrigation Management Services, 2) onfarm improvements, 3) research and demonstrations, 4) extension education and information, and 5) activities of the Technical Field Committee.

Wellton-Mohawk Acreage Reduction:

Irrigable land in the Division will be reduced from the 75,000 acres authorized for development to 65,000 acres. This will eliminate economically marginal operations on citrus land, and discontinue operation of land with the lowest irrigation efficiency. The objective is to reduce drainage return flows from land with low irrigation efficiency.

Painted Rock Reservoir Land Acquisition and Operation Schedule Modification:

A number of potential alternative release schedules for Painted Rock Dam floodwater storage have been studied by the

Corps of Engineers, and six viable plans have been identified. The recommended plan would schedule releases between 250 ft^3/s and 22,500 ft^3/s, depending on the reservoir content. These proposed release schedules, in conjunction with land acquisition for increased storage rights, are still under study.

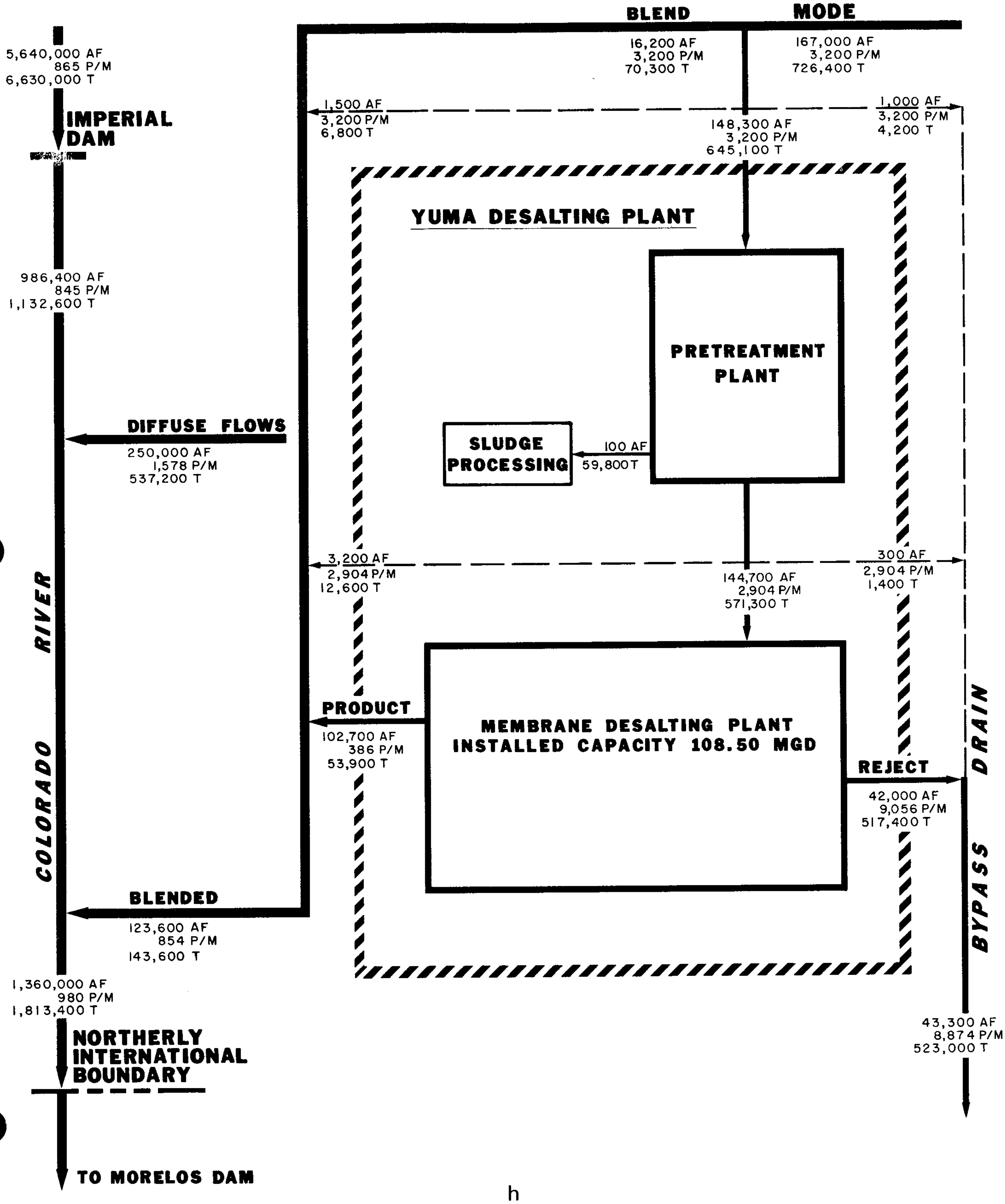
Fish and Wildlife Mitigation Measures:

Approximately 900 acres of land will be acquired and assigned to the Arizona Game and Fish Department for designation and use as a wildlife and recreation management area. Fish rearing facilities will be constructed to provide for the annual stocking of 200 to 300 surface acres of ponds, lakes, rivers, and canals in the Yuma area. An outlet control structure and shallow well will be constructed to maintain the 12 acres of water surface in the Hunter's Hole pond complex adjacent to the limitrophe section of the Colorado River.

TABLE S-1
ANNUAL OPERATION CAPABILITY
DESALTING COMPLEX UNIT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

	Volume 1,000 Acre-Feet	Salinity p/m	Salinity 1,000 Tons
FLOW ARRIVING AT IMPERIAL DAM	5,640	865	6,630
IMPERIAL DAM RELEASE TO MEXICO	986.4	845	1,132.6
INFLOW BELOW IMPERIAL DAM (Excluding Blended)	250.0	1,578	537.2
WELLTON-MOHAWK DRAINAGE (MODE)	167.0	3,200	726.3
MEMBRANE PLANT PRODUCT	102.7	386	53.9
BLEND	20.9	3,155	89.7
Normal Operation	16.2	3,200	70.3
Operational Transients	4.7		19.4
REJECT	43.3	8,874	523.0
Normal Operation	42.0	9,056	517.4
Operational Transients	1.3		5.6
OPERATIONAL LOSS - Sludge Processing	0.1		59.8
BLENDED TO RIVER (Plant Product plus Blend)	123.6	854	143.6
DELIVERED TO NIB	1,360.0	980	1,813.4
DIFFERENTIAL - IMPERIAL DAM TO NIB	373.6	115	680.8

FIGURE S-1
HYDROLOGIC SCHEMATIC
DESALTING COMPLEX UNIT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona



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ABBREVIATIONS

A	ampere
ASHE	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
bhp	brake horsepower
Btu	British Thermal Unit
CaO	calcium Oxide
$Ca(oH)_2$	calcium hydroxide
CFR	Code of Federal Regulations
cm	centimeter
CO_2	carbon dioxide
CRSP	Colorado River Storage Project (computer simulation model)
CRT	cathode ray tube
dc	direct current
^oC	degrees Centigrade
^oF	degrees Fahrenheit
dgal	daily gallon
ED	electrodialysis
ft^2	square feet
ft^3	cubic feet
ft/s	feet per second
ft^3/s	cubic feet per second
FY	Fiscal Year
gal/d	gallons per day
gal/d/ft	gallons per day per foot
gal/min	gallons per minute
gm	gram
HFF	hollow fine fiber
hp	horsepower
IMS	Irrigation Management Services
IX	ion exchange
kgal	kilogallon
km	kilometer
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatthour
lb/d	pounds per day
lb/in^2	pounds per square inch
Lic.	Licenciado
meq	milliequivalent
Mgal/d	million gallons per day
MODE	Main Outlet Drain Extension
m^3/s	cubic meters per second
MSF	multistage flash
Mvar	megavoltampere reactive
MW	megawatt
NIB	Northerly International Boundary

NO_x	nitrogen oxide
pH	hydrogen ion concentration of a solution
p/m	parts per million (USGS procedure or approximation)
r/min	revolutions per minute
RO	reverse osmosis
ROW	right-of-way
RTU	remote terminal unit
SCS	Soil Conservation Service
SHMP	sodium hexametaphosphate
SIB	Southerly International Boundary
SO_2	sulphur dioxide
Sions	summation of ions
SW	spiral wound
TDS	total dissolved solids
USGS	United States Geological Survey
V	volt
VC	vapor compression
VF	vacuum freeze
VTE	vertical tube evaporator
WMIDD	Wellton-Mohawk Irrigation and Drainage District
WMMCC	Wellton-Mohawk Main Conveyance Channel
WY	Water Year

REFERENCES

The following references are listed in chronological order to better establish the framework of technical and general data that preceded this report. The references cited in the text are identified numerically from this list. (*Included in Supporting Documents)

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*29. Memorandum of Understanding; (relating to the Bypass Drain in Mexico), Bureau of Reclamation and International Boundary and Water Commission, United States Section, August 6, 1975.

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31. Arizona Statistical Review; 31st Annual Edition, Valley National Bank of Arizona, September 1975.

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I. INTRODUCTION

The Desalting Complex Unit is one of three components authorized under Title I - Programs Downstream from Imperial Dam - of the *Colorado River Basin Salinity Control Act, Public Law 93-320* [18], of June 24, 1974. The other two components of Title I are the replacement of the first 49 miles of the Coachella Canal in California's Imperial Valley with a concrete-lined canal (or lining the existing canal), and installation of well fields in Arizona to extract ground water within 5 miles of the Arizona-Sonora border, primarily on the Yuma Mesa. These latter two components are respectively identified as the Coachella Canal Unit and the Protective and Regulatory Pumping Unit.

The Desalting Complex Unit will be comprised of both structural and nonstructural measures to be implemented in the lower Gila and Colorado River valleys in southwestern Arizona and northwestern Sonora, Mexico. Structural features include construction of the world's largest membrane desalting plant (108.5-million-gallons-per-day (Mgal/d) production capacity) near Yuma; a 50.7-mile long concrete-lined bypass drain to carry plant reject to the Santa Clara Slough in Mexico; replacement of a steel flume section of the Main Outlet Drain Extension (MODE) in Yuma with 3,491 feet of buried concrete inverted siphon (completed in 1976); and associated works such as access roads and bridges, electric power transmission lines, continued operation of the currently operating Yuma Desalting Test Facility, and acquisition of land and construction of works to mitigate damages to fish and wildlife habitat.

Nonstructural measures include the current Irrigation Efficiency Improvement Program and acquisition of undeveloped and low irrigation efficiency land in the Wellton-Mohawk Division of the Gila Project (operated by the Wellton-Mohawk Irrigation and Drainage District [WMIDD]) to reduce the volume of irrigation drainage from the Division; and the possible acquisition of land for flood storage in, and modification of floodwater release schedules from, Painted Rock Reservoir, located on the Gila River about 60 river miles upstream from the Wellton-Mohawk Division, in order to reduce infiltration into the Wellton-Mohawk aquifer.

A. Authority for the Status Report

The preparation of this report is authorized by the Federal Reclamation Laws (Act of June 17, 1902, 32 Stat. 388 and Acts amendatory thereof and supplementary thereto).

B. Scope of Investigation

The scope of this investigation is to develop detailed locations, sizes, and operating criteria for the features to be constructed, and objectives and details of the implementation of nonstructural measures of the Desalting Complex Unit of Title I Division of the Colorado River Basin Salinity Control Project. Separate investigations are being conducted to develop final plans for the Coachella Canal Unit, the Protective and Regulatory Pumping Unit, and replacement sources for the desalting plant reject stream.

C. History

The initial factor which led to the eventual inception of the Desalting Complex Unit was the increase, in 1961, of total dissolved solids (TDS) in the Colorado River water delivered to Mexico at the Northerly International Boundary. The average annual salinity of the water increased that year from about 800 parts per million (p/m) TDS to nearly 1,400 p/m TDS, then to nearly 1,500 p/m TDS in 1962 (all salinity measurements cited herafter are considered to be TDS). Two concurrent and principal factors led to this increase in salinity. In 1961, the pumping of saline waters (initially averaging 6,000 p/m) was begun by the WMIDD to lower ground-water levels below the crop root zone in the aquifer that underlies the Division. This drainage was discharged to the Gila River, a tributary of the Colorado River, and consequently delivered to Mexico at the Northerly International Boundary. Also, excess Colorado River flows, which Mexico had received prior to 1961, significantly decreased due to low runoff in the upper basin. This latter situation has continued with the filling of Lake Powell since 1963.

Prior to this time there had never been any definite stipulations concerning the quality of water to be delivered to Mexico. *The Colorado River Compact* of 1922 [1] only contemplated, under Article III(c), that the United States might, as a matter of international comity, thereafter recognize in Mexico a right to use of waters of the Colorado River system. The Treaty of 1944, between the United States and Mexico, entitled *Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande* [3], provided for an allotment to Mexico of 1,500,000 acre-feet annually . . . *of the waters of the Colorado River, from any and all sources* . . . It was not until 1961, with the increase in river water salinity, that the quality of the water became a chief concern to Mexico. In November of that year Mexico formally protested to the United States that . . . *the delivery of water that is harmful for the purposes stated in the treaty constitutes a violation of the treaty* . . . .

In response to efforts by Mexico in 1963 and 1964, the United States began to modify its river operations. In March 1965, a 5-year agreement was reached by the two Governments, referred to as *Minute No. 218* [6] of the International Boundary and Water Commission. The Minute, under which each country reserved its legal rights, became effective on November 16, 1965, and provided for practical measures to further reduce the salinity of waters reaching Mexico. These measures consisted of the construction and operation of the 12-mile-long MODE from the end of the Wellton-Mohawk Main Conveyance Channel (WMMCC) to Morelos Dam to enable the United States to discharge Wellton-Mohawk drainage water to the Colorado River either above or below Morelos Dam (Mexico's diversion structure on the river), and the installation and operation of additional drainage wells in the Wellton-Mohawk Division to facilitate selective pumping. When scheduled deliveries to Mexico were the Treaty minimum, the United States discharged all Wellton-Mohawk drainage below Morelos Dam, and the difference was made up by other water largely from above Imperial Dam. This amounted to about 50,000 acre-feet per year. By the end of 1971 (*Minute No. 218* had been extended 2 years), these operations, coupled with a gradual improvement in the quality of Wellton-Mohawk drainage water, had reduced the average annual salinity of water available for delivery to Mexico at the Northerly International Boundary to about 1,245 p/m, with monthly averages varying from 1,105 to nearly 1,500 p/m. Mexico concluded, however, that it would not use water with a salinity greater than about 1,240 p/m in the Mexicali Valley and asked the United States, under terms of *Minute No. 218*, to bypass an additional 40,000 to 75,000 acre-feet of Wellton-Mohawk drainage flows annually. The effect was to further reduce the average salinity of water diverted by Mexico at Morelos Dam to about 1,160 p/m in 1971.

A change in the political administration of Mexico and deliberation between the two Governments on proposals to succeed *Minute No. 218* had resulted in its 2-year extension, but early in 1972, Mexico requested a prompt, permanent settlement. On June 17, 1972, the President of the United States indicated he would designate a special representative to develop a solution and to submit a report to him which, once approved by the United States Government, would be submitted to Mexico for consideration and approval.

The two Governments, in order to effect an immediate improvement in the quality of water delivered to Mexico above Morelos Dam, approved a new minute, *Minute No. 241* [12] of the International Boundary and Water Commission, signed July 14, 1972. It provided for the bypass of 118,000 acre-feet of Wellton-Mohawk drainage water annually without charge against the Treaty (more than twice the rate of the United States bypass under *Minute No. 218*), and its replacement by other water primarily from above Imperial Dam, but also from wells on the Yuma Mesa. The operations under *Minute No. 241* reduced the average annual salinity of water available to Mexico at the Northerly International Boundary to 1,140 p/m in 1973. However, Mexico again requested the United States to bypass additional Wellton-Mohawk drainage without replacement. All of the drainage water from the Division was consequently bypassed to the Colorado River below Morelos Dam. The additional bypass amounted to about 100,000 acre-feet annually. These operations reduced the salinity of water delivered to Mexico at the Northerly International Boundary from 1,160 p/m in 1971 to less than 1,000 p/m for the year ending June 30, 1973.

On August 30, 1973, the joint recommendations of the special representative designated by President Nixon, Herbert Brownell, Jr., and the Secretary of Foreign Relations of Mexico, Lic. Emilio O. Rabasa, were approved by their respective Presidents, and formally approved by the two Governments, and incorporated into *Minute No. 242* [14] of the International Boundary and Water Commission (terminating the life of *Minute No. 241*).

Minute No. 242, in effect to date, provides that the approximately 1,360,000 acre-feet of the Treaty water annually delivered to Mexico upstream of Morelos Dam have an annual average salinity of no more than 115 $\pm$ 30 p/m over the annual average salinity of Colorado River water arriving at Imperial Dam. It further provides for the delivery to Mexico on the land boundary at San Luis and in the limitrophe section of the Colorado River downstream from Morelos Dam approximately 140,000 acre-feet of water annually, with a salinity substantially the same as that of waters customarily delivered there. As part of the measures required to maintain this salinity differential, the Minute provides that the concrete-lined MODE be extended from Morelos Dam to the Santa Clara Slough in Mexico at the expense of the United States.

Those provisions of the Minute which were dependent for their implementation on construction of works or on other measures which required expenditure of funds by the United States became effective upon authorization by the United States Congress and notification by the United States to Mexico of such authorization. This authorization was encompassed in *Public Law 93-320* [18], the *Colorado River Basin Salinity Control Act*, enacted June 24, 1974. Section 101, Title I, of the Act gives authorization for the construction of the Desalting Complex Unit.

D. Project Description

The seven measures to be implemented in the Desalting Complex Unit are: (1) construction of the Yuma Desalting Plant; (2) construction of the Bypass Drain in the United States and Mexico; (3) implementation of measures for Wellton-Mohawk irrigation efficiency improvement (Irrigation Management Services, Onfarm Systems Improvement, Research and Demonstrations, Education Program, Technical Field Committee); (4) Wellton-Mohawk acreage reduction; (5) Painted Rock Reservoir land acquisition and operation schedule modification; (6) construction of the MODE Siphon; and (7) fish and wildlife mitigation measures.

D.1. Yuma Desalting Plant

The primary feature of the Desalting Complex Unit from an economic, technical, and political standpoint will be a membrane desalting plant that will reduce the salinity of WMIDD pumped drainage before it is returned to the Colorado River. The proposed plant site is about 4 miles west of Yuma, near the Arizona Public Service Yucca-Axis Powerplant, and is known as the Yucca site. There is some possibility that an alternate site may be considered if ongoing seismic monitoring indicates this necessity prior to final design. In any case, the plant capacity as determined by this investigation will be 108.5 Mgal/d. The annual plant production capacity will be 102,700 acre-feet of product water at 386 p/m and, consequently, 43,300 acre-feet of concentrated reject at 8,874 p/m.

Wellton-Mohawk drainage is expected to total 167,000 acre-feet annually when the plant becomes operational in 1981. Approximately 20,900 acre-feet of MODE water which will not be desalted will be blended with the product water to result in 123,600 acre-feet of total blended water at 854 p/m to be returned to the Colorado River. This flow, combined with other flows to the river below Imperial Dam, will result in 1,360,000 acre-feet of water at 980 p/m for delivery to Mexico at the Northerly International Boundary. Consequently, the salinity of water arriving at the Northerly International Boundary will annually average 115 p/m $\pm$ 30 p/m more than the salinity of water arriving at Imperial Dam, in accordance with the provisions of *Minute No. 242.*

The design plant capacity is based on a "worst case" condition. The "worst case" condition is the maximum plant capacity required during projected hydrologic conditions which could occur during years when the plant output requirement would be greatest. During the period 1982 through 1993, operation studies indicate that the average annual plant production will be 60,000 acre-feet with 26,000 acre-feet of reject.

D.2. Bypass Drain

A bypass drain will be constructed to carry reject from the desalting plant. Construction will extend from the end of the MODE at Morelos Dam, through Arizona and Sonora, to the Santa Clara Slough. The Slough eventually terminates in the Gulf of California, but the end of the drain will be at the upper end of the Slough, approximately 30 miles from the Gulf. The drain will be 50.7 miles long with a capacity equal to that of the MODE, 353 cubic feet per second (ft^3/s), and will be concrete lined. The normal flow will be the desalting plant reject, which will be a maximum of about 62 ft^3/s.

Reject will be carried in the existing MODE for 2 miles from the MODE-2 bifurcation at the desalting plant (MODE-2 is a discharge channel from the MODE to the Colorado River at the proposed plant site) to MODE-3 at Morelos Dam (MODE-3 is the discharge channel from the MODE to the Colorado River on the downstream side of Morelos Dam). All blended water will be returned to the Colorado River through the

MODE-2 channel. The MODE-3 channel below Morelos Dam will remain operational for emergencies. The Bypass Drain will begin at the terminus of the MODE at Morelos Dam and will be adjacent to the Yuma Valley Levee on the east side of the river channel nearly all of the 16.0 miles to the Southerly International Boundary. The boundary crossing will be near the Colorado River west of San Luis. Mexico will construct the remaining 34.7 miles (55.8 km) of the Bypass Drain, at United States expense, from the Southerly International Boundary to the upper end of the Santa Clara Slough.

D.3. MODE Siphon

A 12-foot-6-inch-diameter semicircular metal flume section of the MODE has been replaced with a buried circular concrete siphon. The flume was adjacent to the Colorado River in Yuma at the foot of Prison Hill. The siphon is 3,491 feet long and 10 feet in diameter, and was completed in June 1976. The flume had been used several years beyond its intended temporary life and had deteriorated.

D.4. Wellton-Mohawk Irrigation Efficiency Improvement Program

An Irrigation Efficiency Improvement Program is in progress in the Wellton-Mohawk Division to reduce drainage flows from irrigation. All drainage is pumped from the aquifer beneath irrigated lands to maintain a desired minimum water table depth of 8 feet. The program is actually a combination of several subprograms--Irrigation Management Services, onfarm improvements, research and demonstrations, accelerated education, and the work of the Technical Field Committee--and, in conjunction with the acreage reduction program, functions to improve the average irrigation efficiency in the Division from 56 percent to 64 percent by the time the desalting plant comes online in 1981, and ultimately to a level of 72 percent. This will result in a reduction of drainage flows from 214,000 acre-feet annually to 167,000 acre-feet annually by 1981, and ultimately to 136,000 acre-feet annually.

D.5. Wellton-Mohawk Acreage Reduction

The irrigable land of the Division will be reduced to approximately 65,000 acres from the 75,000 acres authorized for development. This will reduce existing marginal operations of developed land, and prevent further development of undeveloped land. Part of the land is still in Federal ownership, and most of the balance will be acquired with a consideration of the most beneficial project effects. The objective is to reduce drainage return flows from land with low irrigation efficiency.

D.6. Painted Rock Reservoir Land Acquisition and Operation Schedule Modification

The Corps of Engineers has studied a number of release schedules for Painted Rock Dam and has identified six viable plans for the discharge of floodwater stored in the reservoir. The Corps' preliminarily recommended plan would schedule releases varying from 250 ft^3/s to 22,500 ft^3/s depending on the reservoir stage.

Public Law 93-320, in Section 101. (j), authorizes the acquisition of additional land in Painted Rock Reservoir that would be required for temporary storage capacity due to operation schedule modifications. The law does not, however, authorize the expenditure of funds for this purpose until it has been determined by a Federal court that the Corps of Engineers lacks legal authority to use such lands for this purpose; as yet, such determination has not been made.

D.7. Fish and Wildlife Mitigation

Construction of project facilities for the Desalting Complex Unit will result in the loss of approximately 1,000 acres of land, including that for rights-of-way, and about 400 acres of fish habitat. Mitigation will be provided through the acquisition of around 900 acres of land to be assigned to the Arizona Game and Fish Department for designation and use as a wildlife and recreation management area. Fish rearing facilities will be constructed to provide for the annual stocking of 200 to 300 surface acres of lakes, ponds, rivers, and canals in the Yuma area. The Hunter's Hole pond complex, adjacent to the limitrophe section of the Colorado River, will also be maintained through construction of an outlet control structure and a shallow well.

E. Relation to Other Colorado River Basin Salinity Control Projects

The quality of water in the Colorado River is degraded by the addition of dissolved mineral salts (salinity), municipal wastes, industrial wastes, agricultural wastes (pesticides and fertilizers), and mine drainage. Various other parameters which also affect water quality are dissolved oxygen concentration, temperature, pH, heavy metals, toxic materials, nutrients, bacteria, radioactivity, mercury, and sediment. Salinity, among all of these water quality factors, is the most serious one within the river system.

Any attempt to significantly decrease salinity must involve an enormous effort which no single measure can accomplish. The objective of the Desalting Complex Unit and the other measures of the Colorado River Basin Salinity Control Project is to reduce or maintain the salinity of the water of the Colorado River. Titles I and II of *Public Law 93-320* authorize the construction of several projects throughout the river basin. In addition to the Desalting Complex Unit, the Coachella Canal and Protective and Regulatory Pumping Units are also authorized under Title I (Programs Downstream From Imperial Dam). These are primarily water recovery measures. Advance planning studies are currently underway on four projects authorized for construction under Title II (Measures Upstream From Imperial Dam). These are the Paradox Valley Unit, Grand Valley Basin Unit, Crystal Geyser Unit, and Las Vegas Wash Unit. Also authorized under Title II are 12 accelerated feasibility investigations of salinity control measures classified among the three categories (1) irrigation source control, (2) point source control, and (3) diffuse source control.

Control of the point, diffuse, and irrigation sources under Title II of the program will provide a maximum reduction of about 1.6 million tons of salt annually. This level represents a concentration reduction of about 150 p/m at Imperial Dam under conditions of development anticipated by the year 2000. Thus, the basinwide salinity reductions of Title I and Title II projects will accrue to the Basin States and the Republic of Mexico.

F. Acknowledgments

This report was prepared by the Bureau of Reclamation's Lower Colorado Regional Office with considerable assistance by the Engineering and Research Center in Denver, Colorado and the Yuma Projects Office. Input was also made either directly by drafting paragraphs of supporting data or by assistance in preparation of other supporting data by the International Boundary and Water Commission - United States Section, Soil Conservation Service, Agricultural Research Service, and the University of Arizona Agricultural Extension Service.

II. A GENERAL DESCRIPTION OF THE PROJECT AREA

The overall project area is located in southwestern Arizona (Yuma and Maricopa Counties) and the northwest tip of Sonora, Mexico (between the Southerly International Boundary and the Gulf of California), on the historic flood plain and delta of the Lower Colorado and Gila Rivers. The focal point of the project, however, is a much smaller area centered around Yuma, Arizona, along the Gila River from Texas Hill west to the Colorado River, and from Imperial Dam south to San Luis (Map No. X-300-701). All structural features and nonstructural measures, with the exception of Painted Rock Dam and the Bypass Drain-Mexico, are or will be located within this smaller area, generally referred to as the Yuma area.

A. Physical Characteristics

Each of the project area's various physical characteristics differs from one isolated or unique locale to another within the overall area, but these individual characteristics generally typify the physiography and physiology of the Sonoran Desert. Several of these characteristics--topography, soils, and agricultural vegetation--pertain only to the Yuma area, while others are representative of the entire project area.

A.1. Climate

The regional climate, typical of the desert environment, is hot and dry. The average maximum temperature from June through August is 106°F and the average minimum temperature in January is 40°F. This extent of warm weather results in a frost-free period which averages 348 days a year. Annual precipitation averages 3 inches in the Yuma area, and occurs as brief rains during a primary period from July to October and a secondary period during the winter. Heavy general precipitation may take place in late summer with the arrival of tropical air from off the west coast of Mexico, but such storms occur on an average of only once every 7 years in the delta region. The predominant wind direction is from the south during the warmer part of the year (June through August) and from the north during the colder months (November through February).

A.2. Topography and Soils

The terrain of the Yuma area is characterized by flood plains and terraces crossed by arroyos and separated into valleys by low, rugged hills and mountains oriented in a northwest-southeast direction.

The soils have been developed primarily from alluvial materials that were derived from igneous and sedimentary rocks throughout the Colorado River Basin and from the nearby mountain ranges. These nearby ranges are steep, and are composed essentially of bare rock with little vegetal cover. In the gently sloping alluvium-filled valleys, the soils are deep, quite heterogeneous in texture, and nearly flat in topography. They are quite low in organic material and have not been leached of nutrients. Many of them, however, have been adapted, through irrigation, to the agricultural production of a wide range of crops--particularly cotton, wheat, citrus, and vegetables.

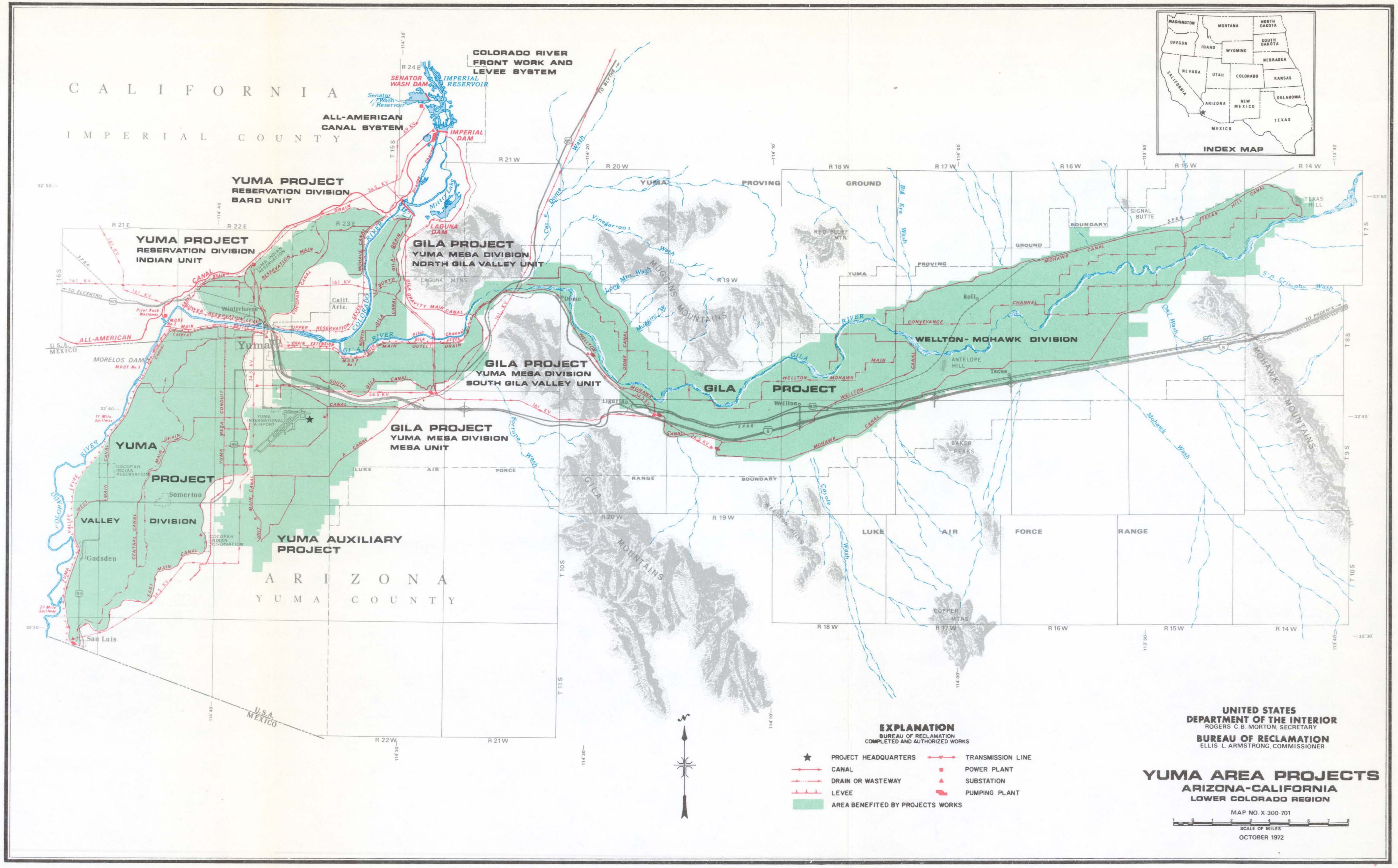
A.3. Agricultural Development Downstream from Imperial Dam

United States agricultural development below Imperial Dam consists of approximately 184,000 acres of irrigable land originally developed as the Bureau of Reclamation's Yuma, Yuma Auxiliary, and Gila Projects, and now cooperatively managed by eight local irrigation districts (Map No. X-300-701). The latest comprehensive yearly records (1974) show that 157,782 acres of these lands were irrigated by 1,353,100 acre-feet of Colorado River diversions, and return flows of 422,300 acre-feet were recorded. The area's principal products are hay and grain crops, winter vegetables and melons, citrus fruit, alfalfa and Bermuda seed, and livestock, all of which are marketed throughout the United States and as far north as Canada.

A.3.a. Yuma Project

This project is the oldest Reclamation development on the Colorado River and one of the first (1904) to be authorized and constructed. Construction began in 1905 and was completed in 1909. The first water deliveries began in 1910.

The project is divided into two divisions. The Reservation Division of the project includes 14,600 acres on the California side of the river and is served by 74 miles of canals and laterals. Until 1910, when a portion was set aside for settlement by non-Indians, it constituted a reservation for the Quechan Indians. Currently, some 7,600 acres are included in the Indian Unit. The remaining 7,000 acres make up the Bard Unit and are under non-Indian ownership. In 1974, 86,200 acre-feet of water were diverted from the All-American Canal for this Division. Irrigation return flows are returned to the river above


YUMA AREA PROJECTS
ARIZONA-CALIFORNIA
LOWER COLORADO REGION
MAP NO. X-300-701
SCALE OF MILES
OCTOBER 1972
UNITED STATES
DEPARTMENT OF THE INTERIOR
ROGERS C.B. MORTON, SECRETARY
BUREAU OF RECLAMATION
ELLIS L. ARMSTRONG, COMMISSIONER
EXPLANATION
BUREAU OF RECLAMATION
COMPLETED AND AUTHORIZED WORKS
PROJECT HEADQUARTERS
CANAL
DRAIN OR WASTEWAY
LEVEE
AREA BENEFITED BY PROJECTS WORKS
TRANSMISSION LINE
POWER PLANT
SUBSTATION
PUMPING PLANT
INDEX MAP
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ARIZONA
YUMA COUNTY
COLORADO RIVER
FRONT WORK AND
LEVEE SYSTEM
ALL-AMERICAN
CANAL SYSTEM
SENATOR WASH DAM
IMPERIAL RESERVOIR
IMPERIAL DAM
LAGUNA DAM
YUMA PROJECT
RESERVATION DIVISION
BARD UNIT
YUMA PROJECT
RESERVATION DIVISION
INDIAN UNIT
GILA PROJECT
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NORTH GILA VALLEY UNIT
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YUMA MESA DIVISION
SOUTH GILA VALLEY UNIT
GILA PROJECT
YUMA MESA DIVISION
MESA UNIT
WELLTON-MOHAWK DIVISION
GILA PROJECT
YUMA PROJECT
VALLEY DIVISION
YUMA AUXILIARY
PROJECT
GILA MOUNTAINS
MUGGINS MOUNTAINS
MOHAWK MOUNTAINS
YUMA PROVING GROUND
LUKE AIR FORCE RANGE
Yuma
Winterhaven
Somerton
Gadsden
San Luis
Wellton
Tacna
Roll
Dome
Ligurta
MORELOS DAM
U.S.A.
MEXICO
TO PHOENIX
TO BLYTHE
TO EL CENTRO

Morelos Dam in open drains. A portion of this return flow water is seepage from the All-American Canal adjacent to the Division. The amount of underflow to the river from the Division is not known. There were 41,300 acre-feet of irrigation return flows recorded in 1974.

The Valley Divison, in Arizona, totals about 53,500 acres, and extends south from the city of Yuma to the Mexican border. The distribution system for the Division consists of three main canals with a combined length of 61 miles and some 118 miles of laterals. There were 329,700 acre-feet of water diverted for irrigation in 1974. Irrigation return flows from the Division are delivered to Mexico at the Southerly International Boundary and make up a part of Mexico's Treaty waters. Drainage is from a system of open drains supplemented by drainage wells along the eastern part of the valley. There were 108,600 acre-feet of drainage and wasteway flows recorded at the Southerly International Boundary in 1974.

Water for project use is diverted from the Colorado River at Imperial Dam, about 18 miles north of Yuma, and is transported to the project by the All-American Canal. A turnout at Siphon Drop Powerplant, several miles southwest of Imperial Dam, was placed in operation in 1941 to furnish water to the 2,000 ft^3/s capacity Yuma Main Canal. This canal supplies a portion of the land of the Indian Unit of the Reservation Division and is siphoned under the Colorado River to serve the Valley Division lands. The remaining lands on the Reservation Division have been irrigated directly from the All-American Canal since 1948. Laguna Dam, the original diversion point for the Yuma Project, located about 13 miles north of Yuma, is still maintained for river control and facilitation of operations at Imperial Dam.

Yuma Project lands produce alfalfa hay and seed, winter vegetables, cantaloupes and watermelons, cotton, sorghums and small grains, pasture crops, dates, and citrus fruit. Some crops also provide for the seasonal feeding and pasturing of livestock.

A.3.b. Yuma Auxiliary Project

This project is situated on the Yuma Mesa in Arizona, about halfway between Yuma and Mexico. Its 3,400 acres are devoted to growing grapefruit, oranges, lemons, and other citrus fruits. As authorized in 1917, the project comprised 45,000 acres of which only a limited area could be served through constructed works. Legislation passed in 1949 reduced the project's boundaries to the present area because the remaining arable land could be served better through the facilities of the Yuma Mesa Division of the Gila Project. However, approximately 101 acres of adjacent Warren Act lands are served through facilities of the Yuma Auxiliary Project. Colorado River water for the project is diverted at Imperial Dam through the Gila Project Canal system. There were 39,800 acre-feet of water diverted for irrigation in 1974. There are no drainage facilities on the project and no recorded return flows.

A.3.c. Gila Project

This project's 112,500 acres of irrigable valley and Mesa lands are located along the Colorado and Gila Rivers in southwestern Arizona. The project authorization limits diversions from the Colorado River for beneficial consumptive use to not more than 600,000 acre-feet annually, with the quantity divided equally between the Wellton-Mohawk and Yuma Mesa Divisions. The Wellton-Mohawk Division's 75,000 acres of irrigable lands extend along the Gila River and on bordering Mesa areas. The Yuma Mesa Division contains 37,500 acres of irrigable land, 20,400 of which are in the Mesa Unit. The North and South Gila Valley Units combined contain 17,100 acres.

Project water is diverted into the Gila Gravity Main Canal at Imperial Dam. The canal extends 21 miles southeast from the Dam to the Yuma Mesa Pumping Plant, where water is lifted 52 feet to the head of the Mesa distribution system. The Mesa Unit has two main canals with a total length of 23 miles, plus 43 miles of laterals. There were 235,600 acre-feet of water diverted for irrigation in 1974. There are no drainage facilities on the unit and no recorded return flows.

The North Gila Valley Unit receives its water from the Gila Gravity Main Canal and from two turnouts, 7 and 11 miles below Imperial Dam. This unit contains 25 miles of canals and laterals. There were 59,300 acre-feet of water diverted for irrigation in 1974. Drainage for the unit is provided by open drains and the adjacent Colorado and Gila Rivers. There were 7,900 acre-feet of return flows recorded that year.

The South Gila Valley Unit diverts water from the Gila Gravity Main Canal into six laterals, and just upstream from the Yuma Mesa Pumping Plant into the 7.5-mile South Gila Canal. The unit has 27 miles of underground pipe laterals. There were 56,200 acre-feet of water diverted for irrigation in 1974. There are no return flows recorded exclusively for the South Gila Valley Unit; however, there are 22 wells in the unit which maintain adequate ground-water levels.

The 18.5-mile Wellton-Mohawk Canal, diverting from the Gila Gravity Main Canal 15 miles from Imperial Dam, has a capacity of 1,300 ft^3/s. Its branches, the Wellton Canal and the Mohawk Canal, are 21 and 43 miles long, respectively. The Wellton Canal has a capacity of 300 ft^3/s. Three large pumping plants along the Wellton-Mohawk Canal lift water a total of 170 feet. Smaller relift pumps are scattered throughout the Division on 227 miles of laterals. In 1974, there were 546,300 acre-feet of water delivered to the Division. There are 106 wells in the area which are used for drainage control. They selectively pump water from the aquifer underlying the Division into the Wellton-Mohawk Main Conveyance Channel. This pumped drainage totaled 206,400 acre-feet in 1974.

The Yuma Mesa Unit grows citrus, alfalfa hay and seed, peanuts, cotton, and grains. Alfalfa, cotton, flax, melons, citrus, grapes, winter vegetables, small grains, and Bermuda grass seed are grown in the North and South Gila Valley Units and the Wellton-Mohawk Division. Cattle and sheep brought from summer ranges are wintered on irrigated pastures of the project before being shipped to feed lots and markets.

A.3.d. Mexicali Valley of Mexico

The history of irrigation in Mexicali Valley is contemporary with that of the Imperial Valley in California. Mexico obtained diversion rights for up to half the water flowing in the Alamo Canal to irrigate lands in the valley in return for granting the predecessors of the Imperial Irrigation District the right to convey Colorado River water in the canal through Mexican territory. In 1920, 220,000 acres were irrigated in Mexico, and in 1942, with the completion of the All-American Canal, 260,000 acres. Ratification of the 1944 Treaty, with its guarantee of minimum annual quantities of water at regulated rates, resulted in a large increase in irrigated acreage; it reached a maximum of more than 500,000 acres in 1957, and was reported to be 410,000 acres in 1962. Crops grown in the Mexicali Valley are primarily cotton and winter wheat. In 1961, more than 70 percent of the cropland was planted to cotton.

A.4. Geology

A.4.a. General

The project area is situated over a large portion of the Colorado River delta. In its broadest sense, the delta includes the sediments in the Yuma area, the Imperial and Mexicali Valleys, and the San Luis Mesa in the United States and Mexico, laid down by the present day and ancestral Colorado and Gila Rivers. Delta building began in late Pliocene time (roughly 5 million years ago) and continued into historic time until the river was brought under control and thoroughly regulated by dams. The normal flow of the Colorado River has been utilized since about 1938; as a result, sedimentation has been in manmade lakes, desilting basins, and, to a minor extent, major channels.

The delta is draped across the boundary between two subunits of the Basin and Range physiographic province of the southwestern United States and northwest Mexico: the Sonoran Desert and the Salton Trough (Figure 1 and Map No. 1292-303-1011). The Sonoran Desert covers much of southwestern Arizona, southeastern California, and northwestern Mexico. Typical of the subunit are subparallel, barren mountain ranges separated by debris-filled basins. The ranges are low but rugged and stand in sharp relief above the seemingly level alluvial basins. The Sonoran Desert encompasses only a small part of the Colorado River delta; the greater part is situated in the Salton Trough. The Salton Trough is a sediment-filled structure roughly 100 miles wide and 800 miles long. It extends from the Transverse Ranges of San Bernardino County in southern California southeastward through Imperial County, California and Yuma County, Arizona, into Mexico.

The Salton Trough is a major rift between two crustal plates, one oceanic and the other continental. Interaction between the two crustal plates involves spreading as well as relative horizontal motion and gravity sliding. Structural deformation is, therefore, more or less continuous, involving constant creep or stick-slip action along a network of northwest-trending faults known collectively as the San Andreas Fault system. Crustal disturbance in this region is indicated by tilted and folded strata, sheared bedrock terranes, ruptured alluvial surfaces, and offset drainageways. Right lateral slip along the San Andreas rift has aggregated about 200 miles or more during 30 million years of Cenozoic time

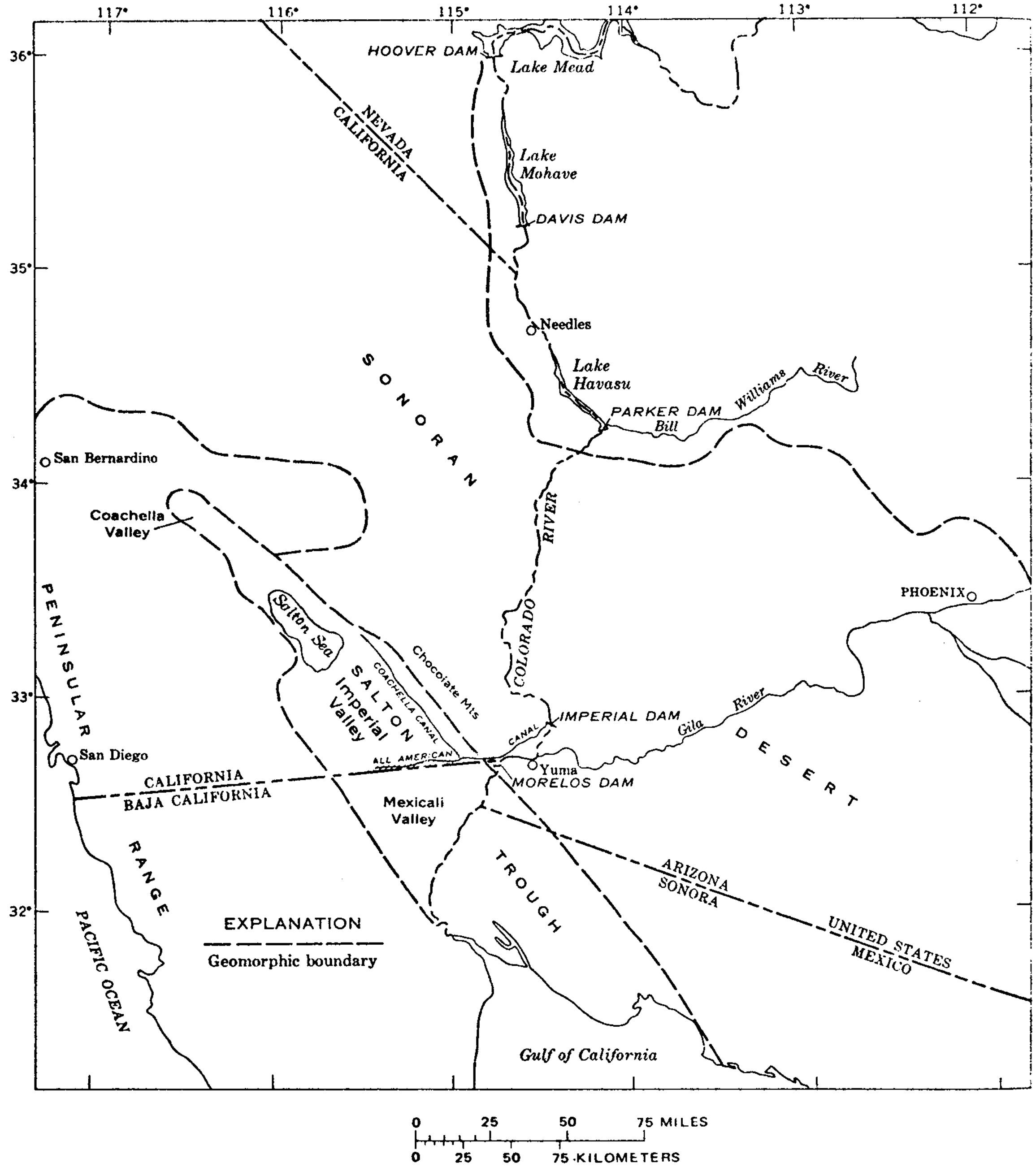
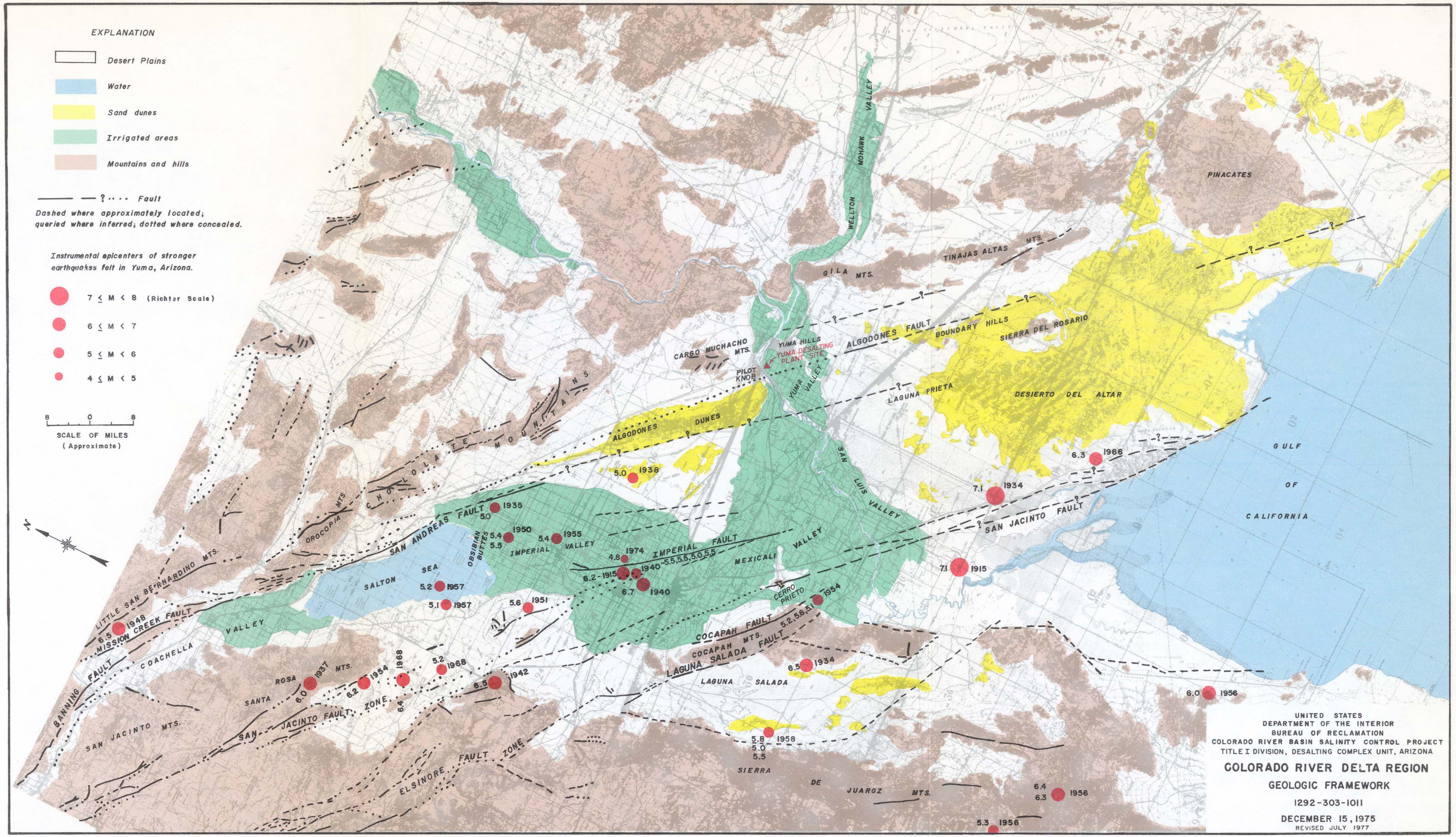


FIGURE 1
PHYSIOGRAPHIC SECTIONS OF SOUTHWESTERN
UNITED STATES AND NORTHWESTERN MEXICO
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
TITLE I DIVISION, DESALTING COMPLEX UNIT, ARIZONA

COLORADO RIVER DELTA REGION
GEOLOGIC FRAMEWORK
1292-303-1011
DECEMBER 15, 1975
REVISED JULY 1977

as the oceanic plate moves northwest, relative to the continental plate. Crustal separation in the Salton Trough is occurring at the rate of 1 to 2 centimeters per year as Baja California and the Peninsular Ranges of southern California (the parts of the oceanic plate that border the Salton Trough on the southwest) move westward, away from the continental plate. Cumulative gravity movement along the faults is sufficient to accommodate a maximum of about 20,000 feet of Colorado River sedimentation as spreading and subsidence proceed.

Colorado River deposits form virtually all of the surface and shallow subsurface geology in the delta region. They are underlain by pre-Tertiary metamorphic, plutonic, and dike rocks, collectively called the basement complex; these rocks also crop out in bordering mountain ranges. Tertiary volcanic rocks are present in some of the bordering ranges and underlie the sediments in part. Locally, very young volcanic rocks are present in the delta region. Eruptions have been recorded in historic times in at least three places within or bordering the Salton Trough. One, in 1934, was in the Pinacates volcanic field in Sonora, Mexico, about 90 miles southeast of Yuma; another, in 1877, was in the Chocolate Mountains east of the Salton Sea; and two, in 1852 and 1927, were at Cerro Prieto, about 20 miles southeast of Mexicali, Baja California.

The thickness of recent alluvium in the Yuma area ranges from a few hundred feet at the apex of the present day delta to more than 2,000 feet at the Southerly International Boundary near San Luis, Arizona. Dune sand overlies the alluvium in local areas of the delta region (Map No. 1292-303-1011).

The alluvium consists largely of waterborne clay, silt, sand, and gravel. It is exposed on the mesas (older stream terraces) and in the present river valleys. Most was deposited by the Colorado and Gila Rivers, but some was deposited by ephemeral streams along the mountain fronts. The river deposits are better sorted and better rounded than the local deposits and contain more fine-grained materials. Sand is the principal constituent, but thick deposits of gravel and clay occur at various levels.

A.4.b. Seismicity

The San Andreas Fault system is the locus of the most intense seismic activity in the United States (exclusive of Alaska) and the northern Pacific Coast Region of Mexico.

The general nature of this earthquake belt is shown on the epicenter map, Figure 2. It has been estimated that earthquakes in California and western Nevada represent about 90 percent of the seismic activity of the contiguous United States.

Geodetic surveys across the Imperial Valley segment of the Salton Trough indicate that shear strain is continuing to build up in this region. Calculations of strain release versus strain accumulation suggest that the seismic "habit" of the northern end of the Gulf Trough is one of relatively frequent moderate-sized earthquakes, as opposed to the infrequent great earthquakes that occur along northern segments of the San Andreas system (such as the famed San Francisco earthquake of 1906).

Recent seismic activity has occurred near the northeast margin of the Salton Trough but there is no record of fault movement in the Yuma area in historic time. The seismic and geologic evidence together indicate that earthquake damage in the Yuma area is less likely from movements on local faults than on those located farther west and south in the Salton Trough and the northern Gulf of California region. Earthquakes centered in these areas have caused substantial damage in the Yuma area in historic time; at least three such events have occurred.

Information related to earthquakes felt in the Yuma area has been recorded in one form or another since at least April 1776, and more than 100 events have been reported through 1975. Between 1776 and 1931, the information is largely in the form of news accounts, but some is from the diaries of military personnel stationed at Fort Yuma. In this period of 155 years more than 70 events felt at Yuma were recorded. At least one of these events (1852) had substantial energy release. Only a few events were recorded prior to 1852. It is probable that strong shocks occurred for which there is no record.

Beginning in 1932, a network of seven seismic stations was established in southern California by the California Institute of Technology at Pasadena. The number of stations increased over the years and by December 1972, 39 stations were in operation for the purpose of monitoring seismic activity. In 1972, the Seismological Laboratory of the Institute reported 40 years of record and listed a total of 15,340 seismic events in the United States and Mexico along the trend of the San Andreas Fault zone. Events of

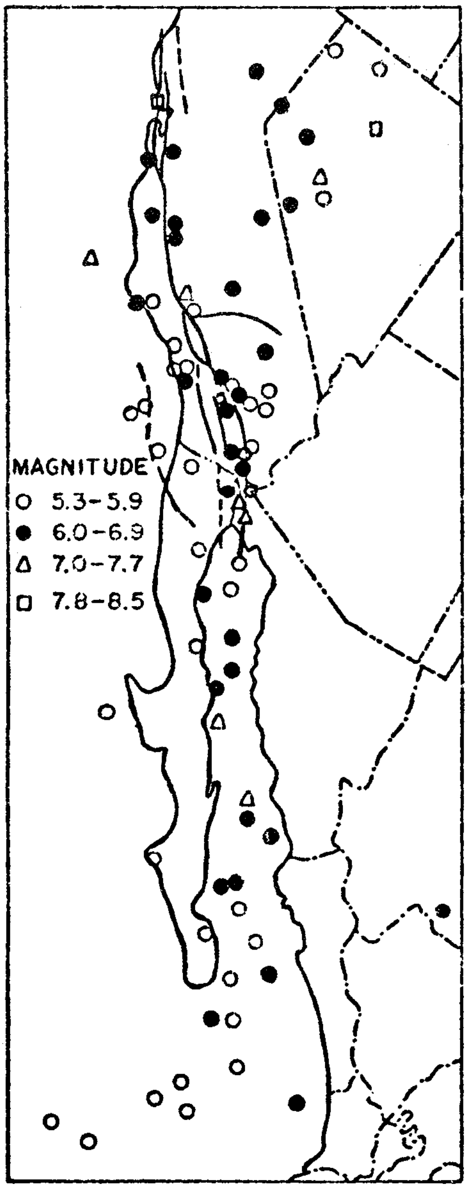


Figure 1a. Epicenters of earthquakes in California and Pacific Coast region of Mexico. Open circles, depth shallower than 60 km; solid circles, depth greater than 70 km. After Gutenberg and Richter (1954, Figs. 8, 9), in Hamilton. (1961, Fig. 3)

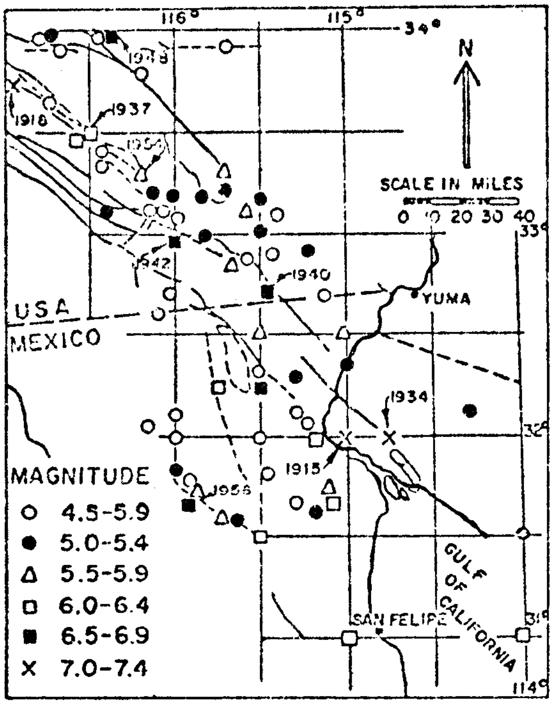


Figure 1b. Seismicity map of Salton trough and adjacent areas, showing shocks of magnitude 4.5 and greater that occurred between 1904 and 1960. Listing prior to 1934 is very incomplete. Data from Gutenberg and Richter (1954) and local bulletins of the Pasadena Seismological Laboratory. After Biehler, Kovach, and Allen (1964, Figure 2).

FIGURE 2
EPICENTER MAP
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

magnitude 3.0 and above in the United States and events of magnitude 4.0 and above in Mexico were reported.

At the present time, five seismograph networks have been installed in the southern California area as part of a cooperative program between the United States Geological Survey (USGS) and the California Institute of Technology. The 20-station Imperial Valley network, one of the five networks, was installed in April 1973. Two of the 20 stations of the Imperial Valley network are near the prospective sites for the Yuma Desalting Plant. One is at Pilot Knob and the other is at San Luis. Installation of an additional five seismograph stations in the vicinity of Yuma was completed in July 1975 by the USGS, under contract with the Bureau of Reclamation. Four are microseismograph stations and one is a strong motion accelerometer.

The in situ effects of an earthquake, damaging or not, depend on its magnitude, its origin with respect to the point being observed, and the geology and ground-water conditions between the two points. The magnitude is calculated from instrumental records and represents the energy released at the earthquake focus. The intensity, which is a measure of the effects of an earthquake, is of more general interest. It is based on direct effects at the observation point, such as damage to buildings, changes in topography, and reactions of people–referred to as macroseismic observations. Intensity varies with the position of the observation point. As a general rule, for the same epicentral distance intensity is greater in unconsolidated sediments than in bedrock terranes. In unconsolidated sediments the grain size and shape, density, water content, depth to water table, artesian pressure, and other ground-water conditions relate to the earthquake intensity.

On the Colorado River delta plain many, if not most, of the unfavorable conditions are present. The delta is underlain by several hundred to several thousand feet of unconsolidated sediments. The upper hundred feet, more or less, consist of low density material. The water table is high, never deeper than a few tens of feet, and often at or near the land surface. The record is clear that the damaging radius of moderate sized earthquakes is large, though effects are far from uniform.

A.5. Biology

The Sonoran Desert environment, due to its harsh conditions, limits the habitation potential of both plants and animals in the project area. The species which inhabit the greater portion of the region, away from the water channels, must be able to withstand extensive periods of drought and extreme ranges of temperature. Animals which cannot adapt to such conditions within a specific locale of the area lead a nomadic lifestyle in order to fulfill their needs. A number of plants, including agricultural products, and animals which live in or around the waterways are totally dependent on that water for their existence. The fish of the area, although having access to an extensive number of waterways as a result of the irrigation projects, are limited in number due to the relatively narrow and shallow dimensions of those waterways. Indigenous southern Sonoran Desert

vegetation is characteristic of a large part of the project area. This growth is typically sparse and consists basically of creosote bush, mesquite, catclaw, big saltbush, spring aster, alkali heliotrope, cholla, barrel cactus, ironwood, paloverde, and ocotillo. Creosote bush is the dominant vegetal type, with some bursage growing in open stands with little or no perennial ground cover. Numerous annual forbs and grasses may occur during periods of favorable moisture. Characteristic species of riparian vegetation, that vegetation which grows along the waterways, lakes, and marshes of the area, include saltcedar, arrowweed, mesquite, cottonwood, catclaw, seepwillow, Gooding willow, Bermuda grass, saltgrass, cattail, bulrush, giant reed, and common reed.

Environmental inventories indicate there are 18 fish species known to inhabit the waterways of the project area. Some of the more common varieties include the threadfin shad, red shiner, carp, yellow bullhead, channel catfish, bluegill, largemouth bass, tilapia, mosquitofish, and mollies. Studies indicate that 13 additional species may occur in the waters of the lower Colorado River, but their presence would be rare.

There are several hundred species of animals which inhabit the project area, either on a permanent basis or during seasonal migrations. The two largest species are the mule deer and the desert bighorn sheep; feral burros are also known to exist in the area, most commonly in riparian communities. Carnivores include the coyote, grey fox, kit fox, striped skunk, ringtail cat, and raccoon. Beaver and muskrat are found along the waterways and in marshy areas, and rabbits are especially abundant in the agricultural-riparian communities. Numerous small rats, mice, squirrels, amphibians, and reptiles, including an extensive number of lizards, also inhabit the area.

Birds, both permanent and migratory, account for over one hundred of the animal species in the region. The dominant upland game birds are the mourning dove, white-winged dove, and Gambel's quail, all of which are found in fairly high concentrations in the agricultural-riparian communities. Migratory waterfowl are present in the area during the fall, winter, and spring.

Invertebrates, especially insects, have successfully established themselves in every environmental niche. Invertebrates common in the area include spiders, scorpions, ants, leaf beetles, cicadas, grasshoppers, crickets, and pest species associated with cultivated crops.

B. Community Characteristics

The community characteristics of the project area are predominantly rural from a geographic standpoint, and metropolitan from a demographic one. The only city of significant size in the area is Yuma, wherein the majority of people in Yuma County reside. The proximity of Yuma to other major western population centers (Phoenix, Tucson, Albuquerque, San Diego, Los Angeles, San Francisco, Salt Lake City, and Denver all lie less than 700 air miles away) makes it a focal point and trade center for the entire local farm area.

B.1. Population

The first white men to arrive in the Yuma area were probably Jesuit Fathers who came north from Mexico. These missionaries may have settled in the Yuma area as early as the 16th century. Indians, of course, had inhabited southwestern Arizona for centuries before the advent of white settlement. Actual population growth and the associated community development did not significantly increase, however, until the establishment of the Butterfield Stage Line in 1857. The area then grew at a slow but steady rate until about 1940. Between 1940 and 1950 the rate of development appreciably increased due to the establishment of large military installations and the development of industry in the area, and a special census taken in 1952 showed the population of metropolitan Yuma to be 19,500. The trend has since continued upward, and as of 1970, 29,007 people resided in Yuma; an additional 9,012 inhabitants resided in the unincorporated areas immediately adjacent to the city.

The extensive irrigation projects which surround Yuma contain within their boundaries several small towns and a number of rural inhabitants. Some of the County Divisions established for Yuma County by the United States Census Bureau encompass the boundaries of these projects and, in 1970, indicated that 9,611 people resided in the areas of the Valley Division-Yuma Project, the Yuma Mesa Division-Gila Project, and the Yuma Auxiliary Project. Since most of the area which is not project land is desert and relatively uninhabited, nearly all of these people are considered to reside in the small towns or on farms within the boundaries of these projects.

The Wellton-Mohawk Division, Gila Project, begins about 10 miles east of Yuma, at the Wellton-Mohawk Canal headworks, and extends roughly 50 miles east to Texas Hill, following the course of the Gila River. Except for some very small towns with nominal populations further east from Texas Hill, along the river, the majority of people within the Census Bureau's Wellton Division reside on the farms and in the small towns of the Wellton-Mohawk Division. The population of this County Division decreased 21 percent in the 1960's, and stood at 3,618 in 1970.

Characteristics of the Yuma area population by race, sex, and age show that approximately 94 percent of the people (48,142) are Caucasoid; 3 percent (1,722) are Negro; and the remaining 3 percent are comprised of American Indian, Japanese, Chinese, Filipino, and all other races. Fifty-two percent (26,490) of the area's inhabitants are male, and 48 percent (24,758) are female. The median age in the area is 23.6 years, with 40.6 percent of the people under 18 years of age and 6.7 percent over 65.

Spanish-speaking people constitute a significant Yuma area community. Those who speak the language as their native tongue account for 25 percent (7,168) of the metropolitan Yuma population. Additional Spanish-speaking people reside on the surrounding agricultural,projects, and a sizable number of Mexican migrant farm workers seasonally occupy the area. Further communities of note are the Cocopah Tribe of Indians, who retain three small reservations in the vicinity of Yuma; a large number of government employees, both civilian and military; and an extensive number of tourists, estimated to be as great as 10,000 people at the height of the season.

B.2. Economy

The economic characteristics of the project area within Yuma County are not readily discernible. Available data exist only for the entire county, which is roughly three to four times larger than the project area within it. However, data do indicate that approximately 83 percent of the county's inhabitants reside within this smaller area where the project features will be located; in addition, 66 percent of the county's farmland, the foundation of its economy, is also located there. Project area economy, then, is the principal constituent of county economy, and a presentation of data for the latter is a relatively accurate description of the former's economy.

The civilian labor force in Yuma County averaged 24,800 in 1974, of which 23,150 were employed; unemployment was 6.7 percent. Major employment occupations in the area include agriculture, public administration, retail trade, education, construction, and manufacturing. Agriculture, while not a leader in employment, is the base of the county's economy and, in 1974, marketed $224,494,000 worth of crops and livestock. Federal expenditures in the county, which implement agriculture through Bureau of Reclamation work, but also include the area's two military installations and all other Federal agencies, totalled $117,407,000 in 1974. Business establishments, enumerated by industry below, also account for a substantial portion of the county's economy. Retail sales volume alone totalled $233,432,000 in 1974.

YUMA COUNTY BUSINESS ESTABLISHMENTS BY INDUSTRY

Industry	No.	Industry	No.
Agriculture and Forestry	33	Wholesale Trade	65
Mining	3	Retail Trade	431
Contract Construction	90	Finance, Insurance, and Real Estate	76
Manufacturing	33	Services	335
Transportation and Utilities	46	Unclassified	16

B.3.. Transportation

Two major highways traverse the project area: Interstate 8 passes through from east to west, and U.S. 95 from north to south. These highways intersect in Yuma. All other roads in the area are small state and county roads, or city streets. A number of major interstate trucking companies and bus lines serve the area. Passenger and freight rail service is provided by a transcontinental line of the Southern Pacific Company. Further transportation facilities are available through the Yuma International Airport, in conjunction with the Marine Corps Air Station, where the largest civilian and military aircraft can be accommodated.

B.4. Utilities

Electric energy is provided in the project area by private, public, Federal, and non-Federal sources operating in the southwestern United States. The supply is generated by nuclear, thermoelectric, and hydroelectric units, but fossil-fuel generation is predominant. At present, the supply of electric energy is low, due primarily to delays in construction caused by environmental considerations and difficulties in securing fossil-fuel supplies. Low-efficiency combustion turbine generating capacity has been installed to meet the area load and reserve requirements. Combined cycle, conventional fossil fuel, and nuclear powerplants are being installed or are in the planning stage.

Natural gas supplies are critical and new customers are not being accepted by Arizona Public Service Company. The Yucca Powerplant normally used natural gas but its allocation was terminated and oil is being used in its place.

Water requirements in the area are provided either by Colorado River diversions or private wells. The City of Yuma has some private wells, and two contracts with the Bureau of Reclamation for over 50,000 acre-feet per year of Colorado River water to be delivered through structures of the irrigation projects. The city's present treatment plant capacity is 15 Mgal/d and average consumption is 11.5 Mgal/d. Gross revenue of all utilities in Yuma County totalled $19,190,000 in 1974.

III. NEEDS

Water quantity and quality are the principal needs under consideration in the project area. The aridity of the environment necessitates the controlled use of water for agricultural purposes, and the effective use of water for such a need is dependent upon its quality; inversely, water quality can be directly affected by drainage return flows from the agricultural areas.

A. Agricultural Water Requirements

A.1. Water Quantity Need

Diversions to the Wellton-Mohawk Division are not determined by any requirement for specific quantities of water, rather they are limited by the *Gila Project Reauthorization Act* of July 30, 1947, (61 Stat. 628) which stipulates that the Division's beneficial consumptive use of water from the Colorado River (that amount of water diverted less return flows) shall not exceed 300,000 acre-feet annually; in recent years diversions for the Division have been the maximum allowable under project authorization.

Irrigation diversions to the Wellton-Mohawk Division are sufficient to meet the needs of its present agricultural production; however, in order to meet the diversion requirements of the overall project area it is necessary that utilization of available water be made in the most efficient manner possible. Return flows from all agricultural areas are very important as they supplement the river's volume for irrigation diversions further downstream. The inability to use the drainage as return flow to the river system, as is presently the case with the Wellton-Mohawk drainage, places a burden on the river's ability to fulfill water demands.

In the Mexicali Valley, water for irrigation of the land west of the Colorado River is diverted at Morelos Dam, a mile below the Northerly International Boundary, and conveyed through the Alamo Canal and its branches. Waste and drainage water from the Valley Division, Yuma Project, is taken across the Southerly International Boundary at San Luis into a canal system which serves land in Sonora, east of the Colorado River.

Mexico has developed a well field on the Sonora Mesa just south of the Southerly International Boundary, east of San Luis. The well field has an existing capacity of 160,000 acre-feet per year with a canal system capacity of 320,000 acre-feet per year. Water pumped from this source is conveyed to the valley in Mexico by means of a 750 ft^3/s concrete-lined canal and lateral system. Table 1 shows the quantities pumped since 1972.

Substantial quantities of wastewater from the Alamo Canal, and drainage and domestic sewage from Mexicali Valley reenter the United States in the channel of the New and Alamo Rivers. Some drainage has been provided in the valley. However, the soils are generally tight and the salts from the irrigation water have accumulated in the soils to the extent that serious problems of soil salinity exist in many parts of the valley.

A rehabilitation program for the Mexicali Valley irrigation and drainage system was initiated in June 1969, and continues to date. It was reported that as of November 30, 1972, about 221 miles of canals had been lined, about 283 miles of drains had been constructed or rehabilitated, 63 wells (all replacement wells) had been installed, and 119 wells had been reconditioned and repaired.

A.2. Water Quality Need

Water quality of the Colorado River varies at Imperial Dam, depending on the quantity of flows arriving there. Between 1941 and 1972, yearly flows varied from a low of 5,615,000 acre-feet to a high of 14,714,000 acre-feet and the salinity level ranged from 649 p/m to 918 p/m. Yearly trends indicate that flows are continually diminishing due to increased consumptive use throughout the river basin and, since 1964, flows arriving at Imperial Dam have consistently been below 6,000,000 acre-feet on a yearly average. Salinity levels, as a consequence, are rising as the river progresses downstream. Imperial Dam salinity averaged 835 p/m in 1974, and current studies project that an annual average of 950 p/m could be reached by 1993.

The need for water of an acceptable quality is inherent to the inception of the Desalting Complex Unit. Mexico has maintained in the past that the poor quality of water the United States delivered under Treaty obligation caused extensive damage to crops in the Mexicali Valley. Indeed, the quality of water used for irrigation purposes is directly related to crop yields. A reduction in the water requirement for leaching, lower fertilizer and drainage costs, and improved soil conditions are benefits that are also attributable to improved water quality.

TABLE 1
WATER PUMPED FROM THE SONORA MESA WELL FIELD
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Unit: Acre-Feet

	1972	1973	1974	1975
January		52	1,376	17,048
February		2,366	3,844	8,944
March		1,845	9,383	13,425
April		12,146	13,649	5,932
May		13,233	13,484	12,717
June		10,682	11,947	9,133
July		13,436	15,544	10,441
August		8,041	15,376	9,622
September		9,489	14,406	2,582
October		8,440	11,846	78
November		7,437	8,085	3,206
December	1,437	0	9,006	13,100
Total	1,437	87,167	127,946	106,228

Note: Monthly quantities converted from metric quantities.

A.2.a. Salinity Tolerance of Crops

Each crop has salt tolerance levels within which a range of productivity may be anticipated. The United States Department of Agriculture publishes Agricultural Information Bulletins which list levels of soil salinity for most crops. These data show that most high value fruit and vegetables require low soil salinity. Conversely, only a few crops can tolerate high salinity and these are generally of low value.

A.2.b. Crop Yields

Increased crop yields are a benefit from using good quality water. Such benefits are measurable and identifiable under conditions where identical salt-sensitive crops are grown with both poor and good quality water, and with similiar deep percolation losses. Under such conditions, yields are higher with the good quality water and benefits are measured as the difference in net income between the two methods.

A.2.c. Water Requirements for Leaching

Total water requirements for irrigation include consumptive use, distribution losses, surface runoff, unavoidable deep percolation, and leaching requirements. With good quality water, the leaching requirement may be zero to 30 or 40 percent of the total water application. However, as the salinity of water increases, substantially larger amounts of water must be percolated through the soil to maintain a desirable salt level. If adequate water is not used for leaching, excessive soil salinity will develop.

A.2.d. Fertilizer and Drainage Costs

Reduced fertilizer and drainage costs are potential types of benefits from using good quality water over poor quality water because as leaching requirements increase, more losses in fertilizers occur. Drainage construction and operation and maintenance costs are less for good quality water than those associated with poor quality water due to differences in leaching requirements. Reduction of these costs is a measurable savings and results in direct benefits for lands where drainage problems exist or are anticipated.

A.2.e. Soil Conditions

A soil's salinity and the salinity of irrigation water applied to that soil over a long period of time are closely related. Due to the effect of electrolytes, an excess of any type of monovalent or divalent ions will flocculate a soil. This results in an increase in permeability and explains why highly saline water will usually percolate rapidly through a soil. Conversely, when the electrolyte level of a soil is reduced substantially by leaching, and the sodium ion becomes dominant in the soil solution, there tends to be a decrease in permeability. Accordingly, the leaching of a saline soil with a low salinity water may cause a relative increase of the sodium ion to the calcium ion, thereby causing an unfavorable physical condition to result. However, if the soil has an adequate supply of soluble calcium, or if the water has a favorable calcium-sodium ratio, leaching can be done without any serious soil deterioration. The physical properties of low salinity soils are generally better than for saline soils, and improved soil conditions generally result in improved yields.

B. Commitments to the Republic of Mexico

Minute No. 242 of the International Boundary and Water Commission establishes that Colorado River water delivered to Mexico at the Northerly International Boundary must have a salinity no greater than 115 p/m $\pm$30 p/m over the salinity of water which arrives at Imperial Dam. The increase in salinity below Imperial Dam, which necessitates the differential, is a result of saline inflows to the river which average approximately 250,000 acre-feet per year at about 1,578 p/m. These flows include the pumped waters from the Yuma Mesa wells, the South Gila drains, and all of the other measured and unmeasured return flows above the Northerly International Boundary. The effect of including Wellton-Mohawk drainage as part of the water delivered to Mexico, the effect of not including it as part of such water, and the effect of desalting it are all shown on Table 2. This comparison is based on the following 1981 conditions:

1. Delivery of water to the Northerly International Boundary will be 1,360,000 acre-feet.

2. Diffuse flows will be 250,000 acre-feet at 1,578 p/m.

3. Flows leaving Imperial Dam will be the difference between the 1,360,000 acre-feet at the Northerly International boundary and the other identified flows.

It is apparent from Table 2 that drainage from the Wellton-Mohawk Division, which has recently ranged between 210,000 and 220,000 acre-feet annually with a salinity of over 3,700 p/m, would increase the salinity of the river far above what is allowable under the provisions of *Minute No. 242.* The desalting plant will treat the majority of the Wellton-Mohawk drainage, thereby reclaiming about 123,700 acre-feet of water per year that is presently being bypassed and, therefore, lost for further use.

TABLE 2
WELLTON-MOHAWK DIVISION DRAINAGE AND ITS EFFECT ON THE COLORADO RIVER WITH AND WITHOUT THE YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Flows	1,000 Acre-Feet	p/m	1,000 Tons
Colorado River Constituents Excluding Wellton-Mohawk Drainage			
Flow arriving at Imperial Dam	6,220	835	7,063
Flow leaving Imperial Dam	1,110	830	1,253
Diffuse Flows	250	1,578	536
Delivery to the NIB	1,360	967	1,789
Salinity differential		132	
Colorado River Constituents Including Wellton-Mohawk Drainage			
Flow arriving at Imperial Dam	6,014	845	
Flow leaving Imperial Dam	904	840	997
Diffuse flows	250	1,578	536
Wellton-Mohawk drainage	206	3,760	1,053
Delivery to the NIB	1,360	1,418	2,622
Salinity differential		573	
Colorado River Constituents Including Desalted Wellton-Mohawk Drainage			
Flow arriving at Imperial Dam	5,640	865	
Flow leaving Imperial Dam	988	845	1,135
Diffuse flows	250	1,578	536
Desalting plant product plus blend flow	122	857	142
Delivery to the NIB	1,360	980	1,813
Salinity differential		115	

IV. WELLTON-MOHAWK DIVISION LANDS

The lands comprising the Wellton-Mohawk Division are located in the southwestern corner of Arizona, in Yuma County, along a 54-mile length of the lower Gila River. They extend roughly from the McPhaul Bridge on U.S. Highway 95 at the western end of the area to Texas Hill at the eastern end. The southern boundary follows the 376-foot contour on the mesa between the Gila and Mohawk Mountains, while the northern boundary largely corresponds to the northern edge of the valley lands.

A. Topography

In the Wellton-Mohawk Division, the Gila Valley varies from 2 to 6 miles in width and is separated from the mesa to the south by a relatively well-defined escarpment some 40 to 75 feet in height. To the west of Wellton the escarpment is replaced by rough hills, and in places it is hard to distinguish between the alluvial flood plain and the mesa terraces. The valley is separated from the mesa lands to the north by a more or less continuous band of small gravelly hills intersected by many washes.

The bottom lands are highly developed for irrigation as a result of their favorable topography, except where the course of the river has meandered and floods have made cuts and formed benches. In other areas of the valley, the storm drainage from the adjacent mesa terrace lands has cut small channels and gullies. Some of these natural drainageways are utilized in removing natural runoff to the river. Areas which were rather uniformly covered with 6- to 8-foot mounds of silt loam and sand loam, and gullied areas, have been leveled resulting in good quality farmlands.

The fairly uniform topography of the mesa lands is broken by Antelope Hill, an arkosic sandstone remnant about 4 miles northwest of Tacna, rising 700 feet above the surrounding mesa, and a smaller hill 1-1/2 miles to the west rising 150 feet above the mesa. Otherwise, the mesa lands consist of rather large areas sloping in the same plane, with a uniform gradient to the north-northwest of 10 to 50 feet to the mile, broken only by scattered sand dunes and occasional washes that cross the mesa in a general south-to-north direction. As these small washes or drainageways approach the edge of the mesa, they combine to form rather deep washes that empty onto the valley.

The topography of the nonarable mesa lands consists of sand dunes, rough lands separating the mesa and valley, gravelly hills along the northern edge of the valley, and a few areas of relatively smooth, coarse, sandy lands.

B. Soils

The materials from which the mesa soils have been formed were laid down chiefly during the floods of the Pleistocene epoch. As the flow of the Gila River diminished toward the end of the epoch, the stream gradually eroded a deeper channel into the sedimentary deposits, forming the present Gila River Valley. In the ensuing years, the river meandered a great deal and laid down alternate layers of silts, clays, and sands. The present valley soils were formed from these often highly stratified deposits.

B.1. Valley Soils

In the valley along both sides of the Gila River, bottom land soils have been formed from the alluvial deposits of sands, silts, and clays from various sources. The soil materials are often stratified and platy and have had noticeable quantities of organic matter added through heavy vegetative growth. The resulting soil colors vary from a light grayish-brown to a dark grayish-brown. The arable soils of the bottom land have a relatively high moisture-holding capacity on account of the predominance of silt. Textures range from coarse sand to clay loam, but the most common textures are silt and silt loam. Base exchange capacities range from 10 to over 40 milliequivalents per 100 grams of soil. The organic content and inherent fertility of these soils are noticeably higher than the mesa soils. The soils are permeable to moderately permeable except in a few cases near the base of the escarpment where heavy textures and a high exchangeable-sodium-percentage condition have caused deflocculation.

B.2. Mesa Soils

In general, the arable mesa lands are composed of loamy sand and sandy loam soils that are rather low in native fertility, have a low organic matter content, possess a base exchange capacity ranging from 4.0 milliequivalents per 100 grams of soil to as high as 20 milliequivalents, and have a water-holding capacity that varies from 3 to over 6 inches of plant available water per 4-foot profile. Colors of mesa soils vary from a light pinkish-brown to a deep brown. Only a slight profile development has taken place, as evidenced by a limited downward movement of lime and clay. In the native state, it was not unusual for the total salts and/or pH to be relatively high. The mesa lands generally are inferior to the valley lands of this area for irrigated agricultural use.

C. Land Classification and Productivity

In late 1940, Bureau of Reclamation representatives met with staff members of the University of California, College of Agriculture, in Berkeley, California, to discuss the development and settlement problems that might be encountered on the Gila Project in Arizona and the All-American Canal system in California.

Following the Berkeley conference and a study of the problems in the field, the Bureau representatives prepared a memorandum for the Commissioner in which it was emphasized that a detailed and systematic land classification was an indispensable first step in determining the fitness of the lands for settlement and agricultural utility, and that such a classification should be undertaken at an early date by the Bureau. They also recommended that standards of classification be set up with great care and subject to the approval of an expert board of review.

Through correspondence between the Commissioner and Chief Engineer, a board of review was selected. It was decided to transfer land classification personnel from northern locations about December 1, 1940, for work on the Gila Project.

Land classification standards for the area were established by the Bureau and reviewed by the Advisory Committee, previously called the Board of Review, when it had its first meeting in Yuma, Arizona, on March 19, 1941. A representative of the State of Arizona accompanied the Committee over the Wellton-Mohawk area. After a field examination of the area, the Committee approved the methods, procedures, and standards as outlined by the Bureau and, in the Committee's report to the Commissioner, made the suggestion that particular attention be paid to the following details in the Wellton-Mohawk unit:

> ... (a) soil textures as they may affect moisture penetration and loss of water, and (b) microrelief as it may affect the cost of leveling and farming operations and management, including the use of fertilizers, etc.

C.1. Land Classification - 1941

The classification of 108,000 acres located below the 345-foot contour in the Wellton-Mohawk Division was completed within the period January 24 to April 26, 1941, except for an area of approximately 13,000 acres that was inundated and inaccessible because of floods on the Gila River. The object of this classification was to determine the extent and character of the land suitable for development under irrigation. The factors considered were soil characteristics, topography, and drainage conditions as shown by the standards on Table 3.

The lands were separated into areas regarded as arable and nonarable. The arable lands were further separated into: (1) Class 1 lands, which were considered highly productive and desirable in every respect for a permanent irrigated agriculture, and (2) Class 2 lands, which were considered of intermediate character, suitable for development, but of somewhat limited productivity attributable to a deficiency in one or more of the factors considered. The lands designated as Class 6, or nonarable, were either too low in production capacity or could be developed and maintained in a productive state only at such great expense that the returns would be insufficient to provide a living for a farm family and repay project construction costs.

Classification was projected on topographic base maps having a scale of 400 feet to the inch and showing contour intervals of 1 or 5 feet. The lands were traversed in sufficient detail to determine the character of each 40-acre tract. Examination of soil profiles was made to a depth of 4 feet at each 16th corner, and soil samples were taken for salinity and alkalinity determinations. Where soil texture was considered the limiting factor, the samples were subjected to mechanical analyses. The results of the classification showed that 62,100 acres were considered arable. Of this area, 37,780 acres were classified as Class 1, and 24,320 acres as Class 2 land. A preliminary draft of a report was prepared for project use.

C.2. Land Classification - 1947

In June 1946, the Lower Colorado River District Manager, in a letter to the Regional Director, requested that lands above the 340-foot contour and up to the 376-foot contour on the Wellton Mesa be classified, and that the Wellton Mesa lands below the

TABLE 3 1/

TENTATIVE LAND CLASSIFICATION STANDARDS, GILA PROJECT, ARIZONA - 1941

Colorado River Basin Salinity Control Project

Title I Division, Desalting Complex Unit, Arizona

Land Characteristics	Class 1-arable	Class 2-arable
Soils		
Texture	Loamy sand to friable clay loam	fine sand to friable clay
Depth 2/		
To sand, gravel, or cobble	24-30 in. plus free working soil	18-24 in. plus good free working soil
To relatively impervious subsoil material	48-in. plus	36 in. plus
To penetrable lime zone	18 in. with 48 in. penetrable	14 in. with 36 in. penetrable
Alkalinity	pH less than 9.0 in surface 3 ft. Higher pH permissible in section of soil profile below 3 ft. if highly calcareous and total salts are low	pH 9.0 or less in surface 2 ft. Higher pH permissible in section of soil profile below 2 ft. if highly calcareous and total salts are low
Salinity	Total salts not to exceed 0.2% except in open permeable soils that will permit ready leaching of neutral salts	Total salts not to exceed 0.5% except in open permeable soils that will permit ready leaching of neutral salts
Rock and rocky soil	No solid rock or loose rock that will interfere with ordinary cultivation	No rock in place. Easily removable loose rock limited to that generally cleared in similar communities where irrigation is practiced.
Topography		
Slopes	Smooth slopes up to 3% in general gradient; reasonably large sized bodies sloping in the same plane	Smooth general slopes of 5% or rougher slopes which may be less than 3% in general gradient.
Surface	Even enough to require only small amount of leveling and no heavy grading.	May require considerable leveling and moderate grading, but in amounts generally found feasible in like areas where irrigation is practiced.
Drainage	Soil and topographic conditions such that no specific drainage requirements are anticipated	Soil and topographic conditions such that some drainage will probably be required, but artificial drainage practicable at reasonable cost

1/ Extracted from "Land Classification Report, Wellton-Mohawk Division, Gila Project, Arizona, Revised March 1952," Table 1.

2/ At the lower range of minimum depths, the texture must be a good grade loamy sand or heavier with some fine material mixed with the coarse sand or gravel. A poor grade loamy sand or fine sand underlaid by coarse sand or gravel should be 24-30 in. deep (depending on the percent of silt and clay) to qualify for Class 2.

340-foot contour be reclassified, using recently developed laboratory procedures for control and correlation of fieldwork, especially with reference to moisture-holding capacity. Authority for the work was given in August 1946. In view of the high potential construction costs in the Wellton-Mohawk Division, it was further requested that the 1941 classification of the valley lands be refined, or the area reclassified to the extent of determining the character of the lands in each 10-acre tract. This information was desired especially for planning a distribution system and location of farm turnouts.

C.2.a. Standards and Specifications

Standards and specifications used in this classification to designate the minimum requirements for each land class are presented in Table 4. Several additions, omissions, and slight changes were made in the standards prescribed by official Reclamation Instructions, Volume 5, Irrigated Land Use, Part 2, Land Classification. In all cases, the changes were made to give additional information and to make the standards more applicable to the specific area. Additions were made only after careful correlation of field and laboratory data on areas actually under irrigation, and the comparison of these data with the results of recent soil research by the United States Department of Agriculture, Regional Salinity Laboratory, Riverside, California, and at the Universities of Arizona and California.

As an example, Table 4 expresses salinity both in terms of percent total salts, as in the Manual, and in terms of conductivity of the saturation extract. Measuring the conductivity of saturation extracts is now considered to be a more realistic way of appraising soil salinity and its expected relation to crop response and growth.

C.2.b. Arable Land Classes and Subclasses

The Bureau of Reclamation land classification system subdivides lands into six classes on the basis of the degree of suitability for irrigated farming. Classes 1, 2, and 3 are described as "arable," that is, susceptible of development for irrigated farming. Class 6 is used to designate nonarable lands. Class 4 is used to designate lands which are not definitely arable or nonarable (Class 5 has not been used in this classification); lands which have an excessive, specific deficiency in one factor that is susceptible of correction, such as areas of high salinity and alkalinity.

TABLE 4 1/
LAND CLASSIFICATION MINIMUM STANDARDS
WELLTON-MOHAWK AND NORTH AND SOUTH GILA DIVISIONS
GILA PROJECT, ARIZONA 1947-48
Colorado River Basin SalinityControl Project
Title I Division, Desalting Complex Unit, Arizona

Land Characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable 2/	Class 4 Limited Arable 7/
Texture (average)	Sandy loam or heavier	Loamy sand or heavier	Loamy sand, fine sand and some sands	Loamy sand or heavier
Water-holding capacity-plant available water in upper 4 ft	Over 5.8 inches	Over 3.2 inches	Over 2.5 inches	Over 3.2 inches
Depth to clean sand or gravel 3/	36 inches or more	24 inches or more	18 inches or more	24 inches or more
Depth to shale or sandstone 4/	60 inches or more	48 inches or more	42 inches or more	48 inches or more
Alkalinity (on soil paste)	pH 9.0 or less	pH 9.0 or less	pH 9.0 or less	pH 9.0 or less
Salinity				
Total salts	0.2 percent 6/	0.5 percent 6/	0.5 percent 6/	Usually over 0.5 percent
Conductivity saturation extract	4 millimhos/cm or less 6/	8 millimhos/cm or less 6/	15 millimhos/cm or less 6/	Over 15 millimhos/cm
Permeability (P=QL/TAH) 5/	.3 inches/hr or more	.2 inches/hr or more	.2 inches/hr or more	.3 inches/hr or more
Base exchange capacity	Over 8 meq/100 gm soil	Over 6 meq/100 gm soil	Over 4 meq/100 gm soil	Over 6 meq/100 gm soil
TOPOGRAPHY				
Slopes	Smooth general slopes up to 2 percent	Smooth general slopes up to 3 percent; rough slopes less than 3 percent in general gradient	Smooth general slopes up to 5 percent; rough slopes less than 3 percent in general gradient	Smooth general slopes to 3 percent; rough slopes less than 3 percent in general gradient
Surface	Require only small amount of leveling	Require moderate amount of leveling	Require large amounts of leveling but within amounts found feasible in the area	Require moderate amounts of leveling
Cover (rocks)	Insufficient to affect culture or clearing costs	Sufficient to reduce productivity, clearing required but feasible at low cost	Will require expensive, but feasible clearing	Sufficient to reduce productivity, clearing required, but feasible at low cost
DRAINAGE				
Soil and topography	Such that no specific farm drainage requirements are anticipated	Some farm drainage may be required, but is feasible at low cost	Significant farm drainage required, expensive but is feasible	Some farm drainage may be required, but is feasible at low cost

CLASS 6 - NONARABLE

Lands which do not meet the minimum requirements for Class 3 or 4 and are not suited for continuous agricultural production.

1/ Extracted from "Land Classification Report, Wellton-Mohawk Division, Gila Project, Arizona, Revised March 1952," Table 2.
2/ A marginal class, preferably irrigable only in conjunction with lands of better quality.
3/ Required depths may be slightly more or less than those given, depending on the quality of the soil material.
4/ May be 6 inches less, providing 6 inches of gravel overlays impervious material.
5/ Minimum for any significant soil horizon in upper four feet.
6/ For lands under irrigation. Virgin lands may be higher if the permeability is high and the exchangeable sodium-gypsum ratio is favorable.
7/ Would be equivalent to Class 1 or Class 2 in productive capacity and use after reclamation and correction of saline condition.

The deficiency that caused the land to be graded below Class 1 was indicated by a letter following the land class. A soil deficiency was indicated by the letter "s", a topography deficiency was indicated by the letter "t", and a drainage deficiency by the letter "d". In addition to these, the letter "A" was used after the Classes 4s and 4st lands to indicate an alkaline or saline condition.

C.2.b.(1) Class 1 Lands

These lands represented 14.8 percent of the total area classified, and 23.9 percent (21,977 acres) of the valley lands. There were no Class 1 lands mapped on the mesa. This was due to a number of factors, the major one being that the majority of mesa soils were either too sandy or too shallow to meet Class 1 specifications.

The valley lands had smooth and gentle slopes, most below 1 percent. The typical soil was a silt loam underlain by fine sand at 4 to 8 feet. Some areas were characterized by a rather high concentration of soluble salts in the soil, but there was usually no associated drainage problem.

C.2.b.(2) Class 2 Lands

These lands comprised 34 percent (50,510 acres) of the total area classified; 26,896 acres on the mesa and 23,614 acres in the valley.

On the mesa, 23,083 acres of the land were mapped as Subclass 2s. These were lands of favorable slope with relatively coarse textured soils. The typical soils were loamy sands which became slightly finer textured with depth. Rough topography or a combination of topographic deficiencies and lack of depth caused 3,813 acres of additional mesa lands to be placed in Subclasses 2t and 2st.

In the valley, 2,076 acres were classed as 2s. Characteristically, they usually had silt loam in the first 2 feet underlain by clean, fine sand or loamy sand. Here it was the lack of soil depth which reduced the land to Class 2. Some 18,588 acres of hummocky or dissected valley lands, despite their excellent soil, were graded down on topography to Subclass 2t. It should be noted that topographic deficiencies encountered in this classification were, almost universally, deficiencies of microrelief and seldom degree of slope. Approximately 20 percent of the valley lands were classed as 2t. Nearly 2,950 acres of valley lands were downgraded to Class 2 due to various deficiency combinations of soil, topography, and drainage.

C.2.b.(3) Class 3 Lands

These lands consisted of 9.2 percent (13,608 acres) of the total area; 6,479 acres on the mesa and 7,129 acres in the valley.

The typical Subclass 3s soil profile on the mesa was loamy sand to fine sand, underlain by sand at 2 to 3 feet. The mesa 3st land was usually hummocky and windblown; that is, a 2s soil combined with a 2t topography.

The valley 3s areas were usually characterized by shallow soils, 18 to 24 inches of silt loam over coarse sand. Near the bed of the Gila River there were about 4,650 acres of 3st. This was hummocky or dissected land with only medium depth soils. Some of the valley 3st was considerably wind worked to form small dunes of loamy fine sand, and had vegetation similar to that of the mesa. In addition, 1,507 acres of 3t lands were mapped in the valley. These were chiefly lands with deep silt loam soils that had been deeply dissected with washes. In large areas near Growler, they included mesquite covered mounds made up of fine sandy loam and silt loam material.

C.2.b.(4) Class 4 Lands

These lands comprised 11.8 percent (17,586 acres) of the entire area. Lands were placed in this classification due to factors of salinity or alkalinity. In general, Class 4 was used to identify areas in which the salt content was more than 1.0 percent and/or the pH was more than 9.0.

The two subclasses, 4sA and 4stA, represented differences of topography. The 9,986 acres of 4sA lands had favorable, even slopes, while the 4stA areas, comprising 7,600 acres, were dissected by stream channels or had scattered silt loam mounds. The two subclasses were kept separate on the map and acreage summary, as the 4stA lands would have been the more expensive to develop and, therefore, had a slightly lower payment capacity.

C.2.b.(5) Class 6 Lands

Lands in this class comprised 30.2 percent (44,911 acres) of the total area. Subclasses 6s, 6st, and 6std were the principal Class 6 areas delineated within the project's boundary. In Subclass 6s, coarse soil texture and low soil moisture holding capacity were instrumental in keeping the land out of an arable class. Subclass 6s lands had gravels or sands of various grades of fineness, either at the surface or underlying the topsoil, at depths of less than 18 inches. Subclass 6st lands had either a 6s soil and unfavorable topography, or they were areas of only moderately deficient soil combined with very rough topography. The bed of the Gila River and all drainage channels of any appreciable size were designated as Subclass 6std. Small areas such as dykes, steep slopes between benches, and the steep banks of some drainageways were mapped as 6t.

C.2.c. Results of Classification

Approximately 69.8 percent (103,681 acres) of the area classified was found to be arable; 47.3 percent (70,306 acres) in the valley, and 22.5 percent (33,375 acres) on the mesa.

Eighty-one percent of the arable mesa lands were Class 2, and 19 percent were Class 3. The total mesa acreage consisted of 48 percent Class 2 lands, 11 percent Class 3 lands, and 41 percent classed as nonarable, including the rough lands between the mesa and the valley.

Twenty-three percent of the arable valley lands were Class 1, 26 percent were Class 2, 8 percent were Class 3, and 19 percent were Class 4. It was expected that 80 percent of the arable valley lands would have a productive capability equal to that of Class 1 lands after leaching and leveling.

V. WATER SUPPLY AND HYDROLOGY

A. Streamflow

A.1. Colorado River

The Colorado River meanders generally southwest from its source high in the northwest section of Colorado's Rocky Mountain National Park, 70 miles northwest of Denver, where the peaks rise over 14,000 feet (Map No. X-300-819). Its 1,400-mile course, draining an area of approximately 244,000 square miles, traverses geologic strata of all ages, from those of the Archean Age (the oldest known geologic period) to those of recent alluvial deposits, including igneous, sedimentary, and metamorphic types. Climatic conditions are extreme, ranging from year-round snow cover and heavy precipitation on the high peaks of the Rocky Mountains to desert conditions with very little rain in the southern part of the basin. The Green River, its major tributary, originates in western Wyoming and travels 730 river miles to its confluence with the Colorado River in southeastern Utah. Although the drainage area of the Green River is 70 percent larger than that of the Colorado River above their confluence, it produces only about three-fourths as much water. Other principal tributaries of the Colorado are the Gunnison, San Juan, Little Colorado, Virgin, and Gila Rivers. Recorded flows of the Colorado at Lees Ferry, Arizona, the administrative division between the Upper and Lower Basins, are shown on Table 5.

The flows of the Gunnison River are controlled by the Curecanti Unit Dams, those of the Green River by Fontenelle and Flaming Gorge Dams, and those of the San Juan by Navajo Dam. Glen Canyon Dam is the only major dam on the mainstream of the Colorado above Lees Ferry, yet it does permit control of almost all flows leaving the Upper Basin. There is no significant storage on the Colorado or its tributaries between Glen Canyon Dam and Lake Mead. The intervening tributary inflow is sporadic, but the long-time average annual flow is approximately the same as the evaporation from Lake Mead.

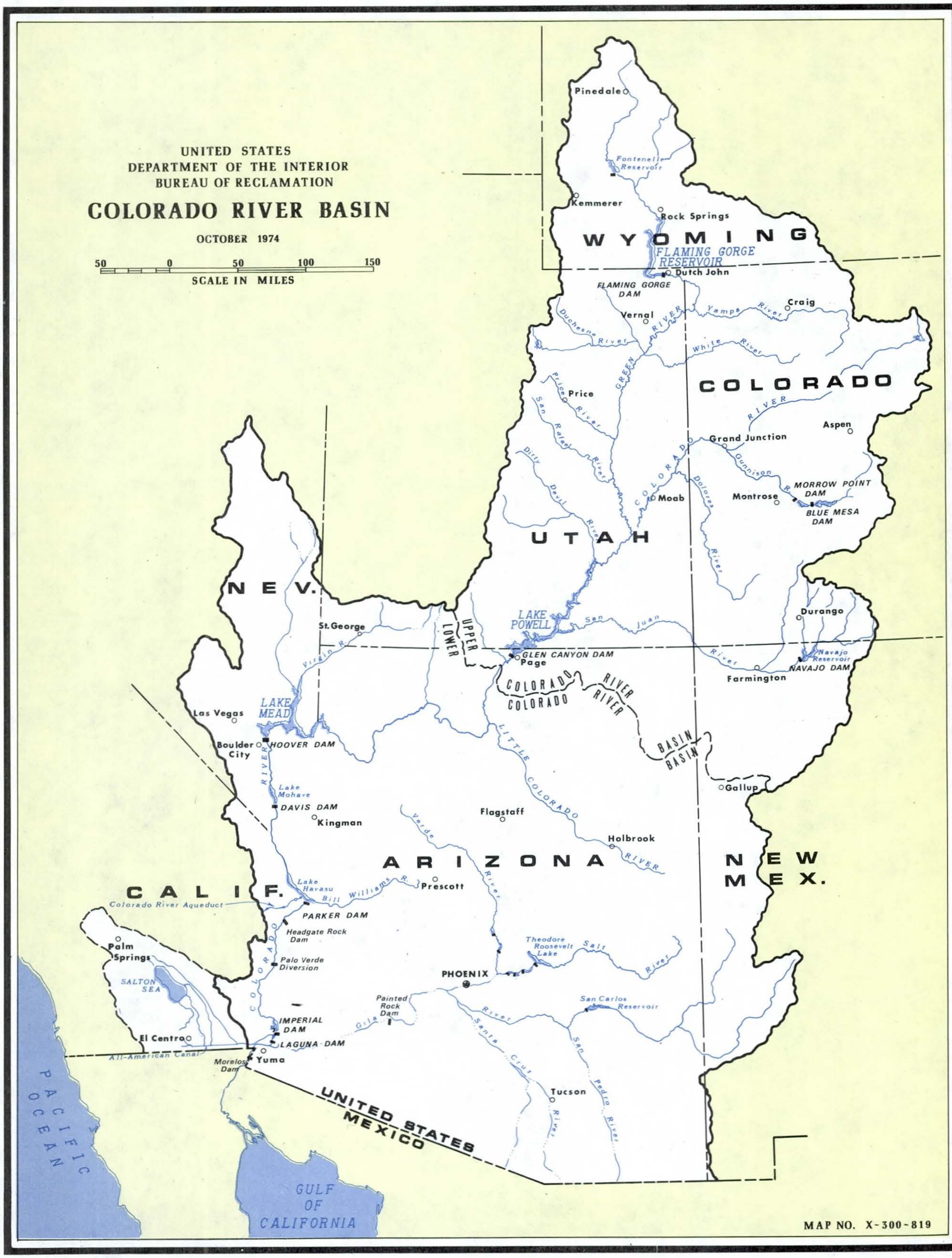
The Lower Basin's flow is mainly controlled by a series of storage and diversion dams, starting at Hoover Dam and ending at Imperial Dam.

TABLE 5
HISTORIC FLOWS OF THE COLORADO RIVER, 1914-1973 1/
LEES FERRY, ARIZONA
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Unit: 1,000 Acre-Feet

Water Year	Flow	Water Year	Flow	Water Year	Flow
1914	19,304	1934	4,377	1954	6,101
1915	12,486	1935	9,895	1955	7,290
1916	17,286	1936	11,935	1956	8,740
1917	21,859	1937	11,870	1957	17,320
1918	13,620	1938	15,414	1958	14,220
1919	10,842	1939	9,360	1959	6,742
1920	19,719	1940	7,055	1960	9,182
1921	20,691	1941	16,024	1961	6,643
1922	16,275	1942	17,010	1962	14,770
1923	16,237	1943	11,244	1963	2,500
1924	12,462	1944	13,202	1964	2,414
1925	11,312	1945	11,529	1965	10,820
1926	13,976	1946	8,722	1966	7,854
1927	16,541	1947	13,490	1967	7,798
1928	15,307	1948	13,670	1968	8,334
1929	19,188	1949	14,340	1969	8,823
1930	13,051	1950	11,040	1970	8,672
1931	6,376	1951	9,817	1971	8,591
1932	15,248	1952	17,960	1972	9,310
1933	9,729	1953	8,787	1973	10,109

1/ 1914-1973 from USGS Water Supply Papers, actual records began in June 1921.


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN
OCTOBER 1974
50 0 50 100 150
SCALE IN MILES
WYOMING
COLORADO
UTAH
NEV.
ARIZONA
CALIF.
NEW MEX.
UNITED STATES
MEXICO
PACIFIC OCEAN
GULF OF CALIFORNIA
Pinedale
Fontenelle Reservoir
Kemmerer
Rock Springs
FLAMING GORGE RESERVOIR
Dutch John
FLAMING GORGE DAM
Vernal
Craig
Yampa River
Duchesne River
GREEN RIVER
White River
Price
Price River
San Rafael River
Dirty Devil River
COLORADO RIVER
Aspen
Grand Junction
Gunnison R.
MORROW POINT DAM
BLUE MESA DAM
Montrose
Moab
Dolores River
Durango
LAKE POWELL
San Juan River
GLEN CANYON DAM
Page
Navajo Reservoir
NAVAJO DAM
Farmington
UPPER
LOWER
COLORADO RIVER BASIN
St. George
Virgin R.
LAKE MEAD
Las Vegas
Boulder City
HOOVER DAM
Lake Mohave
DAVIS DAM
Kingman
LITTLE COLORADO RIVER
Gallup
Flagstaff
Holbrook
Verde River
Prescott
Lake Havasu
Bill Williams R.
Colorado River Aqueduct
PARKER DAM
Headgate Rock Dam
Palo Verde Diversion
Palm Springs
SALTON SEA
Theodore Roosevelt Lake
Salt River
PHOENIX
Painted Rock Dam
Gila River
San Carlos Reservoir
IMPERIAL DAM
LAGUNA DAM
El Centro
All-American Canal
Morelos Dam
Yuma
Santa Cruz River
San Pedro River
Tucson
MAP NO. X-300-819

Lake Mead, the reservoir behind Hoover Dam, provides most of the storage and regulation in the Lower Basin, with the water being stored... *First, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and satisfaction of present perfected rights in pursuance of Article VIII of said (sic) Colorado River compact; and third, for power ... (2)* Releases for power production alone have not been made since 1951.

Lake Mohave, formed by Davis Dam, backs up at high stages about 67 miles upstream to the tailrace of Hoover Dam Powerplant. Storage in Lake Mohave is used for some reregulation of releases from Hoover Dam, for the meeting of treaty requirements with Mexico, and for developing a power head for the production of electric energy at the Davis Powerplant.

Lake Havasu backs up behind Parker Dam for about 45 miles and covers about 25,000 acres. Lake Havasu serves as a forebay from which the Metropolitan Water District of Southern California pumps water into the Colorado River Aqueduct. Lake Havasu will also serve as the forebay for the Central Arizona Project Pumping Plant and Aqueduct. Lake Havasu and the Alamo Dam and Reservoir on the Bill Williams River, which enters the Colorado just above Parker Dam, are both used to control floods originating between Davis Dam and Parker Dam.

Headgate Rock Dam, Palo Verde Diversion Dam, and Imperial Dam all serve as diversion structures with practically no storage. Imperial Dam, located 150 miles below Parker Dam, is the major diversion structure for irrigation projects in the Imperial and Coachella Valleys of California and the Yuma, Arizona, area. Water is diverted to the All-American Canal on the west bank of the river for deliveries to the Yuma Project in both Arizona and California and to the Imperial and Coachella Valleys in California. Water is diverted on the east bank of the river to the Gila Gravity Main Canal for deliveries to the Gila Project (including the Wellton-Mohawk Division) in Arizona.

Senator Wash Dam, which closes off a huge arroyo beside the river, is used for reregulation of Colorado River water in the vicinity of Imperial Dam. This structure is instrumental in saving large quantities of water and provides extra regulation for the delivery of water to Mexico.

The water that is not diverted from Imperial Dam then flows in a southerly and westerly direction for about 20 miles to Mexico's Morelos Dam, located near Yuma, Arizona. Morelos Dam diverts the balance of the river's flow into the Mexicali Valley of Mexico for irrigation.

A.2. Gila River

The Gila River traverses an irregularly shaped basin of 58,200 square miles (57,900 square miles excluding all closed drainage basins) which extends from the continental divide in southwestern New Mexico to the Colorado River near Yuma, Arizona. It includes practically all the southern half of the State of Arizona and constitutes a region of widely varying topographical and climatological characteristics. The river is 654 miles long and rises in an area of high mountains and plateaus, and flows westward in a generally central course through the basin.

Most of the eastern section of the basin is extremely irregular and rugged with elevations ranging between 3000 and 10,000 feet. The southwest section of the basin consists largely of long desert valleys lying between north-south ranges of rugged mountains, and the elevations are generally lower. The southwest third of the basin consists essentially of broad, flat, low-lying desert valleys and isolated mountains of relatively low relief; the elevation near Yuma is about 130 feet.

The Gila River is now essentially a "dry" river in the lower valleys. Following the completion of the dams in Central Arizona's Salt River Project, and the Corps of Engineer's San Carlos Dam, it ceased to flow in the lower valleys except during local storms and unusually wet years in the upper watershed. Large flows in the "dry" river occurred in the Wellton-Mohawk area in 1941, 1951, 1966, and 1973.

Painted Rock Dam, constructed by the Corps of Engineers in 1959, protects the lower valley from floods. It is located 60 river miles upstream from the eastern edge of the Wellton-Mohawk Division. Floodwater was first impounded in 1966, and again in 1973. The dam is capable of impounding 2.5 million acre-feet of water but not without flooding developments within the reservoir. To protect these interests, the original operating criteria called for releases varying from 2,500 to 22,500 ft^3/s, depending on the water level in the reservoir. Releases so far have not destroyed irrigation works or other developments in the Wellton-Mohawk Division, except for road crossings, but infiltration to ground-water and resultant high-water tables have caused considerable crop damage and increased drainage costs.

The basin downstream from Painted Rock Dam covers about 7,300 square miles of gently rolling desert plains. The moderate slopes in the valleys along the lower Gila River have permitted the development of irrigation systems, primarily west of Texas Hill, located in the Wellton-Mohawk Division. Below Painted Rock Dam, the flood plain ranges from less than a mile to several miles in width and the river flow meanders over the generally flat bottom of a shallow channel about 1,000 to 3,000 feet wide, much of which is covered with a heavy growth of phreatophytes. The average gradient of the river between Painted Rock Dam and Texas Hill is about 3.3 feet per mile, and through the extensive irrigation developments downstream from Texas Hill, about 3.0 feet per mile. Infiltration into the sandy streambed is nearly 100 percent with flows up to about 250 ft^3/s between Painted Rock Dam and Texas Hill, and with flows up to about 3,000 ft^3/s downstream from Texas Hill.

A.3. Other Streams

In addition to smaller rivers, streams, creeks, and washes, many of which run only during periods of heavy local precipitation, the Colorado River also receives inflows from municipal, industrial, and agricultural drainage. Inflows from both municipal and industrial sources are minor, but agricultural returns throughout the basin are substantial.

B. Ground-Water Resources

The Colorado and Gila Rivers, under historic conditions, were the source of almost all ground-water recharge in the Yuma and Wellton-Mohawk areas. Later, with the construction of upstream reservoirs on both rivers and the development of local irrigation systems, the Colorado River alone became the principal source of recharge. Precipitation and local runoff are very minor sources of ground-water recharge.

B.1. Yuma Area

Most of the ground water in the upper part of the Yuma area ground-water reservoir is infiltrated river water. The more highly mineralized water of the lower part of the reservoir, in the older rocks, may include some connate water which has not been completely flushed out. Patterns of ground-water recharge have changed both in geologic time and in historic time, which indicate that the configuration of the water table and the chemical character of the ground water are in a state of flux.

Water level contours for 1925 indicated that the Colorado River, at that time, was a source of ground-water recharge during both low and high flows. The water table sloped away from the river channel so that a ground-water ridge was formed, and water moved away from the channel on both sides. Substantial quantities of ground-water recharge occurred during floods when most of the flood plain was covered with slow moving sheets of water.

Subsequent to the construction of Hoover Dam, Imperial Dam, and other upstream dams, the Colorado River channel was cut down to its present level, 10 to 20 feet below the adjacent flood plain, from Laguna Dam to the Southerly International Boundary. The lowered river channel now acts primarily as a drain rather than as a source of ground-water recharge. However, some recharge from the river still occurs during occasional high flows and along the various reaches where significant quantities of ground water are pumped from adjacent wells.

The principal aquifers of the Yuma area are the wedge zone and the coarse-gravel zone. Subordinate aquifers include the nonmarine sedimentary rocks, the conglomerate in the basal part of the Bouse formation, and a few relatively coarse-grained beds in the upper, fine-grained zone. Outside the river valley and apart from the Yuma Mesa, the older alluvium is regarded as an individual, single heterogeneous aquifer.

Transmissivity values of the wedge zone generally increase in a southwestward direction from near zero along the relatively thin east and north margin of the zone, to values of more than 500,000 gallons per day per horizontal foot (gal/d/ft) beyond a northwestward trending line 4 miles southwest of the Algodones Fault, where the zone is more than 2,000 feet thick. The wedge zone makes up the major part of the water-bearing deposits, which are of Pliocene to Holocene Age, beneath the river valleys and the Yuma Mesa. Except for two small areas, the water in the wedge zone is fresh.

Transmissivity values for the coarse-gravel zone range from zero to about 1,000,000 gal/d/ft. Maximum values of transmissivity for the coarse-gravel zone occur in the South Gila Valley, south of the confluence of the Colorado and Gila Rivers.

Transmissivities of more than 500,000 gal/d/ft occur beneath the west edge of Yuma Valley and southwestward from a line 3 to 5 miles southwest of the Algodones Fault, along the boundary between the southern Yuma Mesa and the Upper Mesa. The most permeable deposits in the Yuma area, and the ones that are tapped by nearly all of the producing wells, are the coarse-gravel strata in the upper part of the older alluvium. This has been recognized as the primary source of ground water pumped in the Yuma area.

B.2. Wellton-Mohawk Area

The flows on the river above the Wellton-Mohawk area have been controlled by Painted Rock Dam since 1960. The infiltration of Gila River floodflows into the Wellton-Mohawk area is of great concern since the water must be pumped from the aquifer to maintain ground-water levels. The 1966 flood caused 54,000 acre-feet of water to infiltrate the aquifer, and 57,000 acre-feet infiltrated during the 1973 flood.

The Wellton-Mohawk Aquifer consists of saturated, river-borne, unconsolidated sediments delineated into two zones on the basis of the texture of the sediment. The lower zone is predominantly gravel, and the upper zone is predominantly sand with silt and clay lenses and erratic occurrences of gravel lenses.

The upper or sandy zone is present throughout the entire Wellton-Mohawk aquifer. The sand is fairly well sorted and is, therefore, fairly permeable. The thickness of the sand zone ranges from 21 to 79 feet and averages about 50 feet. The individual lenses of clay and silt range in thickness from about 1 foot to about 44 feet. The clay lenses retard the vertical percolation of water in the aquifer locally, but since they are lenticular, this effect is not aquifer-wide.

The Wellton Mesa is a topographic feature south of, adjacent to, and about 70 feet above the Wellton-Mohawk Valley. The Mesa is underlain by predominantly fine-grained sediments, and since only small deposits of gravel occur erratically, semiperched water tables can be expected.

C. Hydrologic Systems in the Wellton-Mohawk Division

C.1. Canal and Lateral Losses and Waste

The losses in the Gila Gravity Main Canal between Imperial Dam and the bifurcation works at the Wellton-Mohawk Canal are about 3 percent of the amount diverted for the Division. The Wellton-Mohawk Irrigation and Drainage District initiated a program of independent water delivery measurements during the 1972 and 1973 irrigation seasons for the purpose of improving the accuracy of the water delivery charges to farmers. These measurements indicated an average farm overdelivery of 7.7 percent in three Zanjero districts in 1972, and an overdelivery of 5.35 percent in three other Zanjero districts in 1973. Water deliveries were adjusted on the basis of these measurements and canal and lateral losses were computed to be about 11 percent of the net supply, as shown in the following tabulation.

Adjusted Distribution System Efficiency

	Percentage of Net Supply			
	1970	1971	1972	1973
Reported Efficiencies	83.6	81.4	84.3	86.6
Adjusted	–	–	90.8	91.2
Difference	–	–	6.5	4.6

Average Difference (6.5 + 4.6) divided by 2 = 5.55%

Average Reported Efficiencies (83.6 + 81.4 + 84.3 + 86.6)
Divided by 4 = 83.98

Average Adjusted Efficiency 83.98 + 5.55 = 89.53

Canal and Lateral Losses Adjusted to 11 Percent of Net Supply

It was determined after a careful review of the operations of the distribution system that there is very little possibility, either through improved management or the addition of special facilities, to reduce canal and lateral losses and wastes below about 11 percent.

Physical features of the irrigation system have been maintained in a satisfactory condition, but the increasing age of the system and the need for more precise control of flows call for increased maintenance levels to eliminate any malfunctions that could affect the control of flows. The District takes the opportunity, during the short annual water outage on the Gila Gravity Main Canal, to inspect and repair structures and canal linings, as any lining that is broken causes large losses of water and creates further ground-water problems.

C.2. Consumptive Use

Consumptive use of water in the Wellton-Mohawk Division was calculated by using the Blaney-Criddle method and Technical Bulletin 169, *Consumptive Use of Water by Crops in Arizona,* of the Agricultural Experiment Station, University of Arizona. Table 6 shows the consumptive use values for the crops grown in the Division. Since the average frost-free period is 348 days, with short periods of lower nighttime temperatures, most crops do continue to grow and require some water all year long.

The total water consumed in the Wellton-Mohawk Division is dependent upon cropping patterns. For example, acreages of alfalfa have been increasing steadily from 13,790 acres in 1970 to over 22,730 acres in 1974. Since more alfalfa has been grown recently, the total consumptive use has increased, yet the return flow has remained nearly the same, with even a slight decrease in water pumped. Indications are that overall irrigation efficiencies vary significantly with the type of crop grown. However, return flow figures are not conclusive because of variations in ground-water levels, floodwater intrusion, and other hydrologic factors.

On the other hand, if acreages of alfalfa should decrease in the future in favor of crops that have a lower water use efficiency, such as lettuce, melons, and citrus, the recent decreasing trend in return flows would probably reverse unless the best possible management practices and potential system improvement methods were used.

C.3. Irrigation Efficiency

Present practices use gravity irrigation systems to apply water to the land. The onfarm systems are well developed and normally provide good control of the irrigation water. Essentially, all of the farm ditches are lined and most of the lands are well leveled. Improved irrigation efficiency will be dependent upon a more efficient irrigation application in conjunction with the correct amounts of water being applied at the proper soil moisture depletion levels.

Water budgets reflected onfarm irrigation efficiencies of 60 and 58 percent for 1973 and 1974, respectively. The significant Gila River flows during 1973 have required additional pumping to remove infiltrated floodwaters from the aquifer. Therefore, return flows will probably remain in the 200,000 to 220,000 acre-feet per year range for a number of years to restore the ground-water levels to pre-1973 conditions.

TABLE 6 1/
ANNUAL CONSUMPTIVE USE VALUES USED IN
WELLTON-MOHAWK MODEL STUDIES
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

	Acre-Feet/Acre Consumptive Use (Ft.)
Wheat (includes barley)	1.91
Sorghum	2.12
Alfalfa	6.19
Pasture	3.70
Corn Fodder	2.00
Cotton	3.43
Lettuce	.70
Cantaloupe (including honeydew)	1.60
Miscellaneous	2.00
Bermuda Grass Seed	3.27
Grapefruit	3.99
Lemons and Limes	4.20
Oranges and Tangerines	3.26
Phreatophytes	.48-4.91

1/ Extracted from *Preliminary Sizing Study, Yuma Desalting Plant, Arizona,* Special Report, July 1975; Table 11.

Note: Data based on *Consumptive Use of Water by Crops in Arizona,* Technical Bulletin 169, reprinted August 1968, Agricultural Experiment Station, University of Arizona.

C.4. Leaching Requirement

The leaching requirement is the fraction of water that must percolate through the soil, below the root zone, to prevent soil salinity from exceeding a specified value. Leaching requirements for most crops grown in the Division are taken care of by the application of enough irrigation water to obtain the desired consumptive use requirements. The minimum leaching requirement for each crop is based on its allowable root zone salt tolerance.

C.5. Nonbeneficial Consumptive Use

Irrigation water which is not utilized directly by crops and does not return to the river is said to be consumed nonbeneficially. The two main ways in which this can occur are by evaporation and, most prevalently, use by phreatophytes. Riparian vegetation grows along the irrigation canals, streams, lakes, and marshes in the Wellton-Mohawk area, and to a considerable extent utilizes the water therefrom. Characteristic species responsible include saltcedar, arrowweed, mesquite, cottonwood, catclaw, seepwillow, Gooding willow, Bermuda grass, saltgrass, cattail, bulrush, giant reed, and common reed.

D. Return Flow in the Main Outlet Drain

D.1. Historic Return Flows

The lands in the Wellton-Mohawk Division were originally supplied by Gila River diversions until the construction of dams on the upper river, which reduced the river's flow to practically nothing. The consequent reduction in riverflows necessitated the pumping of ground water to sustain crop production, but likewise drastically lowered the water table. The result was a gradual deterioration of the agricultural economy which could only be revived by the diversion of Colorado River water.

The Gila Project delivered the first Colorado River water to the Wellton-Mohawk Division in 1952, and the entire distribution system was in operation by the end of 1957. That same year, due to the accumulated deep percolation of 6 years of Colorado River diversions without drainage facilities, the water table reached a level that threatened to drown the crops. In order to remove the excess ground water, some of the old irrigation wells were reactivated as drainage wells, and the construction of others was begun. Drainage water from these wells was originally discharged directly to the Gila River.

In 1960 and 1961, the concrete-lined Wellton-Mohawk Main Conveyance Channel was constructed for the entire length of the Division to carry the drainage water from the wells. This water then emptied into the Gila River near its confluence with the Colorado River, and then flowed via the Colorado River to Morelos Dam where it was diverted by Mexico. Historic return flows for the years 1967 through 1975 are presented in the following tabulation:

Pumped Drainage Flows--Wellton-Mohawk Irrigation and Drainage District

Flows in Acre-Feet

Year	MODE Flow	Year	MODE Flow
1967	212,565	1972	210,149
1968	219,782	1973	207,588
1969	218,735	1974	206,465
1970	218,852	1975	209,715
1971	215,324		

USGS Station 09529300 final data.

D.2. Deep Percolation

Deep percolation water is that water which filters downward through the soil and is not consumptively used by the crops. The two primary sources of deep percolation are irrigation diversions and floodflows.

Agricultural water diversions in the Wellton-Mohawk area apply enough water to cause deep percolation. Water must be applied to the land to the extent that excess salts in the root zone are leached from the soil profile. Such water is in addition to that which is consumptively used by the crops.

Accumulated deep percolation, however, causes an increase in the ground-water level to such an extent that drainage pumping is necessary. Large contributions to the water table occasionally result from Gila River floodflows, which infiltrate the ground-water basin in the area and must be pumped out along with the percolated irrigation water. Only four floods of significance have occurred to cause Painted Rock Dam releases, but in each case return flows from the Division were affected. If storage rights to more land in Painted Rock Reservoir can be obtained, then a greater storage of floodflows could be realized and infiltration of such waters to the Wellton-Mohawk Division could be minimized.

E. Water Quality

E.1. Colorado River

There are several water quality factors which affect the Colorado River system; among them, salinity is currently the most serious one. The present total dissolved solids concentration of the water increases from below 50 p/m at the river's source to over 800 p/m at Imperial Dam, and to nearly 1,000 p/m at the Northerly International Boundary. The overall increase in salinity is due to a combination of factors, such as natural diffused sources, irrigation drainage returns, and municipal and industrial returns.

Natural diffused sources are those sources of salt contribution which occur gradually over long reaches of the river system. Salt pickup occurs over large areas of surface and underlying soils, from stream channels and banks, and is difficult to identify, measure, and control. This source contibutes the largest amount of salts to the Colorado River.

A major portion of the basin water supply is consumptively used for irrigation. Crops grown throughout the basin concentrate the salts in the water and return them, by way of the drainage water, to the river. Additional salts are dissolved from the soils on which the crops are grown, which also add to the salt concentration of the river.

Water for municipal use must meet the recommended limits of the 1962 Public Health Service drinking water standards. High salinity levels affect the taste of drinking water and, possibly, the digestive system in some people. Domestic use concentrates and adds salts to the water supply and then normally returns the degraded water to the original supply. This water in turn is usually the source of domestic or municipal water for users further downstream.

Industrial use of Colorado River water has not been extensive in the past, but future uses are expected to increase primarily because of increased demand for electric power generation plants. Although increased salinity will be a resultant overall factor, many times industry uses the water and does not allow any return flow; therefore, no salt is returned to the system.

E.2. Ground-Water Infiltration

The ground-water basin in the Wellton-Mohawk area is easily infiltrated by the waters lost from the Gila River. The quality of the infiltrated floodwater from the 1973 flood was estimated to average about 600 p/m compared to the present average of about 3,700 p/m for ground water, but dilution of the overall aquifer was insignificant. Measurable dilution of the ground water has been noticeable only in the active wells near the river.

E.3. Main Outlet Drain

The Main Outlet Drain carries the pumped drainage water from the Wellton-Mohawk Division. The quality of this brackish water has improved since pumping operations began in 1957. At first, the water was pumped into the Gila River channel where it flowed to the Colorado River. This drainage water was quite brackish and averaged about 6,000 p/m.

The concrete-lined Wellton-Mohawk Main Conveyance Channel, of which the Main Outlet Drain is an extension, was constructed in the early 1960's to carry the drainage water from the 106 drainage wells located throughout the Division. The drainage water has continued to improve in the drain, one reason being the scheduling of the drainage wells pumped. In 1972, the drainage water averaged 3,700 p/m. By the time the desalting plant is operational it is predicted that the drainage water will be about 3,200 p/m. It is anticipated that in the future complete salt balance can be achieved for the Division, which would result in drainage water of about 2,950 p/m, depending on the irrigation efficiency achieved.

E.4. Return Flows to the River Below Imperial Dam

There were about 257,000 acre-feet of drainage water, excluding Wellton-Mohawk returns, that entered the river below Imperial Dam in 1974. The salinity of these return flows was about 1,535 p/m. These flows have a considerable effect on the water released from Imperial Dam, yet for the first operating year under *Minute No. 242*, ending June 25, 1975, the salinity differential was about 138 p/m.

E.4.a. Yuma Mesa Wells

This system was originally designed to furnish 60,000 acre-feet per year, and in recent years has approached this amount. The salinity of this pumped water was about

1,330 p/m when the Yuma Mesa system was originally installed in 1967-68, and since then the trend of change has been slowly upward.

E.4.b. South Gila Drainage

It was originally contemplated that the annual total drainage required from the South Gila area would be about 65,000 acre-feet in order to maintain ground-water levels. More recent estimates indicate that 55,000 acre-feet per year of drainage pumping is sufficient as long as the Yuma Irrigation District and the adjoining Yuma Mesa Irrigation and Drainage District operate the system in the same manner as is currently being done. The annual requirement from each well is that quantity that must be pumped to satisfy drainage requirements in the area of a well's influence. Within this requirement, there is some latitude for seasonal variation in the total quantity and quality of drainage water. The average annual salinity of 2,200 p/m was developed by considering the very slow quality improvement trend. Since pumping operations are primarily for drainage, the wells at the bottom of the mesa are pumped the most; as these happen to be the better quality wells, the 2,200 p/m figure may not be representative of the average quality of water in the aquifer.

E.4.c. Other Measured Returns

The other measured returns for the last several years have averaged about 70,000 acre-feet per year. There is no apparent trend in the annual variation and it is believed that the annual amount from this source will remain unchanged. Salinity of these flows is projected on the basis of presently measured rates by reason of a rather consistent quality record for the past years.

E.4.d. Unmeasured Returns

The unmeasured returns are derived by subtracting the known sources of flow and their salt loads from the measured flows and salt loads at the Northerly International Boundary. The computed unmeasured returns have varied considerably in quantity and quality in the past. The quantity of flow has trended upward since 1970, and the 1970-1973 average was about 65,000 acre-feet per year. The salinity of the unmeasured return flows is projected on the basis of present records for the quality of drainage returns from the Yuma Valley Division and the Reservation Division, which has been within the range of 1,350 to 1,650 p/m in the past. During the year 1974, the average salinity of the unmeasured return flows was 1,507 p/m. Therefore, 1,500 p/m is considered representative of the quality of unmeasured return flows, although the computed values may show considerable variation.

VI. PLAN FORMULATION

A. Provisions of *Public Law 93-320*

Public Law 93-320, the *Colorado River Basin Salinity Control Act,* is divided into two sections. The first, Title I of the Act, provides for programs downstream from Imperial Dam to implement the provisions of *Minute No. 242*. Title II of the Act provides for measures upstream from Imperial Dam.

Title I specifically authorizes three major features: (1) a desalting complex, (2) a new concrete-lined canal section, or lining of the presently unlined first 49 miles, of the Coachella Canal, and (3) protective and regulatory ground-water well fields. In reference to the desalting complex, the structural features as determined by this investigation will consist of: (1) a membrane-process desalting plant of approximately 100 Mgal/d capacity with a pretreatment system and the necessary appurtenant works to treat the pumped drainage from the Wellton-Mohawk Division, (2) the construction of a concrete-lined bypass drain from Morelos Dam to the Santa Clara Slough in Mexico, and (3) replacement of an existing metal flume section of the Main Outlet Drain Extension with a concrete siphon. Nonstructural measures consist of: (1) an irrigation efficiency improvement program in the Wellton-Mohawk Division to minimize the quantity of drainage return flows by accelerating a cooperative program of irrigation management services and providing Federal cost-sharing assistance for onfarm irrigation system improvements, (2) an irrigable acreage reduction program in the Wellton-Mohawk Division to eliminate potential increases in drainage return flows associated with additional development, and (3) acquisition of land, if needed, in Painted Rock Reservoir to permit a change in operational releases to minimize infiltration in the Wellton-Mohawk Division. As compensation to the Cocopah Tribe of Indians for rights-of-way for project features, the Act provides for ceding approximately 340 acres of Federal land to the Tribe in Secs. 25, 26, and 27, T. 9 S., R. 25 W., of the Gila and Salt River meridian, Arizona.

In conjunction with the Title I features authorized below Imperial Dam are those of Title II upstream of Imperial Dam. It is understood that no single feature can solve the salinity problem of the entire Colorado River; therefore, all features proposed and authorized are designed to improve specific local quality problems and concurrently assist other existing projects in the improvement of the river system.

Title II specifically authorizes the construction, operation, and maintenance of four salinity control projects: (1) the Paradox Valley Unit, Montrose County, Colorado, consisting of facilities for the collection and disposition of the saline ground water of Paradox Valley; (2) the Grand Valley Unit, Colorado, consisting of measures and all necessary appurtenant and associated works to reduce the seepage of irrigation water from the irrigated lands of Grand Valley into the ground water and thence into the Colorado River; (3) the Crystal Geyser Unit, Utah, consisting of facilities for the collection and disposition of saline geyser discharges; and (4) the Las Vegas Wash Unit, Nevada, consisting of facilities for the collection and disposition of the saline ground water of Las Vegas Wash. Authorization has also been given for planning reports on 12 units throughout the River Basin.

Public Law 93-320 directs the Secretary of the Interior to implement these measures in accordance with the salinity control policy adopted for the Colorado River in the *Conclusions and Recommendations* published in the proceedings of the Reconvened Seventh Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries, held in Denver on April 26-27, 1972.

B. Proposed Plan

B.1. Reduction of Wellton-Mohawk Return Flows

An advisory committee on irrigation efficiency in the Wellton-Mohawk Division was established at the direction of President Nixon to determine and implement methods of improving onfarm irrigation efficiency so as to reduce irrigation drainage flows from the Division. The Technical Field Committee, under the guidance of the Advisory Committee, prepared the Special Report, *Measures for Reducing Return Flows from the Wellton-Mohawk Irrigation and Drainage District,* September 1974 [19], which analyzed irrigation efficiencies in the Division and the measures required to improve water management relative to a reduction of return flows. The report findings indicate that overall Division irrigation efficiency is 56 percent and the drainage return flow associated with this efficiency is about 214,000 acre-feet annually.

Improvement of the present level of irrigation efficiency, expected to reduce return flows, is currently the objective of the Irrigation Management Services program. The program was devised and implemented in order that correct amounts of water might be applied to replenish soil moisture depletion as well as for leaching, and to achieve as near a uniform distribution of water on the field as possible using large flows, automatic systems, and level fields.

Further increases in irrigation efficiency are expected to be attained by improvement of onfarm irrigation systems. Four program levels were developed by the Technical Field Committee to evaluate the cost of onfarm improvements and their effect on reducing return flows. The program levels considered and the irrigation efficiency, estimated return flow, and cost associated with each are presented in the following tabulation:

Program Levels and Costs

Level	Efficiency (percent)	Return Flow (1,000 acre-feet/yr)	Installation 1/ (x10^6$)	Annual Equivalent 2/ (x10^6$)
1	64	167	1.65	0.10
2	67	155	5.53	0.33
3	72	133	7.51	0.45
4	82	94	11.15	0.67

1/ Based on 75 percent Federal cost sharing for permanent onfarm irrigation improvements plus program expenditures for technical assistance, Irrigation Management Services, and research and demonstrations.

2/ Interest at 5-5/8 percent for 50 years.

The highest level considered reasonable of achievement prior to the desalting plant startup has been identified as Program Level 1. The other program levels, although projected as effective in reducing desalting costs and improving irrigation efficiency, are believed to be impractical of achievement within the time required, although efforts will continue to be made to achieve them subsequent to the desalting plant startup. The calculated return flows of Program Level 1 would be 167,000 acre-feet annually with an average Division-wide irrigation efficiency of 64 percent.

Program Level 1 efficiency improvements are primarily management associated without any significant increase in system improvements above the ongoing program of the Natural Resource Conservation District. However, measures are presently underway to implement onfarm structural features through a Soil Conservation Service program, which calls for a farmer to devise a conservation plan of operations for his land. A cost-share rate of 75 percent Federal and 25 percent private participation has been established by the Secretary of the Interior.

Work is progressing toward these improvements and the long-range expectations are to at least reach an efficiency level equivalent to that of Program Level 3. However, there are certain problems inherent with obtaining higher efficiency levels, and the following factors have an important bearing on this goal:

1. The desire and ability of the farmers to achieve the higher efficiencies.
2. The relationships between the landowners and the land operators.
3. The complexity and the variability of the soil patterns within the individual fields.
4. The effects of future economic conditions on crop distribution, investment decisions, labor inputs, and energy requirements.
5. The future salinity conditions at Imperial Dam.
6. The effect of the Irrigation Efficiency Improvement Program in achieving the desired reduction in return flows. This reduction has been conservatively estimated to be 167,000 acre-feet per year, Program Level 1, by the time the desalting plant becomes operational.

It is further concluded that the irrigable acreage in the Division should be reduced by approximately 10,000 acres to preclude additional development that might increase drainage return flows and to insure that water use does not exceed the Division's Colorado River allocation.

B.2. Desalting of Wellton-Mohawk Return Flows

Return flows from the Wellton-Mohawk Division are projected to average about 167,000 acre-feet per year with a salinity of 3,200 p/m in 1981, when the desalting plant becomes operational. On an annual average, the desalting plant is expected to treat a portion of these flows to produce 60,000 acre-feet of product water, which will be combined with 81,000 acre-feet of untreated MODE water for return to the river. Correspondingly, the plant reject will average 26,000 acre-feet per year. The 108.5 Mgal/d design plant, under full production, will annually divert 144,735 acre-feet of the 3,200 p/m MODE flow for pretreatment and desalting. In addition, 6,087 acre-feet of operational transients will be diverted from the MODE and returned to the river, or rejected to the Bypass Drain. Pretreatment will reduce the feed water salinity to 2,904 p/m. Desalting this water will then produce 102,653 acre-feet of product water at 386 p/m and 43,339 acre-feet of reject waste at 8,874 p/m. Both product water and reject will be piped to the MODE-2 bifurcation structure. There, the reject will be discharged on one side of the gate structure (which will prevent the two flows from mixing), and carried south to the Santa Clara Slough via the Bypass Drain. The product water will be discharged on the other side of the gate into the remaining MODE flow, and this mixture will then be carried to the river via the MODE-2 channel. The product water and MODE flow mixture, 123,590 acre-feet at 854 p/m, when blended with Imperial Dam releases and return flows, will result in a salinity level of 980 p/m for the water delivered to Mexico at the Northerly International Boundary. This will be 115 p/m $\pm$ 30 p/m over the 1981 projected Imperial Dam salinity of 865 p/m and will satisfy the differential requirement of *Minute No. 242*.

B.2.a. Yuma Desalting Plant Sizing Study

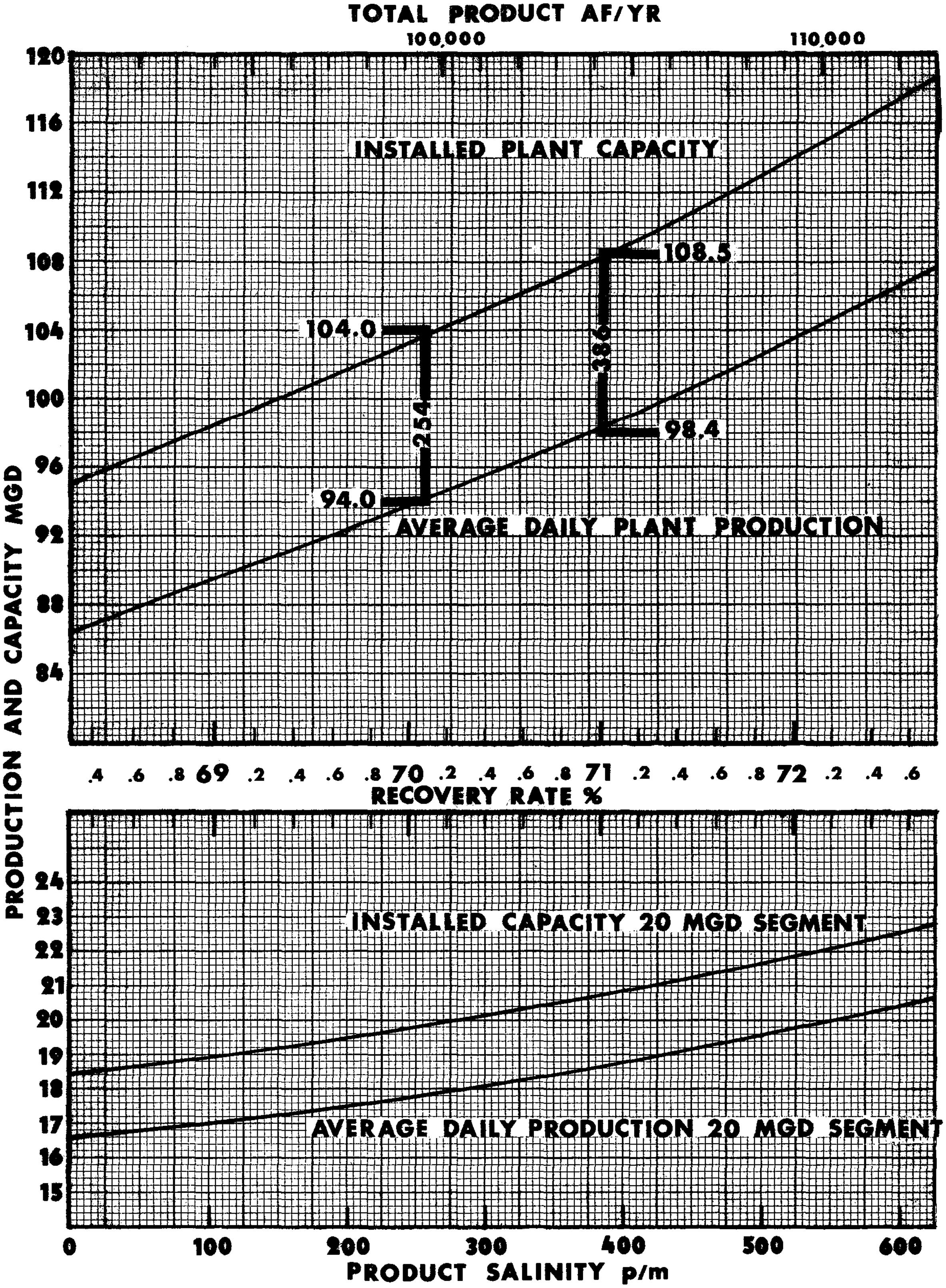
The plant size, as determined in the *Preliminary Sizing Study, Yuma Desalting Plant, Arizona,* Special Report, July 1975 [28], was 104 Mgal/d with a product water salinity of 254 p/m. This plant size and associated product water salinity, although different from, are equivalent to the presently established design plant size and product water salinity. The Sizing Study report, the data of which served as a basis for the design plant, was based on a plant composed entirely of reverse osmosis desalting equipment. An evaluation of test results from the Yuma Desalting Test Facility (see Chapter VII, Paragraph F, for an explanation of the facility's function) and optimization studies of known equipment performance and economics, led to the conclusion that a combination of membrane processes should be considered in the preparation of feasibility level design and cost estimates for this investigation. The result, based on optimized individual and composite process parameters, was a combination of approximately 20 Mgal/d each of hollow fine fiber reverse osmosis, spiral wound reverse osmosis, and electrodialysis, the balance of the plant being equivalent to the average of the three separate processes. Accordingly, product water salinities for the various processes, and other parameters, were updated from data used in the Sizing Study. The resulting composite plant product salinity was determined to be 386 p/m. Installed plant capacity, due to the higher product water salinity, also increased (the 70 percent recovery rate and the 296 p/m pretreatment salinity reduction were held constant); consequently, the installed capacity of the design plant was determined to be 108.5 Mgal/d with a product water salinity of 386 p/m, as shown on Figure 3. The Sizing Study findings, which, again, are the equivalent of the design plant specifications, are presented in this subsection as the data base upon which the design plant size was formulated, and are the basis for evaluation of desalting equipment proposals.

B.2.a.(1) Method of Analysis

B.2.a.(1)(a) Colorado River Storage Project Simulation Model

A projection of upstream conditions of the Colorado River was necessary prior to operation of the Wellton-Mohawk simulation model. An already existing Colorado River Storage Project simulation model (CRSP model) was operated for this purpose. This model, when intertied with a short computer program, operates the entire Colorado River system to Imperial Dam in accordance with the existing legal framework. Input to the model included projections of future Colorado River flows, Lower and Upper Colorado River depletions, salt loadings, and initial reservoir conditions. Output included projections of shortage and surplus conditions, release requirements from all reservoirs down to Imperial Dam, and salinity projections. These data were developed using 13 sequences of possible inflow conditions to account for the degree of uncertainty associated with long-range predictions.

The water supply for the CRSP model study was based on a 1906-1972 period of record of flow at Lees Ferry, Arizona. This flow was modified to reflect



PRODUCTION AND INSTALLED CAPACITY VERSUS
PRODUCT SALINITY AND QUALITY, AND RECOVERY RATE
YUMA DESALTING PLANT

Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Figure 3

the 1968 level of depletions; then it was modified to reflect the estimate of future depletions (see Table 7).

Upper Basin depletions were estimated to total 3.7 million acre-feet in 1975, and reach 5.8 million acre-feet after water year (WY) 1993, annually. Minimum delivery to the Lower Basin was scheduled to be 8.25 million acre-feet annually at Lees Ferry. Lower Basin depletions were estimated to be 6.2 million acre-feet in WY 1975, and increased to 7.4 million acre-feet in WY 1986 when the Central Arizona Project is scheduled to begin diverting Colorado River water. A depletion schedule of 7.5 million acre-feet for the Lower Basin was reached in WY 1999. The CRSP model study also incorporated estimates of future Colorado River water quality improvements authorized under Title II of the Colorado River Basin Salinity Control Act, *Public Law 93-320.* These projects include the Paradox Valley Unit (scheduled for completion in fiscal year [FY] 1980), the Grand Valley Basin Unit (under construction from FY 1978 through FY 1988), the Crystal Geyser Unit (assumed to be completed by FY 1977), and the Las Vegas Wash Unit (assumed to be completed sometime between FY 1979 and FY 1981). Lower Basin improvements include the effects of replacing the Coachella Canal (scheduled for completion by FY 1979), the Protective and Regulatory Pumping Unit (scheduled for completion in FY 1981), and the Desalting Complex Unit (scheduled for completion in FY 1981).

B.2.a.(1)(b) Wellton-Mohawk Simulation Model

The Wellton-Mohawk simulation model was used for projecting the operation of the aquifer and the authorized desalting plant. Prior to use of the model, a calibration of the aquifer portion was accomplished by modifying certain physical parameters within a reasonable range. The adequacy of model calibration was verified by (1) the model's ability to "simulate" known historic data such as the depth to ground water and aquifer salinity, and (2) the reasonableness of modified basic data such as aquifer volume and storage coefficients. Physical parameters established during the calibration were then used for projection throughout the Wellton-Mohawk model studies.

The Wellton-Mohawk Division was divided into six hydrologically and chemically unique segments for evaluation in the model studies. Simulation of the irrigation

Table 7 1/
MEX-5 CAP RATE AND REPAYMENT FOR LC-REGION APRIL 1975
1968 MODIFIED FLOWS AT GLEN CANYON DAMSITE (DEPLETED)
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Unit: 1,000 Acre-Feet

WATER YEAR	RUNOFF SEQUENCE NUMBER													TOTAL	AVERAGE
	1	2	3	4	5	6	7	8	9	10	11	12	13		
1975	15360	12695	15519	18836	12451	5437	10608	14728	7761	8978	8074	6134	8642	145223	11171
1976	19191	16554	19780	14781	14973	13740	10684	15575	12087	16709	16326	13970	8727	193097	14854
1977	9922	11302	11943	14594	13646	8403	13870	10066	12383	7986	13337	6148	10336	143936	11072
1978	18764	16907	9463	10977	17291	3403	8158	11831	12836	5352	6108	7326	11214	139630	10741
1979	10909	10714	17491	9813	11490	8340	5898	10093	9886	6318	8264	14601	11712	135529	10425
1980	12200	14927	18208	11897	5170	9988	14008	7337	8534	7507	5688	8219	11493	135176	10398
1981	15807	18942	14197	14227	13000	10014	14782	11393	15869	15412	13138	8190	8608	173579	13352
1982	10695	11374	13914	12914	7826	13048	9480	11633	7482	12585	5648	9651	14323	140573	10813
1983	15969	8891	10355	16360	2954	7585	11093	12038	4848	5647	6677	10433	17912	130762	10059
1984	10081	16450	9143	10840	7562	5334	9391	9218	5670	7583	13591	10906	9196	124965	9613
1985	14042	17230	11097	4740	9169	13030	6734	7892	6778	5097	7600	10728	17346	131483	10114
1986	17914	13459	13331	12086	9237	13855	10555	14852	14344	12160	7529	7974	10056	157352	12104
1987	10761	13158	12126	7199	12164	8858	10819	6940	11785	5115	8899	13382	11147	132353	10181
1988	8309	9723	15417	2500	7004	10345	11230	4338	5181	6019	9641	16877	14515	121099	9315
1989	15431	8487	10204	6801	4787	8703	8560	5036	6914	12599	10114	8652	9775	116063	8928
1990	16255	10299	4314	8350	12052	6133	7251	6051	4508	6982	9967	16326	14641	123129	9471
1991	12817	12549	11286	8558	13045	9821	13963	13410	11304	6951	7421	9531	9292	139948	10765
1992	12596	11538	6729	11505	8394	10213	6534	11189	4718	8339	12678	10583	13026	128042	9849
1993	9333	14831	2219	6644	9882	10729	4021	4893	5613	9151	16232	13942	16866	124356	9566
1994	8192	9919	6460	4541	8397	8266	4752	6615	12155	9760	8410	9479	10237	107183	8245
TOTAL	264548	259949	233196	208163	200494	185245	192391	195128	180656	176250	195342	213052	239064	2743478	
AVERAGE	13227	12997	11660	10408	10025	9262	9620	9756	9033	8813	9767	10653	11953	137174	10552

1/ Extracted from *"Preliminary Sizing Study, Yuma Desalting Plant, Arizona, Special Report,"* July 1975, Table 1.

and drainage operations in the Division began with a monthly estimate of onfarm water requirements for a particular cropping pattern (crop efficiencies are unique for each segment). Distribution system losses, prorated for each segment based on canal and lateral sizes and lengths, were added to the onfarm requirements to determine the required diversion at Station 790+00 on the Gila Gravity Main Canal. The distribution system losses were added to each segment's aquifer with the same salinity as that of the waters arriving at Imperial Dam for that month. The leaching fraction and any unaccounted inflows were also added to each aquifer. Consumptive use requirements of the phreatophytes were then removed from the segment's aquifer volume and, at this point, the depth to water was determined. Drainage pumping was then either computed, based on the depth to ground water, or input as a desired quantity at a desired salinity.

The salinity of deep percolation is greater than that of the irrigation water applied due to the salt concentrating effect of plant transpiration. Chemical interactions besides the concentrating effect occur in the zone between the ground surface and the aquifer. The movement of water and salt entering this zone and eventually moving into the aquifer was simulated within the unsaturated chemistry portion of the model. Chemical reactions included: base exchange, dissociation or precipitation of gypsum and lime, and reactions between calcium sulfate and magnesium sulfate ion pairs in solution. Output from the unsaturated chemistry portion was in the form of slugs of water (including salts) which were then added to the aquifer quantities of water and salts. Chemical reactions within the aquifer were assumed to be negligible and, therefore, were ignored.

B.2.a.(1)(c) Assumptions Used in the Sizing Study

Colorado River flows, released at Imperial Dam, will provide the main source of Mexico's water requirements at the Northerly International Boundary. The Wellton-Mohawk model assumes that surplus flows at Imperial Dam can be regulated in a manner that will permit the use of the minimum desalting plant capacity, while maintaining the salinity differential and delivery requirements at the Northerly International Boundary.

The study also assumes the onfarm efficiencies shown in the following tabulation and the projected cropping pattern shown in Table 2, Appendix A, of the

Sizing Study [28]. Projections of average diversions to the Wellton-Mohawk Division and MODE drainage flows are also shown in the following tabulation:

Date	Onfarm Efficiency %	Diversions 1/ (1,000 acre-feet)	Average MODE Returns (1,000 acre-feet)
1974-79	57-62	474	193
1980-86	64 (level 1)	443	167
1987-90	67 (level 2)	427	155
After 1990	72 (level 3)	400	133

1/ Measured at the Wellton-Mohawk Canal turnout on the Gila Gravity Main Canal.

The onfarm irrigation efficiencies and cropping pattern are those recommended in *Measures for Reducing Return Flows from the Wellton-Mohawk Irrigation and Drainage District, Special Report,* September 1974 [19]. The acreages of each crop, by segment, are based on averages of the 1970, 1971, and 1972 historic crop data. The desalting plant will be sized to handle the 167,000 acre-feet MODE flow during the 1981-1986 design period.

B.2.a.(1)(d) Plant Size Ranges

The primary factor which affected sizing the proposed desalting plant was the quantity of MODE flows. The desalting plant will be operational in 1981, when Level 1 onfarm efficiencies are anticipated to be in effect. Level 1 MODE flows were assumed to continue until 1987, when drainage returns are expected to decrease below 167,000 acre-feet annually. The desalting plant, for this reason, was sized to meet drainage flow conditions in the 1981-1986 period.

In order to approximate the required plant size, the Wellton-Mohawk model was operated without a limitation on plant size. This operation resulted in the plant production shown in Table 8. Plant operation was governed by a rule curve and the only restriction to meeting the monthly salinity differentials, set by the rule curve, was the quantity of MODE flows. It is apparent from looking at Table 8 that a plant capable of producing about 97,000 acre-feet annually will be adequate for all cases shown in the 13 sequence, 1981-1986, design period.

Table 8 1/
PRODUCTION WITH UNLIMITED PLANT SIZE, NO BYPASS, AND A 70 PERCENT RECOVERY RATE
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Unit: 1,000 Acre-Feet

YEAR	RUNOFF SEQUENCE NUMBER													TOTAL	AVERAGE
	1	2	3	4	5	6	7	8	9	10	11	12	13		
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	84	87	8	81	8	88	90	89	88	623	48
1982	10	0	0	0	94	88	35	6	82	89	87	86	71	648	50
1983	0	94	10	0	92	90	6	0	83	91	85	86	0	637	49
1984	0	0	79	77	88	88	91	91	89	89	83	84	97	956	74
1985	0	0	37	92	85	88	88	88	86	86	83	83	6	822	63
1986	0	0	6	93	85	89	87	75	84	82	82	83	92	858	66
1987	79	0	73	85	79	82	80	83	80	74	74	76	93	958	74
1988	95	90	7	83	79	81	79	82	81	71	74	7	7	836	64
1989	4	83	74	77	76	79	78	78	77	69	71	73	78	917	71
1990	0	90	85	74	78	79	77	76	75	72	72	5	5	788	61
1991	0	76	72	63	69	68	67	63	61	62	63	69	73	806	62
1992	0	71	67	61	64	63	64	62	47	49	57	64	54	723	56
1993	84	5	65	62	63	62	64	63	51	60	67	5	0	651	50
TOTAL	272	509	575	767	1036	1044	824	848	904	982	988	810	664	10223	
AVERAGE	21	39	44	59	80	80	63	65	70	76	76	62	51	786	60

1/ Extracted from *"Preliminary Sizing Study, Yuma Desalting Plant, Arizona, Special Report,"* July 1975, Table 18.

B.2.a.(2) Desalting Plant Operation Studies

The desalting plant operation studies produced desalted water at 254 p/m which, when combined with the remaining MODE flows for delivery to Mexico at the Northerly International Boundary, conformed with provisions of *Minute No. 242.*

The month-to-month operation of the desalting plant was controlled by the rule curve, which established "target" salinity differentials for each month. This rule curve provided an average annual flow weighted salinity differential between flows arriving at Imperial Dam and the Northerly International Boundary of 115 p/m.

The desalting plant was operated 349 days each year at 90 percent availability. Ten percent of the plant capacity was considered to be out of service for unexpected or ongoing maintenance of plant modules. Sixteen days of complete downtime, scheduled to coincide with the annual MODE maintenance shutdown, were assumed to occur in February of each year. During this time, about 1,300 acre-feet of operational waste were expected to occur due to stopping and starting of plant facilities and dewatering of other drainage features.

It was found that the desalting plant, (based entirely on reverse osmosis), should be designed to produce water at about 250 p/m when the MODE salinity is 3,200 p/m and the plant feed water is pretreated. The salinity of the product water would vary as a function of MODE salinities (over the range evaluated) to maintain the relationship:

Salinity of Product Water = 136.25 + 0.0365 X MODE salinity

Using this relationship, the product water varied between 230 p/m and 260 p/m for 2,600 and 3,400 p/m MODE water, respectively. At 3,200 p/m design salinity for the MODE, the salinity of product water was 254 p/m.

The desalting plant would recover 71.0 percent of all pretreated feed water as product water. The remaining 29 percent of plant feed water would be reject, at about 8,874 p/m.

B.2.a.(3) Selection of Plant Capacity

Operation of the model with an unlimited plant size was limited only by the quantity of MODE flows. Actual plant operation is limited by the quantity of MODE flow and also the plant capacity. Therefore, the data contained in Table 8 represent required plant production under better than actual conditions. This fact was substantiated by operating the Wellton-Mohawk model study with the smallest plant capable of producing 97,000 acre-feet annually. With this size plant, 101 Mgal/d, it was not possible to provide the 115 p/m annual salinity differential in some years. This was caused by lack of sufficient MODE flows in some months to maintain the maximum annual required plant production. For this reason, a 101 Mgal/d desalting plant size was not considered adequate.

The plant size required to meet the design criteria established in the Sizing Study report was a plant capable of producing 104 Mgal/d. This plant would be capable of producing up to 100,000 acre-feet of product 1/, or removing up to 530,000 tons of salt, annually, assuming no restrictions imposed by the monthly quantity of MODE flows. (Note that plant sizes are in terms of production capability.)

B.2.a.(4) Sensitivity Analysis

The results discussed in the Sizing Study report are dependent upon several assumptions: (1) MODE flows, (2) MODE salinities, (3) Imperial Dam salinities, (4) return flows–Imperial Dam to the Northerly International Boundary, and (5) plant recovery rate. Some of these produce a significant change in the study results, while others have virtually no effect. Mode flows and Imperial Dam salinities represent the two parameters that may affect plant size selection the most. Table 9 summarizes the effects of varying several of these parameters.

B.3. Utilization of Desalted Water

The only proposed utilization of the desalted water is to enable Treaty deliveries to meet the established quality differential. During extended periods when surplus water is available at Imperial Dam for release to Mexico, plant production will be proportionally decreased so as to reduce operating costs.

B.4. Bypass of Reject Stream

The discharge of the reject effluent and plant operational waste will be facilitated through the Bypass Drain, which will extend 50.7 miles from the MODE-3 turnout below

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1/ $\frac{100{,}000 \text{ acre-feet}}{(365\text{-}16) \text{ days x } (0.90) \text{ avaibility factor x } (3.07) \text{ acre-feet/day/Mgal/d}} = 104 \text{ Mgal/d.}$

TABLE 9 1/
SENSITIVITY ANALYSIS
PARAMETERS AFFECTING PLANT SIZE
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

	Present Conditions	Anticipated Trends (1981-1986)	Design Value	Anticipated Range (1981-1986)	Effect on Required Plant Size (Mgal/d)
QUALITY					
1. Salinity of flows arriving at Imperial Dam	835 p/m	Upward	865 p/m	-100 p/m to +150 p/m	+10 -15
2. Return flow salinities (excluding Wellton-Mohawk returns)	1,523 p/m	Upward	1,575 p/m	-225 p/m to +100 p/m	-14 + 6
3. Salinity of MODE flows	3,775 p/m	Downward	3,200 p/m	-725 p/m to -525 p/m	- 2 0
QUANTITY					
4. Return flows (excluding Wellton-Mohawk returns)	235,000 Acre-Feet	Upward	250,000 Acre-Feet	-13,000 Acre-Feet to + 7,000 Acre-Feet	- 3 + 1
5. Quantity of MODE Flow	206,000 Acre-Feet	Downward	167,000 Acre-Feet	-32,000 Acre-Feet to +36,000 Acre-Feet	-20 +23

1/ Extracted from *Preliminary Sizing Study, Yuma Desalting Plant, Arizona, Special Report,* July 1975; Table 26.

Morelos Dam to the Santa Clara Slough. The drain will have a capacity of 353 ft^3/s (10 m^3/s), which will enable the entire drainage flow to be bypassed to the Slough during periods of plant shutdown.

C. Interim Salinity Control

During the period of time between the passage of *Public Law 93-320* and the completion of the Desalting Complex Unit, all of the Wellton-Mohawk Drainage will be bypassed to the river channel below Morelos Dam.

In addition to bypassing Wellton-Mohawk drainage, other measures are also in effect to maintain interim salinity control. The Yuma Projects Office presently schedules pumping requirements for the Yuma area, which includes the Yuma Mesa drainage wells and the drainage wells in the South Gila Valley. Return flows from these wells, which are delivered to Mexico above Morelos Dam, are selectively pumped so that Treaty obligations can be maintained. Releases to Mexico from Imperial Dam are also made in accordance with Treaty regulations. The 115 p/m $\pm$ 30 p/m differential between Imperial Dam and the Northerly International Boundary was negotiated principally on the basis of excluding Wellton-Mohawk return flows and including other return flows to the river below Imperial Dam. The release schedule is integrally connected to the drainage pumping and other return flows below Imperial Dam.

VII. DESALTING PROCESS SELECTION

All major desalting processes were considered for the Yuma Desalting Plant. Considerations for process selection were based on Colorado River flow and quality data, the project criteria, the constraints inherent within the desalting processes themselves, and *Public Law 93-320's* stipulation to use *advanced technology commercially available*.

A. Processes Considered

Broad categories of available desalting processes include distillation, crystallization, ionic, and liquid-liquid extraction. The distillation category includes multiple-effect evaporation, multiple-stage flash evaporation, vertical tube evaporation, solar, vapor compression, and supercritical distillation. The crystallization processes include freeze separation and hydrate separation. Ionic processes are ion exchange, electrodialysis, reverse osmosis, transport depletion, piezodialysis, electrochemical, and biological systems.

Few of the processes have been commercially applied, and since this was a basic criteria for the selection of the desalting process, the list of applicable processes was reduced to:

1. Distillation Processes - multiple-effect, multiple-stage flash (MSF), vertical tube evaporation (VTE), and vapor compression (VC); and
2. Ionic Processes - ion exchange (IX), electrodialysis (ED), and reverse osmosis (RO).

B. Process Performance Requirements

Specific requirements for desalting plant process performance have been established by *Public Law 93-320* only insofar as concerns the approximate quantity of water to be treated daily, the product water recovery ratio, and the TDS reduction of the feed water. *Public Law 93-320*, in Section 101.(b)(2), specifies a daily treatment capacity of approximately 129 million gallons, not less than a 70 percent product water recovery ratio, and not less than a 90 percent reduction of the dissolved solids in the feed water. These criteria, which were based on present industry capabilities, are the only criteria set forth in *Public Law 93-320* by which such equipment must operate. The water quality differential requirement stipulated in *Minute No. 242* of the International Boundary and Water Commission (which will be dependent on certain variables other than plant process performance such as MODE quantity and quality, and inflows below Imperial Dam), is a factor which must be met through the operational capability of a manufacturer's equipment to produce product water of a quality which, when combined with the other variables, will satisfy the Minute.

B.1. Operational Design Parameters

There are certain operational parameters which will make requisite the performance of desalting processes within a given range applicable to each specific parameter. The parameters to be considered are salt concentration of the feed water, temperature of the feed water, desired product water quality, availability of energy, dependability of the feed water source, reject disposal, site location, and environmental factors.

B.1.a. Feed Water Salt Concentration

The feed water concentration has a practical bearing on a process selection. Ranges of application for the various processes, based on feed water salt concentrations and considering economic and practical application factors, are:

Process	Feed Water Salt Concentration - p/m
Distillation	10,000-50,000
ED	1,000- 5,000
RO	1,000-10,000
IX	less than 2,000

It is apparent that the ED and RO processes are the most appropriate under design conditions for the Yuma Desalting Plant, where feed water salinity will be approximately 3,200 p/m.

B.1.b. Feed Water Temperature

Feed water temperature affects the economy of a given process. The Yuma Desalting Plant will deal with feed water temperatures of 65° to 85° F. The feed water temperature range which results in the lowest water cost for each process is as follows:

Process	Feed Water Temperature
Distillation, MSF, VTE	Cool
VC	Warm
RO	Warm
ED	Warm
IX	Warm

The upper range of temperatures for RO and ED, based on operating experience, is 95°F and 100°F, respectively. Ion exchange temperature limitations are sensitive to the resins used. Other processes are relatively insensitive within the temperature ranges considered.

B.1.c. Product Water Quality

The product water quality is determined by the quality of water which must be delivered to Mexico, as established by *Minute No. 242*. To meet this requirement, the Yuma Desalting Plant will be designed to produce product water with a salinity of 622 p/m or less. The water qualities produced by the different processes under normal conditions are:

Process	Product Water Quality - p/m
Distillation	5 - 50
ED	350 -500 +
RO	100 -500
IX	0.01-300

Generally, an integrated design of pretreatment, desalting, and post-treatment must be made to obtain the desired water quality from a given feed water situation. Actually, water can be produced at any quality between the lower limit and the feed water quality.

B.1.d. Energy

All desalting processes require a form of energy in order to operate. An analysis of energy required for the various processes, expressed as a percentage of the cost of the desalted water, is shown below.

Process	Steam	Electricity	Fuel	Total
MSF	40	7		47
VTE-MSF	49	5		54
VC-VTE-MSF			21	21
RO		12		12
ED		18		18

The availability of energy by type and source is a major consideration. There are no fossil fuel sources in the Yuma area. Natural gas is piped in for residential use, but supply to new customers has been curtailed. The Yucca Powerplant, adjacent to the site, presently utilizes fuel oil. Electric power appears to be the most reasonable energy source.

B.1.e. Feed Water Source

Feed water source relates to quantity, quality, and variations in supply. These factors are all variable at the Yuma site. All the processes can be designed to operate within the range of fluctuations expected.

B.1.f. Reject Disposal

Reject disposal presents an important consideration in plant design. Possible methods of disposal are discharge to surface waters, deep well injection, solar evaporation, and further concentration followed by evaporation to dryness through crystallization.

Discharge has been selected for the Yuma Desalting Plant. The plant reject stream will flow through the Bypass Drain to the Santa Clara Slough in Mexico.

B.1.g. Site Location

Desalting plants are normally located where all of the following conditions exist:

1. Proximity to saline water resources
2. Shortage of other economic, good quality water resources
3. Growing water needs

The location for the Yuma Desalting Plant is generally defined by legislation and the physical location of the feed water.

B.1.h. Environmental Factors

Desalting plants must be planned, designed, and operated to minimize the effects of thermal, reject, chemical, and air pollution. The planning and design effort has considered these factors.

Ionic processes eliminate the thermal pollution effect. Transporting waste brines to the Santa Clara Slough should improve the Slough's condition since the design reject stream salinity will be less than the salinity of the Slough's water. Chemicals used in a process require neutralization and disposal. The RO and ED processes generally use fewer chemicals that require disposal. Air pollution is not expected to be a factor in process selection.

C. Comparison of Processes

In theory, for an ideal process, the thermodynamic work required for salt removal is the same regardless of the method employed.

Commercial evaporation-distillation processes produce 8 to 20 pounds of product water for each 1,000 British thermal units (Btu) of thermal energy input. At $0.0018 per pound, 1,000 Btu times the energy cost for the most efficient units is about $0.75/1,000 gallons. Modern distillation plants normally employ energy recovery systems to recapture some of the thermal energy in the form of electrical energy, thus reducing overall energy costs while operating.

Electrodialysis requires energy in direct proportion to the quantity of salts to be removed. Power consumption is generally 5 kilowatthours (kWh) per 1,000 gallons of product per 1,000 p/m reduction in salinity for the process, and 3 kWh/1,000 gallons of product for pumping.

Reverse osmosis processes use hydraulic pressure to force the feed water through a membrane. Like electrodialysis, it uses energy at a rate depending on the quantity of salts to be removed, but not in direct proportion. Energy requirements for pumping are about 15 kWh/1,000 gallons of product at normally used pressures (300 to 400 pounds per square inch [lb/in^2]).

C.1. Process Cost Comparison

Relative comparisons of costs of desalting processes are shown on Table 10 for plant investment and water production. A further source of information (*Water Desalting*, 1974; A. A. Delyannis and E. A. Delyannis)[17] cites the results tabulated below.

TABLE 10 1/

PLANT INVESTMENT AND WATER PRODUCTION COSTS RELATIVE
TO A 10-MGAL/D MULTISTAGE FLASH REFERENCE PLANT
Colorado River Basin Salinity Control Project
Title I Division, Yuma Desalting Plant, Arizona

Process Description	Feed Water	Relative Plant Investment Percent Plant Capacity, Mgal/d					Relative Water Costs Percent Plant Capacity, Mgal/d				
		1	5	8	10	50	1	5	8	10	50
Multistage Flash (MSF)	Sea water				100	82				100	79
Vertical Tube Evaporator (VTE-MSF)	Sea water				79	59				89	69
Vapor Compression (VC-VTE-MSF)	Sea water			109					87		
Vacuum-Freeze Vapor-Compression (VF-VC)	Sea water	179	154				161	129			
	5,000 p/m	134	116				134	108			
Reverse Osmosis (RO)	5,000 p/m	89			55		111			69	
	2,500 p/m	80			50		103			65	
Electrodialysis (ED)	4,000 p/m	93			59		113			71	
	2,500 p/m	75			48		85			55	

1/ Extracted from *Desalting Handbook for Planners*, U.S. Department of the Interior, Office of Saline Water and Bureau of Reclamation, 1972; Table 5-2.

Comparison of Costs for Various Processes

Process	Plant Capacity	Percent Plant Capital Cost	Percent Energy Cost
MSF	50 Mgal/d	33	47
VTE-MSF	50 Mgal/d	27	54
VC-VTE-MSF	8 Mgal/d	40	21
VF-VC	5 Mgal/d	39	22
RO	10 Mgal/d	23	12
ED	10 Mgal/d	25	18

The percents of maintenance and replacement are 32 and 15 percent for RO and ED, respectively, primarily for membranes. Studies and testing programs are being conducted to improve membrane life and lower manufacturing costs.

C.2. Plant Investment and Operating Cost Comparison

Accurate information on costs is difficult to obtain. Costs quoted often do not define plant limits or equipment lists. Reported operating costs are practically nonexistent, and those available use widely varying bases or methods, making comparison difficult. Many of the plants are built by foreign companies and/or in foreign countries, further complicating economic analysis. The following costs must be considered in light of these factors.

Over the last 5 years, installed capital costs for distillation have varied from \$1.24 per daily gallon (dgal) to \$2.21/dgal for seven plants considered. The 48 Mgal/d plant at Hong Kong costs \$1.24/dgal. A recent bid for a 2.4 Mgal/d plant in Abu Dhabi was \$2.00/dgal, showing the effect of recent material cost increases.

The operating cost for the 2.25 Mgal/d Key West Plant was projected to be \$0.85/kilogallon (kgal), but current estimates are \$2.90 to \$3.00/kgal due primarily to increased fuel costs. The operating costs for two 0.3 Mgal/d plants in Nicaragua were quoted at \$1.91/kgal with \$0.80/million Btu steam, \$50/ton sulfuric acid, and 15 mils/kWh electric power.

The only information readily available on electrodialysis is from Ionics, Inc. In the last 5 years, they have bid several plants at \$0.50/dgal. These include the 4 Mgal/d Corfu Plant in Greece and the Sorrento Shores addition in Florida. Other figures quoted are \$0.57/dgal for a 0.8 Mgal/d plant and \$0.48/dgal for a 2.4 Mgal/d plant. The Orange County Water District 5 Mgal/d plant was bid by Ionics, Inc. at \$.77/dgal.

Operating costs are scarce. A report by DSS Engineers, Inc. (Paragraph E.), *Commercial Membrane Desalting Plants, Data and Analysis* [30], gives recent operating costs on four ED plants, one in Wyoming and three in Florida. The costs are:

Gillette, Wyoming (ED)	- \$1.23/kgal at 21.6 percent load factor
Sanibel Island, Florida (ED)	- \$0.97/kgal at 62.1 percent load factor
Siesta Key, Florida (ED)	- \$0.52/kgal at 60.7 percent load factor
Sorrento Shores, Florica (ED)	- \$1.22/kgal at 87 percent load factor

The plant sizes are 1.5 Mgal/d, 1.2 Mgal/d, 2.0 Mgal/d, and 70,000 gallons per day (gal/d), respectively. The high cost at the Gillette Plant is due to low utilization; that of the Sorrento Shores Plant is due to the small size.

Reverse osmosis operating costs given in the DSS report, for the Ocean Reef Plant (930,000 gal/d) and the Rotunda West Plant (500,000 gal/d), are as follows:

Ocean Reef, Florida (RO)	- \$0.895/kgal at 75 percent load factor
Rotunda West, Florida (RO)	- \$1.25/kgal at 47.5 percent load factor

D. Process Selection Conclusions

Based on the preceding parameters and comparisons, the ion exchange process is not considered applicable to the Yuma Desalting Plant. Specifically, feed water salinities are excessive, as are chemical disposal requirements by comparison with distillation and membrane processes. It is further concluded that distillation processes would be more expensive than the membrane processes. Electrodialysis and reverse osmosis processes are, therefore, technically and economically preferred for the Yuma Desalting Plant.

E. Membrane Plant Operating Experience

During the past several years, the number of membrane desalting facilities in commercial operation has grown tremendously. The Office of Water Research and Technology's *Desalting Plants Inventory Report No. 5* lists a total of 370 membrane plants having a capacity of 25,000 gallons or more per day worldwide as of January 1, 1975. Two hundred and twelve of these, over half the total, were ordered during the 2-year period 1973 to 1974.

On May 16, 1974, DSS Engineers, Inc., was authorized by the Office of Water Research and Technology, under Contract No. 14-30-3275, to review, analyze, and summarize the design, operation, and maintenance of 11 commercial membrane desalting plants. These plants ranged in size from 2,500 gal/d to 2.0 Mgal/d and included four electrodialysis and seven reverse osmosis installations. In the concluding report [30], emphasis is placed on operating experience and problems, including brackish water supply and pretreatment, membrane scaling and fouling, equipment and material failures, and field modifications. Information on six of the larger plants includes performance and production cost analyses over extended operating periods.

Several operating plants were visited and analyzed by Government personnel during preliminary investigations for the Yuma Desalting Plant. The following conclusions were extracted from the DSS report and generally correspond with conditions observed by Government personnel.

E.1. Conclusions

The general conclusions in the report, based on the membrane desalting plants surveyed, are set forth in two categories: design and operation.

E.1.a. Design

Raw water pretreatment systems have not been satisfactory as installed in the majority of these plants. The omission of acid injection systems is responsible for most problems.

There seems to be no consensus on the selection of high pressure feed pumps for reverse osmosis systems. Three distinct types of pumps have been used in the plants surveyed: positive displacement piston, multistage centrifugal, and two-stage conventional centrifugal.

Corrosion of copper alloys, stainless steels, aluminum, cast iron, and carbon steels has occurred in raw water service at one plant or another. No universally applicable set of materials selection seems possible because of the great variety of raw water constituents and concentrations encountered.

Plastic pipe and fittings do not corrode, but are subject to cracking due to vibration and, in at least one case, attack by an oxidizing acid.

E.1.b. Operation

Scaling of electrodialysis membranes by calcium carbonate or calcium sulfate has occurred, to some extent, at all electrodialysis plants. This problem has been effectively dealt with by feed water pretreatment, chemical and mechanical cleaning, and polarity reversal operation.

Organic fouling of both reverse osmosis and electrodialysis membranes has been a more persistent problem than scaling. Chemical cleaning with a caustic brine solution has been moderately effective against organic slime in electrodialysis plants. Enzyme detergent flushing has been used at some reverse osmosis plants.

Raw water supply problems have been experienced in the areas of supply shortage, increasing salinity or TDS, excessive suspended solids, and corrosiveness.

Unit treatment costs have generally been much higher than predicted. In addition to the rapid cost escalation which occurred during the operating period surveyed, high unit costs are attributable to low plant load factors, which are caused by low water demand, raw water shortage, and inadequate pretreatment systems.

The rate of membrane performance deterioration with time is low for both electrodialysis and reverse osmosis, if membranes are kept clean.

Except for a plant on St. Croix, the reverse osmosis plants located outside the continental United States have generally suffered from lack of proper maintenance.

E.2. Recommendations

The report's general recommendations, based on the membrane desalting plants surveyed, are also set forth in two categories: planning and design, and operation.

E.2.a. Planning and Design

The quality and quantity of the raw water source must be firmly established before the specification of a treatment plant. This is the single most important technical consideration in the planning of a treatment facility.

Extreme care should be exercised in the design of the raw water pretreatment systems, especially with respect to the equipment selected, to control and monitor feed water chemistry.

The safety hazards posed by acid injection systems should be given careful consideration. Recommendations of the Manufacturing Chemist's Association should be followed in the design of storage and handling facilities.

To assure adequate service and parts availability, maintenance requirements should be fully assessed before purchasing a treatment system or entering into a maintenance contract.

Multiple high-pressure feed pumps, operating in parallel, should be used for all but the smallest reverse osmosis systems.

The use of aluminum for wetted parts in raw water or brine service should be generally avoided unless the alloy is carefully selected for a particular installation and measures are taken to minimize electrolytic corrosions.

Where plastic piping is used, special attention should be given to piping design to prevent failure from vibration or other mechanical damage.

A piped-up or quickly connected cleaning system is desirable for both reverse osmosis and electrodialysis plants.

E.2.b. Operation

Plants should be operated 24 hours a day to minimize startups and unit water treatment costs. This is predicated upon adequate demand and storage facilities.

Plant operation may be partly unattended if adequate supervisory instrumentation is installed.

Detailed accounts of operating costs should be kept, even for small plants, to allow periodic determination of unit treatment costs for comparison purposes.

Treatment plant personnel should include the following:

1. Operators with general knowledge of mechanical and electrical equipment operation and maintenance and with specific training in membrane plant operation.

2. For larger plants, a technician to maintain instruments and monitor plant performance.

A complete chemical analysis of raw and product waters should be made several times a year.

F. Yuma Desalting Test Facility

The Yuma Desalting Test Facility is located east of Yuma, adjacent to the Wellton-Mohawk Main Conveyance Channel at the bifurcation of the Gila Gravity Main Canal and the Wellton-Mohawk Canal. Its purpose is to test pretreatment processes and membrane desalting equipment to potentially be supplied for the Yuma Desalting Plant by utilizing actual Wellton-Mohawk drainage as feed water. (See photograph No. P1292-300-01138.)

The facility is an outgrowth of a mobile test facility originally constructed by the Office of Water Research and Technology (formerly the Office of Saline Water). The mobile test facility was located at the present site in 1971 in support of Departmental studies on various phases of the Colorado River Water Quality Improvement Program. It was expanded through the installation of a larger intake and pretreatment system in 1973.

After this expansion, desalting membrane manufacturers were invited to bring test units to the facility at no cost to the Government. The Government was to provide acceptable pretreated drainwater, since raw drainwater is not suitable for use directly in desalting equipment. Initially, seven manufacturers responded; they were (1) ROGA Division of Universal Oil Products (spiral wound RO), (2) Envirogenics (spiral wound RO), (3) Dupont (hollow fine fiber RO), (4) Dow (hollow fine fiber RO), (5) Dow Asahi (sheet flow ED), (6) Ionics (tortuous path ED), and (7) Westinghouse (tubular RO). All of these units except Westinghouse and Envirogenics have been in continuous operation since they were connected to the feed water in late 1973 and early 1974. Other manufacturers have since expressed interest, and two, Aqua Chem (sheet flow ED) and Hydranautics (spiral wound RO), were both put on line in late 1975.

Major objectives of the test program are:

1. To provide the Bureau of Reclamation and desalting equipment manufacturers data on desalting modules and equipment operating on pretreated drainwater.

2. To allow desalting equipment manufacturers to gain confidence in their equipment for operating on the pretreated water.

3. To provide, in part, information for evaluation of desalting equipment proposed for the Yuma Desalting Plant.

4. To test pretreatment systems and to optimize pretreatment system parameters.

The overriding constraint on the testing is that it is for the benefit of the Yuma Desalting Plant and, thus, units which are clearly inappropriate are not to be tested.

While occupying the same site, the facility has grown from an original throughput of 100 gallons per minute (gal/min) to over 1,100 gal/min and from six membrane test

YUMA DESALTING TEST FACILITY

units with a total capacity of less than 60,000 gal/d to 10 units, the largest of which produces 175,000 gal/d. Nearly all units presently being tested utilize membrane elements that are of commercial size and configuration and are generally representative of the size and type which will be purchased for the Yuma Desalting Plant. Flow paths, unit productivity, and operating parameters have been selected to meet this requirement.

The pretreatment system has been similarly designed to be representative of the system planned for the Yuma plant. Several systems, including filtration, diatomaceous earth, potassium permanganate, manganese zeolite, and alum flocculation have been screen tested since 1974. A partial cold-lime system has consistently provided the best and most reliable results, and projected economics show it to be the most attractive system.

Testing at the facility is scheduled to continue well into the project schedule; potentially, even through installation of equipment in the Yuma plant. This testing includes both membrane equipment operation and pretreatment optimization.

The facility is currently being operated by Burns and Roe, Inc., of Paramus, New Jersey, under a cost-plus-fixed-fee contract that terminates June 30, 1977.

G. Optimization

It is intended that the desalting plant operate as near optimum as possible, under systematic regulation of the variables affecting such operation. Economic considerations and, in this case, the associated legal commitments, serve as a basis for plant optimization.

In the *Preliminary Engineering Analysis* [20], by Burns and Roe, Inc., under contract to the Office of Water Research and Technology, a base case design was developed for a plant which would be split among electrodialysis, hollow fine fiber reverse osmosis, and spiral wound reverse osmosis processes. This "plant split" served to: (1) establish guidelines for the development of bid packages; (2) provide a basis for evaluation of those bids; (3) identify relationships among the different processes; (4) establish a technically feasible plant design that would accommodate the required detail of each possible offering; and (5) provide the maximum amount of information on the design of large membrane plants. The Bureau of Reclamation, while in agreement with these factors, also concluded that no single manufacturer had the capability to bid on the entire plant nor produce the required amount of equipment in the time provided and, therefore, decided that under such conditions the most viable plant design would include a combination of manufacturer's equipment. Consequently, because no process was demonstrably superior, and due to evaluation of results at the Yuma Desalting Test Facility (see Chapter VI, subsection B.2.a.), it was decided to incorporate the three processes into the plant design. Each process was assigned a segment of the plant equivalent to 20 Mgal/d of product water. The remainder of the plant, although unspecified as to process, is expected to perform as the average of the three 20 Mgal/d segments.

Optimization of the actual processes was the result of preliminary studies conducted by the Bureau of Reclamation, Engineering and Research Center. Identical optimization procedures were used for the two reverse osmosis processes. The basis for the optimization was the least annual cost under full design operation. Assuming that the overall water recovery and the total salt removal is fixed, the annual cost is equivalent to the cost per unit of salt removed from the water. The first independent variable considered was the time the membrane element had been in operation. The optimization determined the membrane life, or replacement period, which resulted in the lowest salt removal cost. The parameters considered were pumping cost, membrane ownership cost, mechanical equipment ownership cost, plant structures ownership cost, pretreatment cost, operation and maintenance costs, cost of water lost in reject, and costs insensitive to membranes.

The electrodialysis optimization was based on physical design parameters which fell midway, in performance and physical size, between that of two electrodialysis equipment manufacturers. The product salinity required from the process was set at 622 p/m, which allows for an average blend flow sufficient to take up the expected variation in MODE flow volume. This product salinity, plus the restriction that the inlet pressure to the first stack cannot exceed 60 lb/in^2, permitted determination of the optimum number of stages and the conditions under which each stage would operate, including the flow per cell pair and the current for each stage.

In a further effort to optimize plant performance, each manufacturer providing desalting equipment for the Yuma Desalting Plant will be required to warrant that the type and amount of equipment he provides will produce the required quantity and quality of product when operated under specified operating conditions. The supplier will also be required to guarantee the performance of each individual membrane element for a minimum specified period. Both the product quantity and quality will be included. Any element determined not to meet these specifications during the guarantee period will be replaced at the supplier's expense.

VIII. PROJECT FEATURES

Authorized project features include a desalting plant and appurtenant works, a bypass drain from the MODE-3 outlet to the Santa Clara Slough, a concrete siphon replacement of the old metal flume section of the MODE, an Irrigation Efficiency Improvement Program for the Wellton-Mohawk Division, which includes five separate subprograms, acreage reduction in the Wellton-Mohawk Division, Gila River control measures at Painted Rock Dam, and fish and wildlife mitigation measures.

A. Yuma Desalting Plant

A.1. Location

The proposed desalting plant site, the Yucca site, is about 4 miles west of Yuma, Arizona, adjacent to the MODE in the north half of sec. 36, T. 16 S., R. 21 E., of the San Bernardino meridian. The 60-acre plot measures about one-third mile along the east and south boundaries; the west and north boundaries follow the curve of the Cooper Lateral and the Yuma Valley Levee (see Photograph No. P1292-303-121 and Map No. 1292-300-40).

A.1.a. Soils and Foundations

The foundation material at the desalting plant site consists generally of:

0 to 10 feet	--Silt with minor clay and sand
10 feet to 105 feet	--Sand with scattered gravels and clay layers
105 feet to 170 feet	–Gravel with sand and gravelly sand layers
below 170 feet	–Sand, clay, and gravel interbeds

The depth to bedrock is estimated to be 1,000 feet and the water table is at a depth of about 13 feet.

The silt, being of low density, is quite compressible and is not considered an adequate foundation material for the larger, heavier structures where settlement and differential settlement are of major concern. Also, excessive strains could develop in this material during an earthquake. The relative density of the sand averages 60 to 70 percent, but varies widely. Some of the sands might be subject to liquefaction if a major earthquake should cause severe shaking at the plant site. However, the liquefaction would be sporadic over the area; more dense sands would not liquefy but less dense sands probably would.

The results of this liquefaction would probably be localized sand boils, which would produce a temporary loss of support in the boil area along with local settlements, and perhaps a general settlement of the entire area.

Various methods of in-place densification of the upper 50 feet of sands were investigated. All methods were very costly and it is doubtful if any of them could densify the sand enough to prevent the possibility of liquefaction. Based on these investigations, the decision was made to accept the possibility of sporadic liquefaction and to design the foundations to reduce the effects should it occur.

All the silty material is to be removed and recompacted under each of the major structures and a gravel pad is to be provided. The gravel pad will reduce differential settlement and will also provide a drainage path to reduce the effects of sand boils beneath the structure. The plant area is to be built up about 3 feet to elevation 125.0. This will increase the effective pressure on the sands and make them less susceptible to liquefaction. The compaction involved in building up the area should also reduce future settlement.

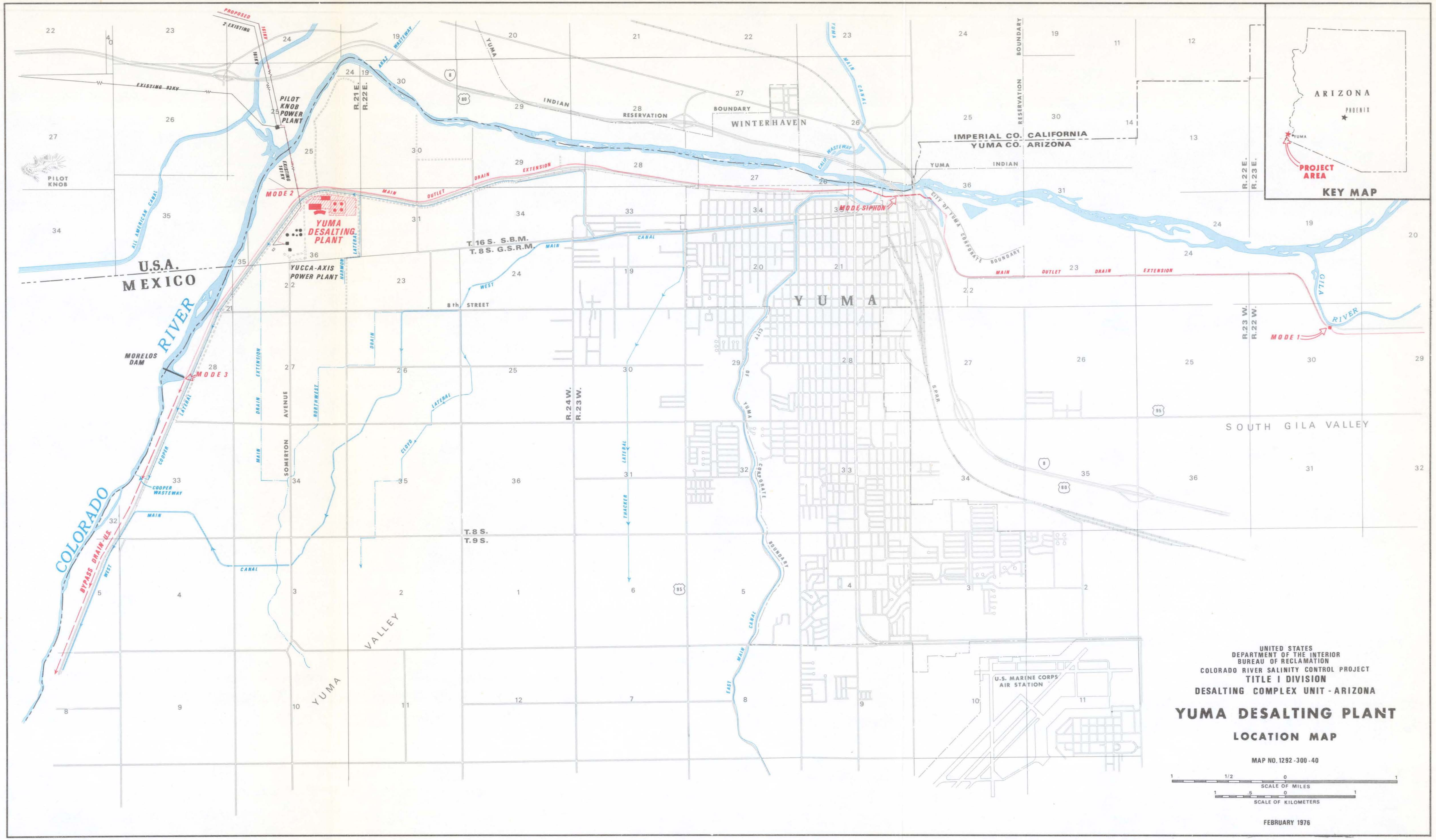
Raft-type foundations will be used for the major structures to reduce foundation pressures, thereby reducing settlement, and to minimize the effect of sand boils on the total structure. Eccentric loadings on structures will be avoided to help equalize foundation pressures and minimize differential settlements. Earthquake analyses indicate that most of the amplification of accelerations occurs in the upper few feet of soil, so the foundations will be kept as low as possible to reduce the earthquake accelerations on the structures.

The intrusion of foundations below the water table will be minimized. Flotation of some structures becomes a problem if they are founded too far below the water table; the unwatering operations required to excavate for and construct the structures in the permeable sand become difficult and very expensive.

A.1.b. Alternate Sites

Seven alternate desalting plant sites were examined in the field in January 1975, at the appraisal level. The prospective sites – the Dome Narrows site, the Dome site, the Fortuna Wasteway site, the Pilot Knob sites, the Prison Hill site, and the Yuma Valley Section 30 site – are located from 1 to 15 air miles distance from the Yucca site along the Colorado and Gila Rivers. Preliminary sketch mapping was done on 7-1/2-minute USGS quadrangle sheets and the surficial geology was briefly investigated.


YUMA DESALTING PLANT SITE
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona



KEY MAP
ARIZONA
PHOENIX
YUMA
PROJECT AREA
IMPERIAL CO. CALIFORNIA
YUMA CO. ARIZONA
YUMA DESALTING PLANT
YUCCA-AXIS POWER PLANT
PILOT KNOB POWER PLANT
PILOT KNOB
U.S.A.
MEXICO
COLORADO RIVER
GILA RIVER
MORELOS DAM
MODE 1
MODE 2
MODE 3
MODE SIPHON
MAIN OUTLET DRAIN EXTENSION
BYPASS DRAIN
ALL AMERICAN CANAL
YUMA MAIN CANAL
EAST MAIN CANAL
MAIN CANAL
WEST MAIN CANAL
COOPER WASTEWAY
WINTERHAVEN
YUMA
YUMA INDIAN RESERVATION BOUNDARY
CITY OF YUMA CORPORATE BOUNDARY
T.16 S. S.B.M.
T.8 S. G.S.R.M.
T.8 S.
T.9 S.
R.21 E.
R.22 E.
R.24 W.
R.23 W.
R.23 W.
R.22 W.
R.22 E.
R.23 E.
8th STREET
SOMERTON AVENUE
YUMA VALLEY
SOUTH GILA VALLEY
U.S. MARINE CORPS AIR STATION
S.P.R.R.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER SALINITY CONTROL PROJECT
TITLE I DIVISION
DESALTING COMPLEX UNIT - ARIZONA
YUMA DESALTING PLANT
LOCATION MAP
MAP NO. 1292-300-40
SCALE OF MILES
SCALE OF KILOMETERS
FEBRUARY 1976

The most viable of the six is the Dome Narrows site, located on the Gila River flood plain about 11 miles east of Yuma, Arizona, in parts of secs. 8 and 9, T. 8 S., R. 21 W., of the Gila and Salt River meridian. The site is wedge-shaped, and is bounded by the Gila Mountains on the south, the Wellton-Mohawk Canal on the north, and U.S. Highway 95 on the east. Subsurface exploration of the site revealed unconsolidated alluvial silts and/or clays from 7 to 20 feet thick overlying from 3 to more than 100 feet of clean, fine sand with subordinate silt and clay interbeds. Sandstone, siltstone, and claystone of undetermined thickness underlie the alluvium and rest upon crystalline bedrock. The ground-water table is within 12 feet of the ground surface.

Foundation exploration consisted of 17 drill holes through the alluvium into the indurated sediments. Penetration resistance tests were conducted and soil samples collected from the alluvium in 15 drill holes, and core samples of the sedimentary rocks were taken. Natural gamma, single point resistance, and self-potential geophysical logs were prepared for each drill hole. Six seismic refraction lines were completed to provide additional data on the thickness of the alluvium and characteristics of the indurated sediments.

A study plan layout was made for the Dome Narrows site. The wedge-shaped site restricted the arrangement of the pretreatment structures, configurations and size of various buildings, and the potential of future expansion of the pretreatment system. Although the site is located next to the highway, a railroad crossing would have to be constructed to provide rail service.

The Dome Narrows site would require two chutes over the Gila Gravity Main Canal, one for reject discharge and one for product water discharge. The existing Main Outlet Drain would be used for reject discharge. A channel for the product water, parallel to the Main Outlet Drain, would have to be constructed for a distance of approximately 7 miles to reach the Colorado River at its nearest point. This channel would require five check structures, two siphons, and an outlet structure into the Colorado River.

The Dome site, about 13 miles east of Yuma, is located on the Gila River flood plain between the railroad and the Wellton-Mohawk Canal, in parts of secs. 2 and 11, T. 8 S., R. 21 W., of the Gila and Salt River meridian. Thickness of the alluvium is not known. Depth to water table is about 12 feet. This site is the farthest from the Yucca site. No subsurface exploration was conducted at this site.

The Fortuna Wasteway site, about 9 miles east of Yuma, is located near the terminal end of the wasteway on the Gila River flood plain, in the southwest quarter of sec. 19, T. 8 S., R. 21 W., of the Gila and Salt River meridian. A small granitic outcrop rises about 30 feet above the flood plain. The ground-water table is 10 to 15 feet below ground surface. Subsurface exploration was not conducted; however, three seismic refraction lines were completed and indicated that depth to bedrock increases rapidly away from the bedrock outcrop.

The Pilot Knob sites are located in California between the Colorado River and the All-American Canal in parts of secs. 25, 26, and 35, T. 16 S., R. 21 E., of the San Bernardino meridian. Foundation materials include granite gneiss, terrace deposits, and flood plain deposits. The Pilot Knob sites are up to 200 feet above the Colorado River flood plain. The depth to the ground-water table is not known. No subsurface exploration was undertaken. Feed water and reject water conveyance structures across the Colorado River would be necessary.

The Prison Hill site, just east of Yuma on the Colorado River flood plain, is located in parts of secs. 22 and 27, T. 8 S., R. 23 W., of the Gila and Salt River meridian. As determined from logs of irrigation wells and one Bureau of Reclamation test hole, the alluvium is about 100 to 130 feet thick and consists of 10 to 20 feet of silt or silty sand overlying clean, fine sand with subordinate clay interbeds. Beneath the alluvium is a gravel layer from 10 to 20 feet thick which rests upon interbedded sand and weakly cemented sand. The depth to bedrock is not known. The depth to the ground-water table is 12 to 14 feet.

The Yuma Valley Section 30 site is located on the Colorado River flood plain about 1 mile northeast of the Yucca site, north of the Main Outlet Drain Extension, the Cooper Lateral, and the railroad, in sec. 30, T. 16 S., R. 22 E., of the Gila and Salt River meridian. Characteristics of the alluvial deposits are probably very similar to those at the Yucca site. The depth to the ground-water table is 12 to 14 feet.

A.2. Description of Desalting Plant

The actual desalting plant will be divided into two distinct systems, the pretreatment system and the membrane desalting system, and the description of each system's equipment will here be given in order of the flow through that system. A general arrangement of the facilities is shown on Drawing No. 1292-D-1075, and the annual mass balance of flows to be treated by the plant on Drawing No. 1292-300-42.

Flow to the pretreatment facilities will pass through the diversion structure in the MODE. The diversion structure will include a vertical bar trashrack followed by a constant head orifice turnout. The blend flow will pass on to the MODE bifurcation structure where it will be diverted into the MODE-2 channel. The MODE bifurcation structure will require automation of the existing radial gates for remote control.

From the constant head orifice turnout, the flow to the plant will pass through four parallel concrete pipes to the four grit sedimentation basins. Each grit sedimentation basin will be 50 feet square and contain a rotating mechanical arm to convey the grit to a sump from which it will be removed by pumps. From the grit sedimentation basins, the water will flow through a set of traveling screens to a common sump, an integral part of the grit sedimentation basin structure. The floating trash collected on the traveling screens will be washed from the screens and collected for disposal, and the wash water will be returned to the grit sedimentation basins.

The intake pumping system will consist of five 55.7 ft^3/s vertical turbine pumps (one a spare) which will pump the water to four solids contact reactors which will operate in parallel. Each solids contact reactor will be 175 feet in diameter, with a flash chemical mixing, flocculation, and settling section. The lime slurry, coagulant, and coagulant aid will be added to the water in the chemical mixing section.

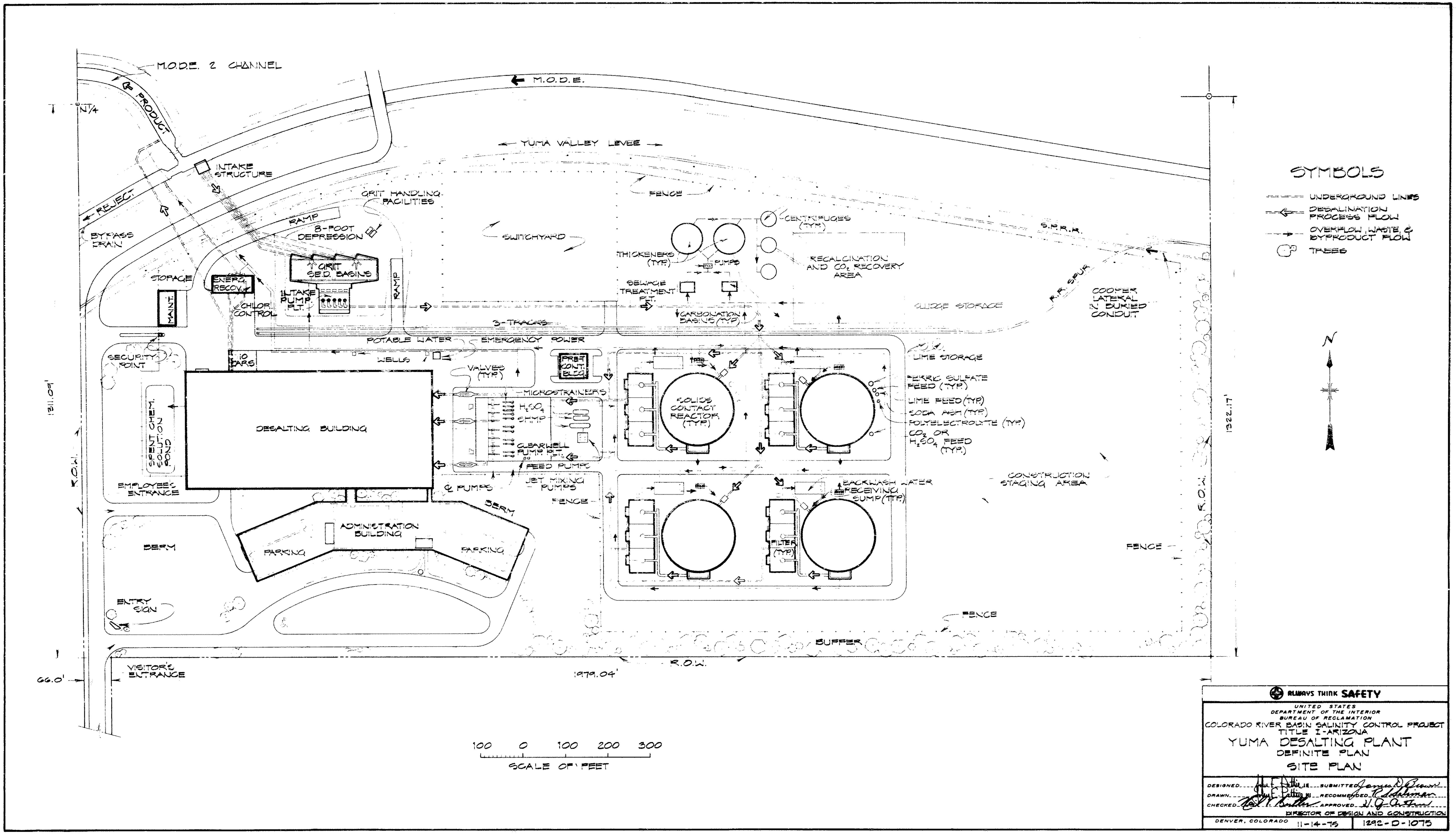
The lime, which will be stored in silos as calcium oxide (CaO), will then be stored on a shift basis, slaked with raw water to form calcium hydroxide ($Ca(OH)_2$) slurry, and pumped as a 10-percent solution by weight to the solids contact reactors. Ferric sulfate will be stored in a single storage bin, then on a shift basis, then mixed and pumped as a 5-percent solution to the solids contact reactors. Polyelectrolyte will also be stored in a single bin, then mixed and pumped as a 1-percent solution to the reactors. Each reactor will have individual chemical feed systems, piping systems, and controls so that one unit can be shut down for maintenance and started up without interfering with the operation of the other three units.

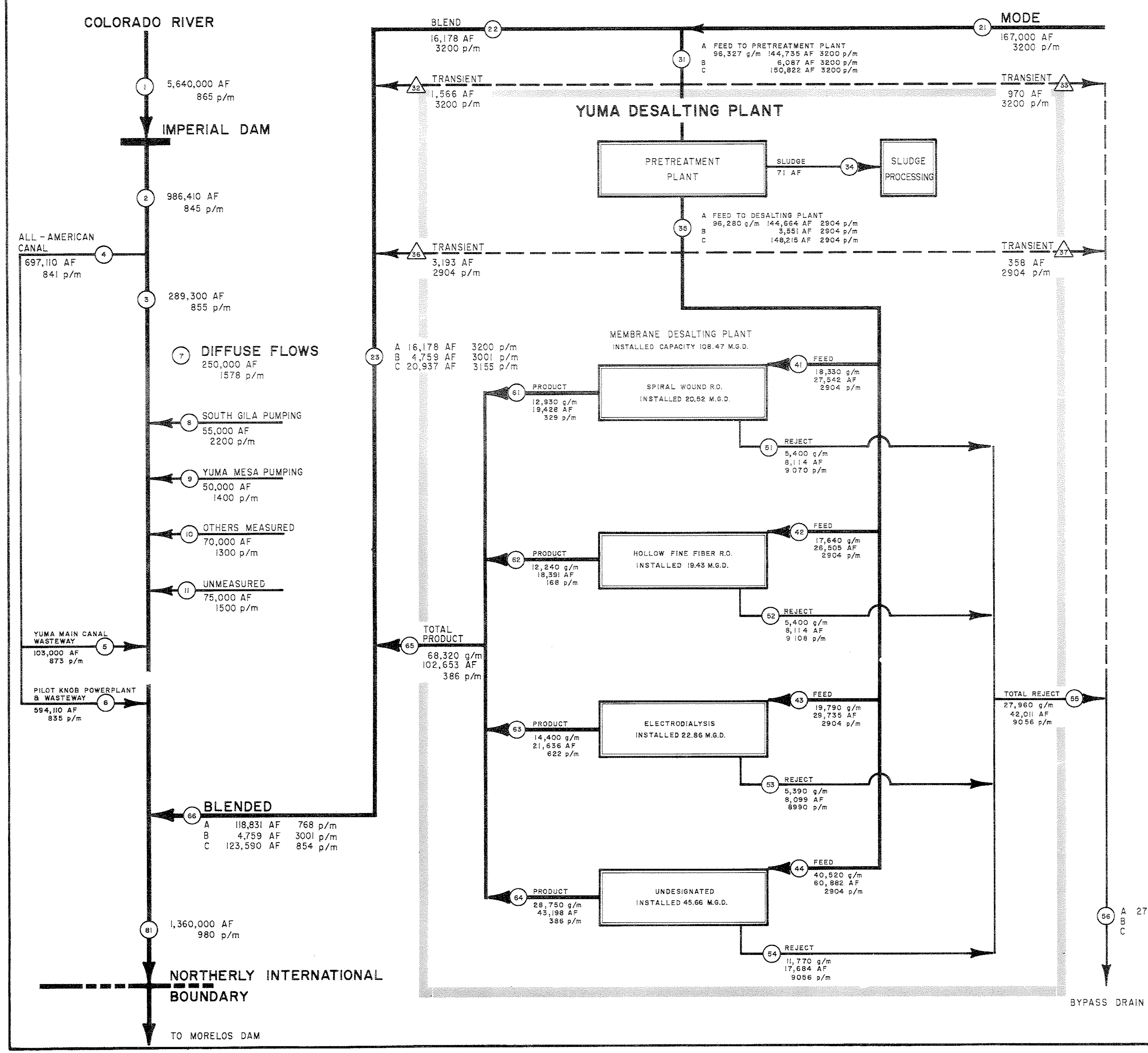
Within the solids contact reactors, the water mixed with the chemicals will flow through the flocculation section and sludge blanket and upward through the settling section. Mechanical agitation will assist flocculation. Rotating mechanical scrapers will move the sludge to a sump from which part will be recycled and the remainder removed to the thickeners. Sludge will be recirculated, as required, to improve solids contact reactor performance; the remainder will go through a concentration system consisting of two 70-foot-diameter thickeners and a centrifuge system which will concentrate the sludge to 60 percent solids. This sludge will be recalcined or disposed off site.

From the settling section of the solids contact reactor, the water will overflow into the launder and then to the gravity filters. Between the launder and the gravity filters, the pH of the water will be adjusted to 8.0 by the addition of carbon dioxide (CO_2) gas or sulfuric acid. Each solids contact reactor will have its own set of gravity filters, about 170 feet by 60 feet, consisting of 12 separate filter cells.

The filter structure will contain storage for backwash water and the filter cells will be backwashed sequentially. The spent backwash water, containing the solids removed from the filter, will be returned to the solids contact reactor inlet. The filtered water will then flow to the clear well. The clear well will provide for storage of pretreated water and serve as a sump for the pumps of the membrane desalting plant. The clear well will be 175 feet wide by 152 feet long with a capacity of 2.7 million gallons, about a 30-minute supply for the desalting plant when operating at design capacity.

Ten 24 ft^3/s vertical turbine pumps (one a spare) will be installed in the clear well, each with its own sump. It will be possible to install stop logs so that individual pumps can be serviced with water still in the clear well. All pumps will discharge through separate microstrainers to a single manifold. From this manifold, the pretreated water will go directly to the electrodialysis section of the plant or to the high-pressure reverse osmosis pumps. There will be seven of these high-pressure pumps (one a spare), each rated at 22.3 ft^3/s. The discharge pipes from the pumps will join in a single manifold.


M.O.D.E. 2 CHANNEL
PRODUCT
N 1/4
M.O.D.E.
YUMA VALLEY LEVEE
INTAKE STRUCTURE
REJECT
BYPASS DRAIN
GRIT HANDLING FACILITIES
RAMP
8-FOOT DEPRESSION
SWITCHYARD
FENCE
THICKENERS (TYP.)
PUMPS
CENTRIFUGES (TYP.)
RECALCINATION AND CO_2 RECOVERY AREA
S.P.R.R.
STORAGE
MAINT.
ENERG. RECOV.
GRIT SED. BASINS
INTAKE PUMP PLT.
CHLOR. CONTROL
RAMP
SEWAGE TREATMENT PLT.
CARBONATION BASINS (TYP.)
SLUDGE STORAGE
R.R. SPUR
COOPER LATERAL IN BURIED CONDUIT
3-TRACKS
POTABLE WATER
EMERGENCY POWER
SECURITY POINT
10 CARS
WELLS
VALVES (TYP.)
PREF. CONT. BLDG.
LIME STORAGE
FERRIC SULFATE FEED (TYP.)
LIME FEED (TYP.)
SODA ASH (TYP.)
POLYELECTROLYTE (TYP.)
CO_2 OR H_2SO_4 FEED (TYP.)
MICROSTRAINERS
H_2SO_4 SUMP
CLEARWELL PUMP PLT.
FEED PUMPS
SOLIDS CONTACT REACTOR (TYP.)
1311.09'
1322.17'
R.O.W.
SPENT CHEM. SOLUTION POND
DESALTING BUILDING
EMPLOYEES ENTRANCE
PUMPS
JET MIXING PUMPS
FENCE
BACKWASH WATER RECEIVING SUMP (TYP.)
CONSTRUCTION STAGING AREA
BERM
ADMINISTRATION BUILDING
PARKING
PARKING
BERM
FILTER (TYP.)
FENCE
ENTRY SIGN
FENCE
BUFFER
R.O.W.
VISITOR'S ENTRANCE
66.0'
1979.04'
N
SYMBOLS
UNDERGROUND LINES
DESALINATION PROCESS FLOW
OVERFLOW, WASTE & BYPRODUCT FLOW
TREES
100 0 100 200 300
SCALE OF FEET
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
TITLE I-ARIZONA
YUMA DESALTING PLANT
DEFINITE PLAN
SITE PLAN
DESIGNED
SUBMITTED
DRAWN
RECOMMENDED
CHECKED
APPROVED
DIRECTOR OF DESIGN AND CONSTRUCTION
DENVER, COLORADO
11-14-75
1292-D-1075



DESIGN CAPACITY MASS BALANCE QUANTITIES

FLOW DIAGRAM * TOTAL TO NIB: FLOW 1/	COMPONENT FLOWS	EFFECTIVE DAYS PER YEAR	FLOW RATE: FT³/S	GAL/MIN	MGAL/D	FLOW VOLUME * TOTAL TO NIB: AF/D	AF/YR: MASS BALANCE	ROUNDED	FLOW SALINITY * TOTAL TO NIB: P/M (USGS)	TONS/YR	PERFORMANCE: PRODUCT ÷ FEED	RECOVERY RATE %	TDS REDUCTION: TONS/YR	%
1							5,640,000		865	6,630,000				
* 2	3+4						* 986,410	* 986,400	845	* 1,132,600				
3							289,300	289,300	855	336,200				
4	5+6						697,110	697,100	841	796,400				
5							103,000	103,000	873	122,200				
6							594,110	594,100	835	674,200				
* 7	8+9+10+11						* 250,000	* 250,000	1578	* 537,200				
8							55,000	55,000	2200	164,500				
9							50,000	50,000	1400	95,100				
10							70,000	70,000	1300	123,700				
11							75,000	75,000	1500	153,900				
21	22+31C						167,000	167,000	3200	726,400				
22		340	24.0	10,760	15.48	47.6	16,178	16,200	3200	70,300				
23A	22	340	24.0	10,760	15.48	47.6	16,178	16,200	3200	70,300				
23B	32+36						4,759	4,700	3001	19,400				
23C	23A+23B						20,937	20,900	3155	89,700				
31A	34+35A	340	214.6	96,327	138.73	425.7	144,735		3200	631,100				
31B	32+33+35B						6,087		3200	25,000				
31C	31A+31B						150,822	150,800	3200	656,100				
32		15					1,566	1,500	3200	6,800				
33		2.35					970	1,000	3200	4,200				
34		340	0.1	47	0.07	0.2	71	100		59,800				
35A	41+42+43+44	340	214.5	96,280	138.66	425.5	144,664		2904	571,300				
35B	36+37						3,551		2904	14,000				
35C	35A+35B						148,215	148,200	2904	585,300				
36		7.75					3,193	3,200	2904	12,600				
37		0.87					358	300	2904	1400				
41	51+61	340	40.8	18,330	26.39	81.0	27,542		2904	108,800				
42	52+62	340	39.3	17,640	25.40	78.0	26,505		2904	104,700				
43	53+63	340	44.1	19,790	28.51	87.4	29,735		2904	117,400				
44	54+64	340	90.3	40,520	58.36	179.1	60,882		2904	240,300				
51		340	12.0	5,400	7.77	23.9	8,114		9070	100,100				
52		340	12.0	5,400	7.77	23.9	8,114		9108	100,500				
53		340	12.0	5,390	7.78	23.8	8,099		8990	99,100				
54		340	26.3	11,770	16.95	52.0	17,684		9056	217,700				
55	51+52+53+54	340	62.3	27,960	40.27	123.6	42,011	42,000	9056	517,400				
56A	55	340	62.3	27,960	40.27	123.6	42,011	42,000	9056	517,400				
56B	33+37						1,328	1,300	3120	5,600				
56C	56A+56B						43,339	43,300	8874	523,000				
61		340	28.8	12,930	18.62	57.1	19,428		329	8,700	61÷41	70.54	100,100	92.00
62		340	27.3	12,240	17.63	54.1	18,391		168	4,200	62÷42	69.39	100,500	95.99
63		340	32.1	14,400	20.73	63.6	21,636		622	18,300	63÷43	72.76	99,100	84.41
64		340	64.0	28,750	41.41	127.1	43,198		386	22,700	64÷44	70.95	217,600	90.56
65	61+62+63+64	340	152.2	68,320	98.39	301.9	102,653	102,700	386	53,900	65÷35A	70.96	517,300	90.56
											65÷31A	70.92	577,100	91.46
66A	22+65	340	176.2	79,080	113.87	349.5	118,831		768	124,200	66A÷(22+31A)	73.85	577,100	82.29
66B	23B						4,759		3001	19,400				
* 66C	66A+66B						* 123,590	* 123,600	854	* 143,600	66C÷21	74.01	582,700	80.23
* 81	2+7+66C						* 1,360,000	* 1,360,000	980	* 1,813,400				

NOTES

1/ SUBSCRIPT: A = NORMAL OPERATION AT DESIGN CAPACITY
B = OPERATIONAL TRANSIENT (STARTUP AND SHUTDOWN)
C = TOTAL ANNUAL QUANTITY

6-22-76 300-FRS	CORRECTED QUANTITIES

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
TITLE I DIVISION - DESALTING COMPLEX UNIT - ARIZONA

DESIGN CAPACITY MASS BALANCE DIAGRAM

ANNUAL DELIVERY OF WATER TO MEXICO
AT NORTHERLY INTERNATIONAL BOUNDARY
DEFINITE PLAN DESIGN

COMPILED F.R. SUMMERS, P.E. SUBMITTED F.R. Summers, P.E.
DRAWN LeRoy P. Sanchez RECOMMENDED W. A. Sezneline
CHECKED F.R.S., K.M.T., C.W.W., E.I.E. APPROVED [signature]

BOULDER CITY, NV. MAY 1, 1976 1292-300-42

From the pump area, three main feed headers will enter the membrane desalting equipment building, the low-pressure header from the vertical turbine pump to the electrodialysis section and the two high-pressure headers from the high-pressure pumps to the reverse osmosis sections. (The interior layout of the desalting building is shown on Drawing No. 1292-D-1076.) Three pipe trenches will carry the main piping to and from the individual segments of the plant. The segments will be arranged along the trenches, with each type of equipment along both sides of a single trench. Space will be provided at the end of the building for installation of the unassigned portion of the plant.

This end of the building will also contain the maintenance areas, installed cleaning system, and the main product and reject headers. The product will be piped from the main header via concrete pipe to the MODE-2 channel, through which it will flow to the Colorado River. The reverse osmosis reject header will extend to the energy recovery turbines located in a separate turbine building. Reject from the electrodialysis section will bypass the energy recovery turbines and join the reject from the reverse osmosis sections on the downstream side of the turbine building. The combined reject stream will then be piped to the Bypass Drain, where it will be conveyed to the Santa Clara Slough.

The main control center will be located in the administration building adjacent to the membrane desalting equipment building. This building will also contain the administrative offices and visitor's center.

A.2.a. Pretreatment System and Associated Works

The general arrangement of the pretreatment facilities are shown on Drawing No. 1292-D-1075. Under design conditions, 214.6 ft^3/s (138.73 Mgal/d) of the 238.6 ft^3/s (154.21 Mgal/d) MODE flow will be diverted to the pretreatment plant; the remaining 24.0 ft^3/s (15.48 Mgal/d) will be utilized as blend flow and be combined in the MODE-2 channel with the desalting plant product for discharge to the Colorado River.

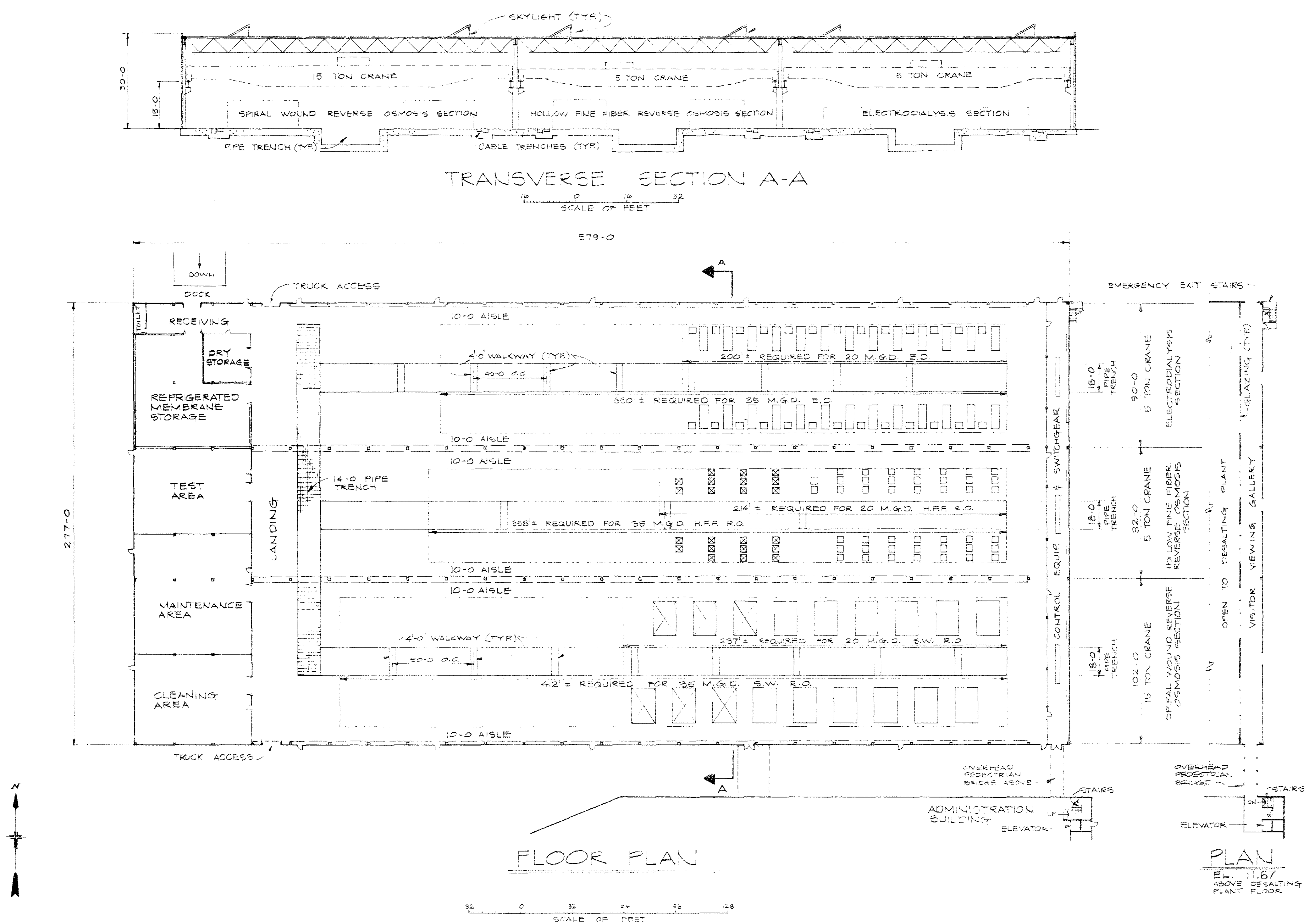
A.2.a.(1) Intake and Chlorination

The plant intake structure will consist of a constant head orifice turnout structure in the MODE. Four 48-inch pipes will convey the water from the MODE, under the Cooper Lateral, to the inlets of the grit sedimentation basins. A skimmer, to be located in the MODE in front of the turnout, will prevent much of the large size bedload sediment in the drain from entering the turnout structure. The 214.6 ft^3/s of MODE flow diverted to the pretreatment plant will be measured by a constant head orifice structure. This water will then flow through four 48-inch diameter precast concrete pressure pipes at a velocity of about 4.3 feet per second and into the inlets of grit sedimentation structures at a water surface elevation of 113.0. The turnout system will be capable of being operated at full capacity through only three of the pipes, in case one basin is out of service for maintenance.

The constant head orifice structure will consist of four sets of two slide gates each and measuring wells. The upstream gates, or orifice gates, will be 72-inch by 36-inch steel slide gates. These gates will be opened about 75 percent of the opening for full discharge. The downstream, or turnout, gates will be 48-inch by 48-inch cast iron slide gates, which will control the water depth below the orifice. These will be operated to maintain a head differential of 0.5 foot across the orifice for a discharge of 214.6 ft^3/s. The two measuring wells will indicate the difference in water surface elevations on upstream and downstream sides of the orifice gates. Flow through the structure will be varied by changing the area of the orifice gate openings.

The skimmer will be a horizontal concrete slab located 8 inches above the invert of the MODE. The top elevation of the slab will be the same as the inlet to the constant head orifice. The slab will extend the full width of the MODE and its length will be the same as the width of the constant head orifice structure. This arrangement will bypass the greatest concentration of sediment carried by the MODE into the MODE-2 channel and then into the Colorado River.

Four trashracks, each with a 2-hp motor, will be provided at the intake structure for the removal of material. Trashrakes, controlled by a differential water level sensing device, will automatically clean the trashracks. When the water level differential across the trashracks reaches a preset amount, the cleaning cycle will be initiated. Each trashrake will operate in sequence and will rake the material to the top of the trashrack structure and dump it onto a conveyor. The trashrack and trashrake will be constructed of steel. All portions mounted on the deck will be painted with red lead and enamel and all portions in contact with the water will be painted with VR-6.



ABBREVIATIONS

M.G.D. – MILLION GALLONS PER DAY

S.W. R.O. – SPIRAL WOUND REVERSE OSMOSIS

H.F.F. R.O. – HOLLOW FINE FIBER REVERSE OSMOSIS

E.D. – ELECTRODIALYSIS

SYMBOLS

FIRST DESALTING STAGE EQUIPMENT

SECOND DESALTING STAGE EQUIPMENT

CRANE RAIL

OUTSIDE LIMITS OF DESALTING EQUIPMENT

GRATING

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
TITLE I - ARIZONA

YUMA DESALTING PLANT
DEFINITE PLAN
DESALTING BUILDING
FLOOR PLAN AND SECTION

DESIGNED ... SUBMITTED ...
DRAWN ... RECOMMENDED ...
CHECKED ... APPROVED ...
DIRECTOR OF DESIGN AND CONSTRUCTION

DENVER, COLORADO NOV. 14, 1975 | 1292-D-1076

The raw MODE water will be chlorinated with 2-1/2 to 5 p/m of chlorine at the intake structure to kill algae and aquatic growth. After treatment with chlorine, most organic matter will settle out in the grit sedimentation basins. The normal dosage of chlorine will be 3,000 pounds per day (lb/d), with maximum dosages to 6,000 lb/d. The chlorine solution will be injected through four diffusers located in the intake structure downstream from the trashrack. After manually setting the dosage, the feed rate will be metered automatically in proportion to the flow rate through the turnout structure. Residual chlorine analyzers will be located in the intake pumping plant and at the clear well. A residual chlorine level of 0.5 p/m will be desirable at the clear well. Chlorine residence time to the intake pumping plant will be about 6 minutes; residence time to the clear well will be about 3 hours.

A sulfonator, injecting sulfur dioxide into the feed pipes to the desalting units, will provide for dechlorination when required. Maximum residual chlorine levels specified by membrane manufacturers range from 0.1 to 1 p/m. Desalting units requiring low levels of residual chlorine can be arranged along the same feed pipe(s) and dechlorinated to suit specifications.

An existing modified Parshall flume at the MODE-2 bifurcation will measure the total flow going into the Colorado River after the product water is mixed with the blend flow.

A.2.a.(2) Grit Sedimentation Basins

The grit sedimentation basins will be constructed to remove as much abrasive sand particles and suspended matter as possible in order to protect the intake pumps from excessive wear and to prevent a buildup of sediment in the forebay of the intake pumping plant. In addition, the grit sedimentation basins will reduce the sediment and sludge load to the solids contact reactors.

The grit sedimentation basins will consist of four reinforced concrete basins, each 50 feet square by 6 feet deep, with 2 feet liquid depth, and a rotary scraper mechanism. The water surface will be at elevation 112.9. The sediment will be pumped to a sediment separation area where four helical screw conveyors will be used to dewater it. The horizontal velocity through the basins will be 0.5 foot per second (ft/s). The adjustable weirs will permit operation of the basins with velocities varying from 0.4 to 0.7 ft/s. One basin could be taken out of service for maintenance while the other three would remain in operation; the velocity would then be about 0.7 ft/s.

The settling basins and separating equipment will remove most of the sediment particles larger than 0.105 millimeter (105 microns) and approximately 50 percent of the particles between 0.105 millimeter and 0.0625 millimeter (62.5 microns). The sediment removed will be on the order of 70 to 80 percent solids. Approximately 10,000 cubic yards of sediment per year are expected, which is an average of 30 cubic yards per day. The estimated maximum per day is 250 cubic yards. The sediment will be removed from the site and transported to a designated area for disposal.

The storage facility for the sediment handling system will have adequate capacity for at least 3 days' accumulation and, therefore, sediment disposal during weekends may not be required.

Since the basin and intake pumping plant area will be located at a lower elevation (elevation 117.25) than the rest of the site (elevation 125.0), storm drainage runoff from the lower area will be collected and diverted to the grit sedimentation basins.

The four grit sedimentation basins and their outlet will form one structure 206 feet long and varying from 55 to 66 feet wide. The bottom of the 18-inch base slab for this structure will generally be at elevation 109.4, with slightly deeper bases for intake areas and grit pump sumps. The outlet of these basins will serve as the inlet for the intake pumping plant and will have the bottom of its 24-inch base slab at elevation 104.0. The existing ground surface is about elevation 122.0 and the water table is about elevation 109.0. A description of the foundation treatment for the grit sedimentation basins has been combined with that of the intake pumping plant in Subparagraph A.2.a.(3).

A.2.a.(3) Intake Pumping Plant

The intake pumping plant will be an outdoor-type plant located directly adjacent to the downstream side of the grit sedimentation basins. It will be a reinforced concrete structure with a deck elevation of 117.75, sump floor elevation of 103.00, and a normal water surface elevation of 112.40. The plant will have a design capacity of 223 ft^3/s at a head of 40 feet, and will have five 25,000 gal/min pumps (one spare), each equipped with 350 horsepower (hp), 2,300 volt (V) induction motors. Each pump will weigh about 18,000 pounds, including the motor.

The flow will enter the pumping plant forebay through overflow weirs from the grit sedimentation basins. It will be channeled into five bays, each housing a traveling water screen. The traveling screens will remove moss and other debris. Each water screen will be of the vertical, traveling type with articulated chains of framed wire trays supported in the structure. The screens will be installed in stationary guides to facilitate removal as an integral unit. A bubble-type differential water level control will turn on the spray pump and screen drive motors for automatic cleaning. Cleaning cycles will be timed to allow cleaning of one screen at a time. The traveling water screens will be constructed with type 316 stainless steel wire cloth, chains, trays, and fasteners. The supported frame, guides, and other wetted parts will be fusion epoxy or coal-tar epoxy coated. Two screen spray pumps, each rated at 240 gal/min at a head of 231 feet, will be installed on the deck of the pumping plant. The pumps will be equipped with 30-hp motors and one will be a spare.

The five intake pumps will be connected to 36-inch-diameter pipes with sleeve-type couplings, and each discharge will be equipped with a 36-inch butterfly valve. The butterfly valves will be rubber or plastic lined with a replaceable, resilient seat. The discharges will be instrumented with sensors to indicate backflow through the pump. A backflow signal will initiate the closure of the corresponding valve. Motor operators on the valves will close the valves in 60 seconds. The butterfly valves in the discharge manifold will not be used for flow control; this will be handled by four flow controllers near the intake of each reactor-clarifier. The 36-inch-diameter discharge pipes will be manifolded into a single 72-inch-diameter pipe which will carry the water about 1,200 feet to the reactor-clarifier area. The pump discharge manifold will be lined with fusion epoxy, coal-tar, or some other suitable lining proven at the Yuma Desalting Test Facility. Exposed surfaces of the manifold will be coated with semigloss enamel. Motor controls for the pumps and traveling water screens will be housed under a sunshade. A 15-ton, 20-hp, mobile crane will be used to service the pumps and other equipment at the intake pumping plant.

The intake pumping plant will be 73 feet 9 inches long by 65 feet wide. The bottom of the 24-inch base slab for the pump sump will be at elevation 101.0 at the inlet and elevation 108.0 under the discharge manifold. The existing ground surface, water table, and final grade will be the same as those for the grit sedimentation basin structure. The base of both structures will rest on a 3-foot compacted gravel pad designed to reduce differential settlement and to reduce the effects of possible sand boils beneath the structures during an earthquake. The pumping plant area must be excavated to elevation 98.0, 11 feet below water table, and the grit basin area must be excavated to elevation 106.4, 2.6 feet below water table, to allow room for the gravel pad. Conventional dewatering of the excavation during construction is anticipated and no sheet piling or placement of concrete by tremie will be required.

The intake pumping plant will be connected directly to the main power supply through a 15-kilovolt (kV) cable. A secondary unit substation at the intake pumping plant will connect the cable to the motor control center. The motor control center will also have a secondary unit substation and will be connected by a 15-kV cable from the recovery generator.

A.2.a.(4) Solids Contact Reactors

Solids contact reactors were selected for partial lime softening and clarification rather than separate inline units for flash mixing, flocculation, and settling. Solids contact reactors provide flash mixing, coagulation, sludge recirculation, flocculation, settling, and sludge collection and removal within the reactor tank. To assure an adequate sludge recirculation rate, additional (external) sludge recirculation will be available by pumping sludge from the reactor sludge collection cone.

With lime as the treatment chemical for combined clarification and partial softening, the solids contact reactors will decrease the level of calcium in the feed water and reduce the addition of sodium hexametaphosphate (SHMP) needed to prevent or minimize scaling of desalting membranes by calcium sulfate. The lime process, with the addition of ferric sulfate coagulant and a polyelectrolyte coagulant aid, as required, will remove or reduce the level of feed water turbidity, organics, bicarbonates, iron, and manganese. This produces a suitable water for removal of any remaining suspended matter by the dual media gravity filters. Removal of most of the bicarbonates will greatly reduce the quantity of sulfuric acid or carbon dioxide needed to lower the pH for membrane desalting. Table 11 shows the projected pretreatment chemistry for the partial lime softening pretreatment process.

The feed water and other recycled water will be thoroughly mixed with recirculated and precipitated sludge, lime, and, occasionally, a coagulant and polyelectrolyte in the mixing zone of the reactors. Chemical feed to the reactors will be proportioned to feed water flow to maintain a selected pH as required by the water alkalinity. Precipitation of calcium carbonate will occur and floc particles of suspended colloidal solids will agglomerate to form a minimal depth sludge blanket with previously formed precipitates of calcium. In this manner, precipitation and equilibrium will be quickly established. The clarified supernatant effluent will be collected from an overflow weir at the top of the reactors, while the calcium carbonate sludge will be withdrawn from the bottom.

The total influent pretreatment flow, including recycled flows, will be 99,478 gal/min (143.2 Mgal/d), and this water will be clarifed and partially softened by the lime treatment process. The flow per reactor will be 24,870 gal/min. The four structural concrete reactors, each 175 feet in diameter with a 20-foot side water depth, will have an upflow rate of 1.0 gal/min per square foot and 150 minutes retention time.

The reactor components, such as the mixing and flocculation compartments, and effluent collection launders, will be fabricated of steel. Wetted portions of steel will be coated with coal-tar epoxy or other approved coatings.

Each reactor will have individual chemical feed systems, piping systems, and controls so that one unit can be started up or be down for maintenance without interfering with the operation of the other three units. With three units in operation during total flow, the upflow rate will be 1.33 gal/min per square foot with 112 minutes retention time. This rate and time are within normal acceptable reactor design parameters.

The reactor flash mixing, recirculation, flocculation, and sludge scraping will be by positive variable speed mechanical means. Each reactor will have a 25-hp motor for mixing, internal recirculation, and flocculation, and a 5-hp motor for the sludge scraper.

Optimum operation of the reactors is expected to require about 75 percent sludge recirculation; if not accomplished by internal recirculation, additional recirculation

Table 11
PRETREATMENT SYSTEM CHEMISTRY
YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Unit: mg/l

Constituent	Raw Water Composition 1/	After 200 p/m of 90 Percent Calcium Oxide
Calcium	258	145
Magnesium	90	85
Sodium	739	739
Potassium	9	9
Strontium	3	2
Bicarbonate	385	19
Carbonate	ND 2/	ND 2/
Chloride	870	870
Sulfate	1,011	1,011
Nitrate	1	1
Phosphate	<1	<1
Silica	25	23
Iron	<1	ND 2/
Manganese	1	ND 2/
pH	8.1	9.5
TDS (Σions)	3,392	2,904 4/
TDS (USGS)	3,200 3/	

1/ Typical for sequence No. 11, projected for year 1981 [26].

2/ Not detected.

3/ Fifty percent of HCO_3 concentration subtracted.

4/ For mass flow balance, 2,904 was used as also being the USGS TDS value.

will be accomplished by pumping sludge from the reactor sludge collection cone. Excess sludge will be continuously or intermittently withdrawn on a controlled time cycle and pumped to the recarbonation basins and then to the thickeners.

Each reactor will be provided with a bypass and overflow. Bypass water will be discharged to the reject drain. Overflow water will go to the backwash water receiving sump for recycling back to the reactors.

Each of the four reactor tanks will have an interior diameter of 175 feet. The outside diameter of the 10-foot-wide ring slab footing supporting the walls will be 186 feet. The bottom of the 24-inch-thick ring footing will be at elevation 121.0. The interior bottom slab of the reactor will slope down toward the center of the tank at 1 inch per foot. The bottom of the 12-inch interior bottom slab will vary from about elevation 122.0 at the outside edge to about elevation 115.0 near the center of the tank. The sludge sump in the center of the tank will have the bottom of the 24-inch base slab at elevation 108.0. The existing ground surface is about elevation 122.0 and the water table is about elevation 109.0. The final grade around the reactors will be at elevation 125.0. The foundation treatment under the reactors has been combined with that for the filters and both are described in Subparagraph A.2.a.(5).

The main source of electrical service to the reactors will be provided by a unit substation located in the center of the pretreatment area. The unit substation will be connected by a 15-kV cable from the main power supply.

A.2.a.(5) Dual Media Gravity Filters

The total clarified waterflow will be 98,158 gal/min (141.3 Mgal/d) or 24,540 gal/min to the filter installation per reactor. The gravity filter unit for a reactor will be a concrete structure consisting of 12 filter cells and three control centers located adjacent to each reactor. Some components of the filter control centers and inlet, outlet, and backwash system will be fabricated either of type 304 stainless or carbon steel. Wetted portions of carbon steel will be coated with coal-tar epoxy or other approved coatings.

The concrete structures will be 60 feet by 170 feet. The design filtration rate will be 3.0 gal/min per square foot and each filter cell will have an area of about 680 square feet for a flow of 2,046 gal/min. If one reactor-filtration system is out of service and the other three units process the full flow, the filter rate will be an acceptable 4.0 gal/min per square foot. The filter structure depth will be about 18 feet because backwashing of a cell will be by filtered water from the other cells, not from a backwash pump, at sufficient head to provide a wash rate up to 20.0 gal/min per square foot.

Each control center will automatically control the operating functions for four filter cells. Each control center motor will be 2.0 hp. All control centers will be connected to a centralized control system.

The filters will receive the clarified water and fine suspended matter overflow from the solids contact reactors. The function of the filters will be to remove fine suspended material and produce a product water with a turbidity of less than 0.5 Jackson Turbidity Unit and a plugging factor of less than 40 percent. Since a partial lime softening process will be used, most of the suspended material should be fine calcium carbonate crystals. To minimize incrustation of the filtering media, achieve more effluent filtration, and require the least amount of backwash water, the filter feed flow will be pH adjusted by acid or carbon dioxide to a pH of about 8.0.

Dual media filters have been selected to achieve deep bed filtration and provide longer and more uniform filter runs, requiring less backwash water. The filter media will have a total depth of 30 inches, consisting of 20 inches of anthracite over 10 inches of silica sand. To provide for uniform distribution of backwash water and to collect the filtered water, the filter media will be placed on a filter underdrain slab and 12 inches of gravel in several graded layers.

Operation of the filters, including inservice operation, drain down, air scour, backwash, and rinse will be automatic, with provisions to override and operate manually. Filter backwash will be activated by a filter head loss, excessive filtered water turbidity or plugging factor, or after filtering for a preset number of hours. Normal filter backwashing is expected to occur at 48- to 72-hour intervals. Control devices will be provided to backwash the filters at any selected head loss up to 6 feet, or at any selected time interval up to 168 hours (7 days). The filter control system will permit only one filter cell serving a reactor to be backwashed at a time. During backwashing, the flow through the other filter cells for a reactor will be at a rate of 3.3 gal/min per square foot. The filter installation will include two air blowers (one for standby) per reactor, each with 125-hp motors, which will provide air-scour flow rates up to 5 standard cubic feet per minute per square foot.

Water used to backwash the filters will discharge to a backwash water-receiving sump and be returned to the reactors by the backwash return pumps at a rate to prevent any hydraulic surge to the reactors. Periodically, as required, the water will be diverted to the Bypass Drain to dispose of accumulated fine sediment that does not settle out when recycled through the reactor. Rinse or initial filter service flow could contain excessive suspended solids and will also be routed back to the reactors via the backwash water-receiving sump.

The filter installation per reactor will be provided with an overflow and a bypass. Overflow of the unfiltered water will be returned to the backwash water receiving sump for recycling through the pretreatment system. The filtered water clear well bypass will be routed to the MODE-2 channel for discharge to the Colorado River.

The filters, immediately downstream of each reactor, will be 170 feet long by 60 feet wide. The bottom of most of the 24-inch base slab will be at elevation 117.5 with the bottom of the deeper outlet area at elevation 115.5. The existing ground surface, water table, and final grade will be the same as those for the reactors.

The area under the reactors and filters will be excavated to about elevation 111.0 to remove all of the soft, silty material overlying the sand. The area under the sludge sumps in the center of the reactor tanks will be excavated to elevation 105.0, 4 feet below water table, to allow room for 3-foot compacted gravel pads. After the sludge sumps have been placed, the remainder of the excavation will be backfilled with select material compacted to 98 percent Proctor maximum density, to 3 feet below the bottom of the structures. A 3-foot compacted gravel pad will be placed over the compacted backfill to complete the foundation treatment for the structures. The compacted backfill will reduce settlement and the gravel pad will provide drainage under the structures. Minor dewatering will be required to excavate and construct the sludge sumps in the center of the reactors.

Loads at the filters will be served by a 480-V cable to each reactor and a 100-kilovoltampere (kVA), 480-V--208/120-V transformer at each reactor.

A.2.a.(6) Clear Well

The clear well, 175 feet long by 152 feet wide by 19 feet deep, will be a reinforced concrete structure with the top about 6 inches above ground level.

The flow through the clear well will have a uniform velocity of less than 0.5 foot per second to the pump suction. The storage capacity, 2.7 million gallons, will provide a 30-minute water supply. This capacity will permit the desalting plant to maintain 30 minutes operation in the event of a complete outage of the pretreatment system. Also, this storage will provide additional time to correct any malfunction in the pretreatment system. The clear well will be covered to keep out dirt and debris, and accoustical walls will be used to suppress noise from the pumps and motors. During steady-state operation, excess pretreated water will overflow from the clear well to the MODE-2 channel.

Provision will be made to maintain cleanliness on the interior surfaces of the clear well. The structure will be compartmentalized so that one segment at a time can be isolated to be unwatered and cleaned. Chemical storage and feed equipment will be located on top of the structural slab of the clear well.

The 24-inch thick base slab of the clear well will rest on a 3-foot compacted gravel pad designed to reduce differential settlement and to provide a drainage path to dissipate the effect of any sand boil which might be caused by liquefaction during a severe earthquake. Since the pump sumps are small and will be centrally located in the overall structure, a sand boil under the sump area should not cause any tilting or differential settlement of the structure; therefore, the gravel pad will not be required under the 24-inch thick pump sump base slab. The area under the pump sumps will be excavated to elevation 99.2, 9.8 feet below the water table, and the area beneath the clear well will be excavated to elevation 103.0, 6 feet below the water table, to allow room to place the gravel pad.

Conventional dewatering of the excavation will be required, but no sheet piling or tremie concrete operations will be necessary.

A.2.a.(7) Backwash Sump

The flow rate of dual-media gravity-filter backwash water would cause a significant hydraulic surge if recycled directly to the solids contact reactors; therefore, these flows will be collected in four backwash water-receiving sumps. The sumps will be rectangular concrete tanks below finished grade and will have sloping bottoms.

Each sump will have a capacity of 140,000 gallons, and be 70 feet long by 30 feet wide by 10 feet deep.

Water in the sump will be returned to the solids contact reactors by either of two pumps. Each vertical-type centrifugal pump will have a capacity of 1,500 gal/min at 40 feet of head with a motor rated at 25 hp.

A.2.a.(8) Bypass Piping Around Clear Well

If an upset of turbidity overload or chemical overdosage should occur in the solids contact reactors, effluent from the reactors will be bypassed to the Bypass Drain. During normal steady-state operation, overflow from the reactors, if any, will drain to the backwash water-receiving sump where the water will be pumped back to the reactors at the discharge side of the rate controllers. In addition, overflow from the clear well will be drained to the MODE-2 channel for discharge to the Colorado River.

To avoid a buildup of fine suspended matter in the solids contact reactors, backwash water will be periodically discharged to the Bypass Drain from the backwash water-receiving sumps. Similarly, supernatant from the thickeners would be discharged to the Bypass Drain in the event the carbonation system does not function as anticipated, which might cause a problem of magnesium buildup in the recycled lime.

A.2.a.(9) Pretreatment Control Building

The pretreatment control building will provide space for a satellite computer, which will control the pretreatment area through master controls located in the administration building. Rooms will be provided for switchyard control boards, electrical equipment storage, electrical maintenance, and batteries; a restroom will also be provided. The building construction will consist of a steel frame with steel roof joists and precast concrete exterior walls similar to the other buildings. A concrete slab on grade will be employed with a raised floor system in the computer area.

A.2.a.(10) Sludge Handling

In the partial lime softening process, approximately 2.2 Mgal/d (9,080 tons per day) of calcium carbonate sludge in excess of that required for recirculation will be precipitated in the solids contact reactors. This sludge, containing 5 percent solids, will be pumped to carbonation basins where carbon dioxide, reclaimed from the flue gases in the calcining operation, will be diffused. The purpose of the carbonator-scrubber system will be to redissolve any magnesium hydroxide that may be in the sludge so that magnesium can be separated from the sludge. This separation operation will then take place in thickeners where the soluble magnesium will overflow to the backwash water receiving sumps for return to the solids contact reactors. The sludge from the thickeners, containing about 20 percent solids, composed mostly of calcium carbonate, will be pumped to the centrifuges. The centrifuges will concentrate the sludge from the thickeners to about 60 percent solids. These solids will be carried on a draining conveyor to a fluidized bed furnace for calcining the calcium carbonate to calcium oxide. Both the supernatant from the thickeners and the centrate from the centrifuges will be returned to the solids contact reactors via the backwash water receiving sumps; or they could be discharged to the Bypass Drain in the event the carbonation system does not function, or to avoid the problem of magnesium buildup in the recycled lime.

The dewatered sludge from the centrifuges will be transferred by screw conveyor either to the fluidized bed furnace or, in emergency situations, to a disposal site. Reclaimed lime will be transferred by screw conveyor to lime storage bins.

Sludge handling loads will be served by a secondary unit substation located in the sludge handling area. The secondary unit substation will be connected to the main power supply by a 15-kV cable and will also be connected to a motor control center. The motor control center will control approximately 30 motors ranging in size from 1 to 75 hp. A second secondary unit substation will also feed the motor control center and will be directly connected by a 5-kV cable from the pretreatment area.

A.2.a.(10)(a) Recalcination

Lime sludge from the centrifuges will be composed principally of calcium carbonate. Recalcination of the sludge will involve heating it to a temperature of 1,600° to 1,800°F. Fluidized bed furnaces were selected for the recalcining system. The following chemical reaction shows the conversion of the sludge to calcium oxide (quick lime):

$$CaC0_3 + H_20 + \text{heat} \quad Ca0 + H_20 + C0_2$$

Sludge Cake + heat Quick Lime + Gas + Gas

The water and carbon dioxide will be discharged from the furnace stack and wet-scrubbed to remove particulates, leaving from 80 to 85 percent calcium oxide, which is usually removed from this type of furnace as hard lumps or pellets. The majority of water will then be condensed and recycled through the pretreatment system. The carbon dioxide will be recovered for use in the carbonation basins.

During calcining in the fluidized bed, sodium carbonate will be added to initiate a nucleus for the deposition of calcium oxide. By increasing or decreasing the dosage of this material, the size of the pellets can be accurately controlled. The control of the pellet size and uniformity of the final calcium oxide product is a unique feature of the fluidized bed furnace.

The recalcining system will contain two furnaces, each 12 feet in diameter and about 35 feet high. The calcining yard area will require about 1 acre. This area will be sufficient for furnaces, centrifuges, all peripheral heat and lime recovery equipment, dust control systems, and lime storage and handling facilities. This area will not include a fuel storage yard. Heat input to a furnace will be about 8,000,000 Btu/ton of lime produced, and fuel requirements will be fulfilled with oil.

The total production of calcium oxide is estimated to be about 211 tons per day, of which about 125 tons will be needed for the pretreatment process. The excess lime can be sold. The required quantity of carbon dioxide will be recovered for use in the carbonation basins and for pH adjustment. Grit and other residuals removed from the lime at the slaker system will be hauled to a disposal area. At the present time, it is anticipated that excess sludge will be transported by rail to an 800-acre disposal site located in parts of secs. 17, 20, and 21, T. 15 S., R. 10 E., of the San Bernardino meridian, in California, and is known as the Cactus site.

A.2.a.(11) Chemical Handling and Storage Facilities

Water for chemical mixing will be pumped from the intake pumping plant when the plant is operating. During initial startup, and startup after scheduled shutdown, the water supply for chemical mixing will be pumped from the onsite deep well. The estimated water required for chemical mixing is 0.60 Mgal/d.

A.2.a.(11)(a) Lime

A complete pneumatic conveying system will transport pebble lime from a hopper bottom rail car to two 12,000 cubic foot (ft^3) storage bins and from the storage bins to four 350 ft^3 shift bins, each located adjacent to a sludge contact reactor. Reclaimed lime coming off the cooler of calcining equipment will be fed into a 600 ft^3 bin, then by pneumatic conveyor to either one of the two pretreatment storage bins. From a shift bin the quick lime will be proportioned with raw water into a slaker. A classifier will remove some of the larger undissolved particles. The slaked lime will enter a mixing tank and will be pumped to a solids contact reactor as a 10 percent calcium hydroxide solution by weight. The pump will have a 60 gal/min capacity and will be rated at 50 feet of head. An equal pump will provide standby service.

A.2.a.(11)(b) Ferric Sulfate

Ferric sulfate, in powder form, will be used as a coagulant in the solids contact reactors at an anticipated dosage rate of 8 p/m (5 tons per day). Site delivery will be by trucks with self-contained unloading systems for filling the single 5,000 ft^3 storage bin, which will hold 175 tons (35-day supply). A pneumatic conveying system will transport the ferric sulfate to mixing wells, where a 5 percent solution will be pumped to the reactors.

A.2.a.(11)(c) Polyelectrolyte

Polyelectrolytes may be used as coagulant aids in the solids contact reactors. Storage will be provided by one horizontal 10,000 gallon steel tank, 8 feet in diameter by 25 feet 9 inches long. The tank will be situated for either rail or truck delivery, and provide approximately 1,200 pounds per day for 70 days, an amount which is about 1 p/m of the pretreatment flow. The polyelectrolyte will be delivered to each solids contact reactor as a 1 percent solution.

A.2.a.(11)(d) Soda Ash

Soda Ash will be used intermittently to reduce the noncarbonate hardness of the pretreatment water. Its storage and handling will be similar to that for ferric sulfate. The dry chemical will be stored in a silo and pneumatically carried to a shift bin at each solids contact reactor, where it will be proportioned with solids contact reactor feed water to form a 5 percent solution. The solution will be mixed in the reactors with the hydrate lime.

A.2.a.(11)(e) pH Adjustment

Operation of the membrane desalting equipment may require pH adjustment to as low as 5.5. This adjustment will be made either with kiln gases containing carbon dioxide or with sulfuric acid. Adjustment will be able to be made at three points in the feed water train: before the gravity filters to stabilize the water, at the clear well, and in the high-pressure manifold (acid system only).

Total sludge recalcining will produce 26,000 pounds per hour of CO_2. This will be five times the theoretical amount of CO_2 required to bring the feed water pH down to 5.5. Part of the kiln gases and carrying liquid can be diverted to an injection point in the 60-inch-diameter pipe between the solids contact reactors and the gravity filters. A quantity of 1,240 standard cubic feet per minute of kiln gas (a 100 percent theoretical excess) and 1,300 gal/min of carrying liquid will provide a pH adjustment from 9.5 to 8.2. Kiln gases not absorbed will be vented by a series of air valves.

The clear well will be designed as a recarbonation basin, with a grid pattern of jet aeration clusters situated on its floor. Recirculated clear well water at 50 lb/in^2 will provide efficient mixing action. One 6,000 gal/min pump rated at 115 feet (250 hp) will provide the water for the aeration jets. This recarbonation system will have the capacity to lower pH from 9.5 to 5.5.

If fly ash or other combustion byproducts in the flue gases prove detrimental to the feed water in the clear well, the pH adjustment with CO_2 will be discontinued and high-pressure acid solution injection will be substituted.

Adjustment of pH to 5.5, using 93 percent sulfuric acid, will require 15 tons of acid per day. The acid will be pumped directly from a railroad tank car into two 7,500-gallon fiberglass tanks, which will provide a 1-week supply.

Up to 10 gal/min of concentrated acid will be injected into a 4-inch, 40 lb/in^2 stream of clear well water coming from the low pressure manifold to produce a 5 percent solution. This solution will be pumped by a 200 gal/min pump to a pressure of 450 lb/in^2. A 4-inch line will carry the acid solution to the metering area, where 2-inch lines equipped with motor operated metering valves will deliver the acid solution to the injection manifolds located upstream from the flow controllers. Splitting and reuniting the feed pipes in two Y-branches will provide mixing of the acid solution with feed water.

A 1-1/2-inch low pressure line will carry acid solution to the 60-inch pipe between the solids contact reactors and the gravity filters, where it will be injected through an injection manifold. Up to 40 gal/min of acid solution will be required at the injection point. A metering valve will control the injection flow.

A.2.b. Desalting System and Associated Works

Final pretreatment of the feed water, prior to its entering the membrane desalting units, will consist of pH adjustment and the addition of sodium hexametaphosphate, for scale suppression, and sulfur dioxide, for neutralization of chlorine residuals, as required by each process. The water from the clear well will be pumped to the reverse osmosis units in a two-step system, and to the electrodialysis units in a single step. The desalting equipment will be housed in a building to protect it from dust and direct sunlight.

A.2.b.(1) Clear Well Pumping Plant

Ten single-stage, vertical turbine process pumps will be located in the plant clear well to lift water to the desalting process feed system. Pertinent data for each pump are as follows:

Type	- turbine, water lubricated
Capacity	- 10,000 gal/min
Rated head	- 170 feet
Head range	- 160 to 180 feet
Speed	- 1,200 revolutions per minute (r/min)
Horsepower (bhp)	- 500
Weight	- 7,900 pounds + 8,200 pounds for motor
Efficiency	- 86 percent at rated head

The pumps will be constructed of the following materials:

Column pipe	- steel - schedule 30 - fusion epoxy coating
Discharge head	- steel - fusion epoxy coating inside
Pump bowls and bellmouth	- cast iron - fusion epoxy coating inside and outside
Shaft enclosing tube	- stainless steel
Column shaft	- stainless steel
Bowl shaft	- stainless steel
Bowl and column shaft bearings	- rubber or combination bronze and rubber, water lubricated
Bowl bearing below impeller	- bronze - grease lubricated
Impeller	- nickel-aluminum-bronze, or stainless steel
Wear rings	- nickel-aluminum-bronze, or stainless steel
Bearing retainers, enclosing tube couplings, and other metalwork in water passageway	- stainless steel

A 10-ton gantry crane with a span of 76 feet will be provided over the clear well for installation and service of all clear well pumps and motors.

The vertical process pumps will discharge feed water into 20-inch lines which will be connected to microstrainers, devices used to protect the desalting units from suspended solids larger than 25 microns (0.001"). Each microstrainer will be rated at 14,000 gal/min and create a pressure drop across its surface, at rated flow in a clean condition, of 3 lb/in^2 or less.

The microstrainers will be housed in steel vessels fabricated in accordance with the ASME Code for a working pressure of 200 lb/in^2. The internal surfaces of the vessels will be lined with 12 to 15 mils of fusion epoxy paint. The inlet and discharge of each vessel will be 20-inch-diameter nozzles with 150-pound flanges.

The straining elements will be constructed of plastic or stainless steel. The strainers and supports will be of sufficient strength and rigidity to withstand a differential pressure of 100 lb/in^2. The straining elements will be either continuously cleaned or cleaned with a wash cycle when the pressure differential across the microstrainer reaches 10 lb/in^2. A typical time requirement for the wash cycle would be 15 minutes; typical water requirements will be 2,800 gal/min. Infrequent cleaning of these microstrainers is anticipated, perhaps once every 3 months. Wash water will be obtained from the vertical pump manifold and will be returned to the reactor clarifiers. When cleaning of a microstrainer is indicated, the respective vertical pump will be shut down and the valves at the intake and discharge of the strainer closed. An electrical interlock will prevent cleaning of more than one strainer at a time. Normally, less than 10 vertical pumps will be operating at the time a strainer cleaning signal occurs, in which case one of the pumps on standby can be phased in to maintain a relatively constant pressure-flow relationship.

Flows will continue from the microstrainers through 20-inch lines to a 42-inch, low pressure manifold. This manifold, which will be fusion-epoxy-lined steel pipe, will deliver water to the electrodialysis units at 65 lb/in^2 or less, and will also serve as a suction chamber for the reverse osmosis process booster pumps.

The reverse osmosis booster pumps will consist of seven horizontal, single section, double suction units. Pertinent data for each pump are as follows:

Type	- centrifugal, water lubricated
Capacity	- 10,000 gal/min
Rated head	- 790 feet
Head range	- to be determined
Speed	- 1,800 r/min
Horsepower (bhp)	- 2,375
Weight	- 12,000 pounds + 15,000 pounds for motor weight
Efficiency	- 84 percent at rated head

The pumps will be constructed of the following materials:

Casing	- cast steel - fusion epoxy coating inside
Impeller	- nickel-aluminum-bronze, or stainless steel
Shaft	- stainless steel
Stuffing boxes	- nickel; seal - stainless steel and "Buna-N" 0-rings
Pump bearings	- ball or roller type - grease lubricated
Wear rings	- nickel-aluminum-bronze, or stainless steel
Baseplate	- structural steel
Other metalwork in water passageway	- stainless steel

The pumps will take water from the low pressure manifold and discharge it to the high pressure manifold through 20-inch intake and discharge lines at 420 lb/in^2 or less. The 42-inch high pressure manifold will be fabricated from fusion-epoxy-lined steel pipe coated with primer and machinery enamel, and deliver water to all the reverse osmosis equipment.

A 20-inch flushing line will connect the low-pressure manifold with the high-pressure manifold. Twenty-inch motor-operated butterfly valves will be provided to isolate all pumps and microstrainers for flow control, strainer back flushing, or servicing. A 20-inch motor-operated butterfly valve will also be provided in the flushing line. This valve will open for flushing the reverse osmosis equipment.

Sodium hexametaphosphate will be used to stabilize the feed water and prevent scaling within the reverse osmosis desalting units. The SHMP feed rate for reverse osmosis equipment should range from 0 p/m to 5 p/m, depending on recovery rates and equipment; the maximum daily requirement expected will be 2 tons per day. No SHMP addition is anticipated for the electrodialysis equipment.

The SHMP will be injected, when required, into the high pressure reverse osmosis feed pipes as a 5 percent solution. A maximum dry weight of 170 pounds per hour will be injected, which converts to a solution metering rate of 400 gallons per hour.

A.2.b.(2) Desalting Building

The desalting building (Drawing No. 1292-D-1076) will be a steel frame structure, 277 feet by 579 feet, with precast concrete wall panels. Long span steel joists, supported by steel columns, will support the insulated, concrete-filled, steel roof deck. Interior construction will consist of finish materials applied to steel studs. There will be no windows, due to climatic conditions, but the roof will contain banks of north-facing skylights. The west end of the building will have a loading dock, and truck access doors will open onto a 28-foot-wide drive-through aisle. On the east end of the building will be an area allocated to the electric control and switchgear equipment. A glass-walled viewing gallery will be constructed over this equipment. Emergency exit doors will be provided throughout the building.

Excavation for the building site will be to elevation 111.0 in order to remove all the soft, silty material overlying the sand. The excavation will be backfilled with select materials, compacted to 98 percent Proctor maximum density, to elevation 120.5 (115.5 under the pipe trenches), and overlaid with a 3-foot compacted gravel pad to complete the foundation beneath the 24-inch concrete building slab. (The compacted backfill will be less susceptible to settlement than existing material and the compacted gravel pad will provide a drainage path for any sand boil that might occur beneath the structure.) Since the bottom of the excavation will be at elevation 111.0, about 2 feet above the water table, no dewatering problems are expected. The final grade around the building will be at elevation 125.0.

The concrete floor system will have transverse bays of 102 feet, 82 feet, and 90 feet, and longitudinal bays of 24 feet. Three pipe trenches, 18 feet wide and 5 feet deep, will be located in the center of each transverse bay and extend from the building's east end for most of its length. Another trench, 14 feet wide and 5 feet deep, will cross the west end of the building to connect the ends of the three main trenches. The bottom of the 24-inch concrete trench slabs will be at elevation 118.5. Each of the three 42-inch-diameter feedlines from the clear well, one for the electrodialysis segments and one for each of the two reverse osmosis segments, will enter their respective trenches at the east end of the building. In addition to the feedlines, each main trench will contain a 30-inch-diameter product line, a 24-inch-diameter reject line, and both a 12-inch-diameter cleaning supply line and cleaning return line. The two reverse osmosis pipe trenches will also contain a 12-inch-diameter second stage flush line, and the electrodialysis pipe trench will contain a 2-inch-diameter anode rinse line. The connecting trench will contain four major pipelines which will leave the building near the west end of its north side. One will be the product waterline and the other three will be reject lines from the three processes. Handrails will be provided around the main trenches and crosswalks. The connecting trench will be covered with steel grating.

The reverse osmosis equipment will be grouped into control blocks located on each side of the pipe trenches. Each control block, or module, will contain 60 vessels which will produce approximately 1 Mgal/d of product water. The modules, each mounted on skid-type supports, will in turn be arranged in two stages. The electrodialysis stacks will also be located on each side of their pipe trench. Each skid-mounted stack will contain four stages arranged hydraulically in series; valving will be on a stack-by-stack basis. Individual modules for all processes will have the capability of being taken out of service, disconnected from the plant, and moved to the assembly and maintenance area on the skid mounts for service and maintenance.

The main process piping will be in the pipe trenches. Risers from the mains, containing valves, will connect the main process piping to manifolds, which in turn will connect to the various modules of desalting equipment. Production capacities and floor areas assigned to the processes will be as follows:

Process	Installed Capacity	Plant Area	Ft^2
(a) HFF RO	20 Mgal/d	62 by 214	13,270
(b) SW RO	20 Mgal/d	82 by 237	19,440
(c) ED	20 Mgal/d	70 by 200	14,000
HFF RO		62 by 208	12,900
(d) Other SW RO	48.5 Mgal/d	82 by 184	15,000
ED		70 by 224	15,600

The total net area required (including pipe trenches) will be 90,210 square feet. However, it should be noted that bay widths and lengths may change to suit the desalting equipment actually purchased.

The direct current (dc) rectifiers for the ED process will be rated at 500 kilowatts (kW). The units will be capable of suppling dc voltages and currents at the following levels:

460 V dc - 350 A	161,000 watts
500 V dc - 320 A	160,000 watts
480 V dc - 240 A	115,200 watts
310 V dc - 150 A	46,500 watts
Total	482,700 watts

The voltages will be independently controllable by a remote processor. The power factor at full load will be 95 percent with 97 percent efficiencies at full voltage input. The rectifiers will be enclosed in cabinets adequately protected from water and reject. Cooling will be sufficient to insure operation in the 50°C ambient temperature expected. The rectifiers will be supplied with fault protection. The loads will be brought up linearly with the voltage, starting at about 25 percent full load.

One bridge crane will be located over each process bay and will run from the east end of the building to the loading ramp beside the service area on the west end. The crane over the spiral wound reverse osmosis bay will have a 15-ton capacity, the remaining two will have 5-ton capacities, and they will all operate on parallel pairs of rails supported by steel columns. Power will be supplied to the cranes by enclosed runway conductor systems. The hoist operation, bridge travel, and trolley travel for each crane will be electrically operated and controlled by a pendant pushbutton station. Each crane will be a double-girder type with one trolley and one hoist.

The west end of the building will contain areas allocated to receiving (1,300 ft^2), testing (3,800 ft^2), maintenance (5,400 ft^2), chemical cleaning (3,900 ft^2), refrigerated membrane storage (4,600 ft^2) and dry storage (900 ft^2). A ceiling will be constructed over the cleaning, maintenance, test, and storage areas, and the refrigerated and air-conditioned spaces will be insulated. Desalting units requiring testing, maintenance, or cleaning will be transported from the landing into the respective areas through large folding doors. The refrigerated membrane storage area will hold a 1-year supply of replacement membranes.

All areas within the desalting building will be temperature controlled according to the use of the different spaces. The main building area will not be heated, but will be either ventilated or evaporatively cooled to maintain acceptable room temperatures during the summer. All other rooms, except the refrigerated membrane storage room, will be heated, ventilated, and air-conditioned. The refrigerated membrane storage room will be air-conditioned by a separate refrigeration system which will maintain room temperature at 45°F (7.2°C).

A.2.b.(3) Administration Building and Visitor's Facilities

A separate structure was determined to be the most advantageous alternative for the administrative function of the Yuma Desalting Plant. The administration building will house the plant control center, computer room, laboratory, plant administrative offices, visitor facility, and support functions.

The administration building will consist of a steel frame, concrete floor system with precast exterior panels and fascia. Long span steel joists will support an insulated metal roof with a 2-inch concrete built-up fill. A raised metal floor system will be used in the computer and control areas. The visitor entry and view to plant areas on the north side will have windows. Standard interior metal stud wall construction with suspended ceilings will separate and enclose the spaces. A stairway and hydraulic elevator will lead to a steel crossover bridge to the desalting building. All spaces, with the exception of the mechanical equipment rooms, will be air-conditioned. Firehose cabinets and fire extinguishers will be employed for fire control by staff personnel. In addition, a halon system will be used in the computer and control areas.

The office complex will include an office suite for the plant supervisor, plant engineer, office manager, payroll clerk, and secretary; an office for computer programers; a laboratory for water analysis; a conference room; lunchroom; and restrooms. The complex will be furnished with pleasing furniture, low maintenance carpeting, and vinyl wall covering with graphics. Architectural screens will separate functions within the administration office suite, and planted areas will provide environmental enrichment.

The control area will consist of a control room with cathode ray tube (CRT) readouts of plant functions and a training room complete with a CRT capable of taking over control from the control room in case of an emergency. The CRTs will provide data to the operator in multicolored displays which will enable the meaningful and clear communication of large volumes of information. The operator will be able to oversee the entire desalting process operation with the CRT consoles. A supervisor station, lunchroom, restroom, and locker rooms will also be provided for the control area.

The computer room will operate in conjunction with the control room. A tape storage area will be provided. A standby air-conditioning system will be employed to guarantee temperature and humidity requirements. A maintenance shop for the computer will also be provided.

A separate area will be provided for visitors. The general public will have limited access to the administration building through the visitor entry during visiting hours. In the visitor area, exhibits will show and explain desalting processes, procedures, and the project. Bilingual signs and tapes will be provided. A viewing area will be provided to view the control room and an audiovisual room will also be provided. From the exhibit area the visitor can go on a self-guided tour of the desalting building by means of an elevated, enclosed, air-conditioned gallery overlooking the process plant. A stairway and an elevator will be provided to the visitor viewing gallery for the general and handicapped public. A receptionist, visitor lounge, vending area, and restrooms will also be provided for the visitors.

A.2.b.(4) Standby Power

Standby power will be provided by a 1,875 kVA 0.8 power factor 2,400/4,160-V diesel engine-generator set. This set will be equipped with associated starting controls. It will be started with a compressed air system consisting of an air receiver, electric motor-operated compressor, and associated equipment.

A.2.b.(5) Fire Protection Equipment

Fire protection equipment will consist of firehose and extinguisher cabinets, hose gate valves, hand portable water stored extinguishers, hand portable carbon dioxide cylinders, wheeled portable carbon dioxide fire extinguishers, wall hydrants, fire alarm systems, manual fire stations, and associated equipment. Fire protection water will be provided by an onsite deep well which will also be used as a domestic water supply source. Standby fire protection will be provided from a second well.

A.2.c. Appurtenant Works

There are a number of additional features associated with the desalting plant; although not all of them are directly connected to the actual desalting process, they all have a specific purpose which relates to the overall development of the complex.

A.2.c.(1) Potable Water Supply

Water for plant domestic use will be furnished from the desalting membrane product line when the desalting plant is operating. A chlorine residual for this product water will be maintained. Two 7,500-gallon storage tanks will be used to control the proper pressure, and pH adjustment will be required for the system. During periods when the plant is down, the water supply will be pumped from an onsite 800-foot deep well. This deep well will be capable of supplying water for domestic and fire protection demands at approximately 3,000 gal/min. The domestic water system will be designed to supply an instantaneous demand of 100 gal/min. The pumps will be controlled by high and low level probes located in the tanks to maintain the proper water level. The tank pressure will be maintained from 40 lb/in^2 to 70 lb/in^2. Power for this area will be supplied from a 100-kVA, 3-phase, 480 - 208/120-V transformer located in the motor control center at the fire pumps.

A.2.c.(2) Sewage Treatment Plant

The sewage treatment plant will be designed for a maximum flow of 7,500 gal/d. Sewage and wastewater from the desalting building, visitor's center, laboratory, and other buildings will flow by gravity to a collection tank located adjacent to the desalting building, where the sewage will be pneumatically lifted to the sewage treatment plant. The top of the concrete pad for the treatment plant will be at elevation 125.50. Flow will be by gravity through the treatment plant to a seepage bed.

Sewage will be treated by the activated sludge process, extended aeration type, with standard packaged equipment. The compartment will be sized in accordance with the equipment furnished. A chlorination well will be provided for future chlorination of the plant effluent, if required. Design of the treatment plant is based on 1,000 maximum visitors per day and 60 plant operating personnel.

Sewage from the pneumatic ejectors will first flow through the screening basket, which will remove any large inert objects that might interfere with operation of the aerator and sludge return pump, then in series through the aeration compartment and settling compartment. The effluent will flow to the seepage bed. The airlift pump and skimmer will return sludge and scum from the settling compartment to the aeration compartment according to operating requirements.

A.2.c.(3) Maintenance Building

The maintenance building will provide for maintenance of equipment. A general maintenance bay, work area, parts and tool room, and restrooms will also be provided. General construction will be steel frame and joists with precast concrete wall panels. Concrete floor slabs with concrete aprons will be provided to support heavy wheel loads.

A.2.c.(4) Energy Recovery System and Chlorine Building

The energy recovery and chlorine equipment will be housed in a building located in the direct path of the desalting plant reject lines. The design will be the same as other buildings, with the exception of a mass concrete foundation for installing the turbine. A crane will also be employed for installation and maintenance purposes.

The energy recovery system will be comprised of two impulse turbines direct-connected to a generator shaft, one at each end of the generator. The runner for each of the turbines will be a single casting of stainless steel and each turbine will be equipped with a single nozzle. The generator will be of the induction type.

Control of the turbine needle will be accomplished by means of a hydraulically operated back-pressure regulating system. The system will operate to position the needle so as to maintain an essentially constant upstream pressure in the penstock.

The induction generator will be brought up to speed with the impulse turbine. A speed switch will be used to energize the breaker control for connecting the generator to the system as operating speed is approached.

The equipment will be contained in a 1.5-kV NEMA III non-walk-in indoor unit. The transformer will have two fused load interrupters rated 500 MVA, 200A, connecting the primary to two 15-kV cables. One cable will go to the switchyard and the other will go to the intake pumping plant. The cable going to the intake plant will provide an alternate path to get power to that area if the main current feeding the intake area is open. Recording watt-hour and power-demand metering, wattmeter, voltmeter, and ammeter will be provided for this generator.

The chlorine portion of the building will house the chlorine control equipment required to administer chlorine to the raw water taken from the MODE. The building will be strategically located between the railroad track, for the chlorine tanker car, and the intake structure. Construction of this portion will be similar to the above; however, sealing the space with positive ventilation will be required in the event of a chlorine leak.

A.2.c.(5) Miscellaneous Structure Foundations

Specific foundation treatment of each of the many miscellaneous small and intermediate structures and foundations in the desalting plant area will be similar to those for the large structures previously described.

All structures, where excessive or differential settlements are a crucial problem, will have the silty material removed and replaced with select backfill material compacted to 98 percent Proctor maximum density and topped with a compacted gravel pad directly under the structure. The compacted material will reduce total and differential settlements, and the gravel will provide drainage under the structure to reduce the effects of sand boils caused by possible liquefaction of the sand if a severe earthquake occurs in the area.

Where settlement or differential settlement are not major concerns, structures will require only minimal foundation treatment, such as local overexcavation and recompaction of existing material beneath the structure. Many of these small structures will be lightly loaded, so settlements should be slight. In any event, repair or replacement would be easy; thus, an expensive foundation treatment will not be necessary.

A.2.c.(6) Pipelines

Piping will be designed and valves will be selected to provide the greatest serviceability consistent with design, operation, seismic, and corrosion requirements. Properly lined steel piping will be used for the feed water, reject, product, and cleaning piping systems involving sizes 60 inches and larger. Piping to the electrodialysis units in sizes smaller than 6 inches will be polyvinyl chloride. Feed water, reject, product, and cleaning manifolds for the reverse osmosis units will be fabricated from stainless steel pipe, type ASTM: A 312, Grade TP316L. The 1-inch product line connections for the reverse osmosis units will be 1-inch nylon reinforced polyvinyl chloride hose. All valves in the membrane area will be butterfly valves of the insert or wafer type and based on the required working pressure.

The 36-inch-diameter reject discharge line will convey 62.3 ft^3/s of reject from the recovery turbine building to the Bypass Drain. The pipeline will connect to a manifold on the discharge side of the recovery turbine and continue to an outlet transition at the Bypass Drain. The pipeline will be steel pipe with a fusion epoxy lining and a coal-tar enamel coating on the outside. The outlet will be a concrete transition with a stainless steel rack over the pipe to prevent persons or animals from entering the pipe.

The product water discharge line will convey 152 ft^3/s of product water from the desalting plant to the MODE-2 channel where it will be blended with the untreated water. The blended water will then be discharged into the Colorado River. The product water discharge line will be a 54-inch-diameter precast concrete pressure pipe. The outlet transition will be concrete with a stainless steel rack over the pipe opening to prevent persons and animals from entering the pipe.

A.2.c.(7) Power Supply Source

The long-range power supply to serve the Desalting Complex Unit (essentially the Yuma Desalting Plant) and the Protective and Regulatory Pumping Unit is presently under study. To meet the near-term needs (1980-1985), however, a portion of the United States' entitlement to the Navajo Generating Station is planned to be used. This source was developed for the purpose of supplying the power requirements of the Central Arizona Project (CAP) and augmenting the Lower Colorado River Basin Development Fund.

A.2.c.(7)(a) Near-term Power (Navajo Project)

The Secretary of the Interior was authorized and directed by Section 303 of the Colorado River Basin Project Act to recommend the most feasible plan for the construction and operation of generation and transmission facilities for the Central Arizona Project. On December 12, 1969, the Secretary signed contracts providing for participation by the United States in the Navajo Project, which consists of a fossil-fueled generating station near Page, Arizona, and associated transmission facilities. The present plant rating is 2,250 MW, of which the United States' share is 546.75 MW.

Because the inservice dates of the Navajo generating units occur prior to the United States' need for Central Arizona Project pumping power, the United States entered into contracts with the Navajo Project participants and the Southern California Edison Company for interim use of United States' entitlement to Navajo Project power. Although these contracts (signed on September 30, 1969) remain in effect for 20 years, the United States can, on 5 years notice, recapture all or a portion of this entitlement for other purposes of the Colorado River Basin Project Act, such as improving the quality of river water (which will be accomplished by the Desalting Complex Unit).

It must be recognized, however, that the outcome of a court suit, brought against the United States by the Arizona Power Pooling Association regarding the propriety of the interim contracts for Navajo Project layoff power, may affect the availability of layoff power for the Desalting Complex Unit and Protective and Regulatory Pumping Unit.

Because of the 5-year notice requirement of intent to recapture, the uncertainty of the power requirement, and the timing of the requirement, strict enforcement of the provisions of the contract would have made it necessary to make the withdrawal effective January 1, 1980, and in an amount somewhat in excess of the estimated maximum kilowatt requirement.

Upon request from the United States, however, Southern California Edison, by letter of agreement dated June 20, 1975, agreed to allow a partial withdrawal of its Navajo layoff power and energy entitlement upon less than 5 years notice under the following conditions.

The United States could withdraw Navajo Project layoff power from Southern California Edison for meeting the power requirements of the Desalting Complex and Protective Pumping Units to the extent of approximately 22 MW in June 1980 and an additional 65 MW in June 1981, provided that the United States gives Southern California Edison:

1. Written notice of such amount of withdrawal within plus or minus 10 percent by January 1, 1978.

2. Written notice of the exact amount of withdrawal not less than 1 year prior to the effective date of withdrawal.

3. The United States and Southern California Edison agree that the power company's costs for transmission of Navajo Project layoff power on the Navajo Project Transmission System would be appropriately reduced with Navajo Project layoff power withdrawals.

The United States would not request additional Navajo Project layoff power withdrawals from Southern California Edison without fully considering withdrawals of power from other Navajo Project layoff power contractors.

Presuming that the outcome of the Arizona Power Pooling Association suit against the United States will not alter present plans, the use of Navajo Project power and energy will meet the near-term needs of the Desalting Complex and Protective Pumping Units through at least 1985, as the Central Arizona Project, which was originally scheduled to be in service in January 1980, will not be in service until at least 1985. Also, it is a resource that was contracted for by the present contractors for an interim period, subject to recapture by the United States for other purposes of the Colorado River Basin Project Act. By the use of the Navajo Project as a near-term source, additional time can be allotted to properly perform investigations of alternative permanent resources.

The nature and scope of the power supply contracts required for long-range power service to the Desalting Complex and Protective Pumping Units are, therefore, presently unknown.

A.2.c.(7)(b) Long-Range Power (Potential New Facilities)

Long-range (permanent - after 1985) energy requirements of the Desalting Complex Unit (essentially the Yuma Desalting Plant) and the Protective and Regulatory Pumping Unit could possibly be supplied by solar, geothermal, or thermal-generation sources.

Solar Energy

Solar energy could help meet the long-range energy requirements of the Desalting Complex and the Protective and Regulatory Pumping Units. The Bureau has initiated discussions with the Energy Research and Development Administration concerning a cooperative solar energy research, development, and demonstration program directed toward the development of solar energy technologies, and the design and construction of a large solar-electric demonstration powerplant.

This program would specifically tie together the current national need to develop all possible sources of energy, including solar, with the energy requirements of the Yuma Desalting Plant.

A solar-electric plant could be situated within a 25-square-mile tract of Federal land located south of Yuma, Arizona, in the vicinity of the proposed Protective and Regulatory Pumping well fields. Since the demonstration solar-electric powerplant would be situated in the proximity of the well fields and the Yuma Desalting Plant, only relatively short transmission lines would be required to serve the plant and to interconnect with the nearby Federal Parker-Davis Project transmission system. The protective pumping well fields could be utilized as a source of cooling water supply for dry-type cooling towers where the only effect would be the transfer of heat to the water.

The four major siting criteria for solar power developments that influence the selection of a site are insolation, meteorological conditions, topography, and environmental impacts. The selection of the South Yuma site has the following considerations in its favor:

1. The South Yuma site averages close to 4,000 hours of sunshine annually.
2. Large areas of Federally owned or acquired land could be made available within the area and would be suitable for a solar collector/heliostat complex. The topography of the land is such that shading by ridges is limited, and the area is relatively flat with good surface drainage.
3. The site is readily accessible to highways and railroads, which would be required for the movement of material and equipment

to the plant site.

4. Environmental considerations are not expected to establish significant limitations for the siting of a solar-electric demonstration powerplant.

Geothermal Energy

In support of the United States Energy Research and Development Program, and in coordination with the Bureau of Reclamation's ongoing geothermal desalting program, the geothermal portion of the Energy Research and Development effort will be aimed at the demonstration of the feasibility of concurrent production of desalted water and electric energy using geothermal fluids. The program is designed to use the Bureau's existing Mesa Test Facilities in the Imperial Valley of southern California.

Initial studies will examine binary-fluid and total-flow systems, as they appear to be the type that would most probably be used with geothermal resources of the temperature found at the Mesa site. There are studies underway by other Federal agencies, such as the Energy Research and Development Administration and the National Science Foundation, for developing concepts which could be utilized in the Bureau's program. Data gathered during the operation of the test desalting units will assist in the design of the powerplant.

Thermal Generating Project Participation

Participation in a thermal generating project, to provide a permanent power supply for the Yuma Desalting Plant, will also be considered. Several such projects are in the planning stages, including various nuclear powerplants in the southwest area. Arrangements to effect participation by the Bureau in such a powerplant would be similar to those involved in the Navajo Project.

Purchase From Local Utility

If solar, geothermal, or thermal participation alternatives are not feasible, purchase of power and energy from an area utility will be considered.

A.2.c.(7)(c) Plan for Developing a Power Supply

The plan for developing a power supply for the Desalting Complex Unit and the Protective and Regulatory Pumping Unit can be broken into three phases. These three phases are:

1. Development of Navajo layoff as a power supply for use during the 1980 to 1985 period.
2. Development of an alternate power supply for use during the 1980 to 1985 period if the outcome of the pending lawsuit should preclude the use of Navajo layoff.
3. Development of a permanent long-range power supply for the post 1985 period.

Navajo Layoff (Near-term)

The following steps outline the plan to develop Navajo layoff as a power supply for the 1980 to 1985 period:

1. Determine power and energy requirements.
2. Determine possible transmission alternates for delivery of Navajo layoff. These alternates may include construction of new facilities, use of existing facilities, wheeling agreements with other entities, or some combination of the preceding possibilities.
3. Make system studies of all practical transmission alternates to determine the technical feasibility of each alternate and its relative merits or disadvantages.
4. Make economic studies of all practical transmission alternates to determine the relative cost of each alternate.
5. Review and analyze technical and economic study results. Also consider overall factors such as environmental impact, necessary contractual commitments, and lead time required to implement each alternate.
6. After complete review and analysis of all pertinent data, choose the best overall transmission alternate for delivery of Navajo layoff.
7. Initiate any required design and/or contract negotiations required to implement the best transmission alternate.
8. Begin construction of any required new facilities.

9. Complete construction and contract negotiations and put system into service.

Because of the uncertainty of the pending lawsuit and the fact that the complexities of any required design and construction or contractual arrangements are not completely known at this time, it is difficult to outline the time frame required for each of the above steps. However, a preliminary schedule is given below:

1. Determination of requirements, determination of possible alternates, and preliminary technical and economic studies should be complete by January 1, 1977.
2. Final technical and economic studies, review and analysis of technical and economic study results, and final decision should be complete by June 1, 1977.
3. Initiation of any required design and/or contract negotiations should begin by June 1, 1977.
4. Construction of any required new facilities should begin no later than January 1, 1979.
5. In service by January 1, 1980.

As more data become available, each of the above steps must be reviewed and reappraised in relation to the time required to complete arrangements and facilities for delivery of Navajo layoff.

Alternate to Navajo Layoff

If the outcome of the pending lawsuit is unfavorable, Navajo layoff may not be available as a power supply. Therefore, it is necessary to develop an alternate to Navajo layoff for the 1980 to 1985 period. Because of the time frame involved, the only practical alternative to Navajo layoff is a purchase agreement with another entity. Therefore, concurrently with the development of Navajo layoff, the following steps should be taken to develop an alternate power supply.

1. Determine power and energy requirements.
2. Determine practical sources of purchased power and energy.
3. Determine possible transmission alternates for delivery of purchased power and energy.

4. Make system studies of all practical sources and transmission alternates to determine the technical feasibility of each source and transmission alternate and their relative merits or disadvantages.
5. Make economic studies of all practical sources and transmission alternates to determine the relative cost.
6. Review and analyze technical and economic study results. Also consider overall factors such as environmental impact, necessary contractual commitments, and lead time required to implement each alternate.
7. After complete review and analysis of all pertinent data, choose the best overall combination of purchased power and energy source and transmission alternate.
8. If Navajo layoff is not available, then initiate any required design and for contractual negotiations required to implement the chosen plan.
9. Begin construction of any required new facilities.
10. Complete construction and contract negotiations and place system in service.

The preliminary schedule for development of an alternate to Navajo layoff should be as follows:

1. Determination of requirements, determination of possible sources and transmission alternates, and preliminary technical and economic studies should be complete by January 1, 1977.
2. Final technical and economic studies, review and analysis of technical and economic study results, and final decision should be completed by June 1, 1977.
3. If Navajo layoff is unavailable as a power supply, initiation of any required design and/or contract negotiations should begin by June 1, 1977.

4. Construction of any required new facilities should begin no later than January 1, 1979.
5. In service by January 1, 1980.

Long-range

The following steps are necessary to complete the development of a long-range power supply for the post 1985 period:

1. Determine power and energy requirements.
2. Investigate and select practical power supply sources such as solar energy, geothermal, thermal or purchased power and energy.
3. Determine possible transmission alternates for delivery of power and energy. These alternates may include construction of new facilities, use of existing facilities, wheeling agreements with other entities or a combination of the preceding.
4. Make system studies of all possible sources and transmission alternates to determine the technical feasibility of each and relative merits or disadvantages.
5. Make an economic study of all practical sources and transmission alternates to determine relative costs.
6. Review and analyze technical and economical study results. Also consider overall factors such as environmental impact, necessary contractual commitments, state-of-the-art of new power and energy sources, and lead time required for each source and transmission alternate.
7. After complete review and analysis of all pertinent data, choose the best overall source and transmission alternate.
8. Initiate required design and contractual negotiations required to implement the best combination of source and transmission alternate.
9. Begin construction of any required new facilities.
10. Complete construction and contract negotiations and put source on line and transmission system in service.

The preliminary schedule for development of a permanent long-range power supply should be as follows:

1. Determination of requirements, determination of possible sources and transmission alternates and preliminary technical and economic studies completed by June 1, 1977.
2. Final technical and economic studies review and analysis of technical and economic study results, and final decision should be completed by June 1, 1978.
3. Initiation of required design and contract negotiations should begin by June 1, 1978.
4. Construction of new facilities should begin no later than January 1, 1980.
5. In service by January 1, 1985.

A.2.c.(8) Power Transmission

Power will be supplied via the Bureau of Reclamation's Parker-Davis Project Transmission System, which connects the Yuma, Arizona area with the systems of the utilities operating in the power supply area. The initial source through 1985 will be the Navajo Generating Station. Other sources are under study to provide a permanent power supply.

A.2.c.(8)(a) Transmission Lines

Additions to the Federal system and interconnection to a private utility system will be required to serve the desalting complex load. All additional transmission lines will initially be operated at 161 kV and will be of wood-pole, H-frame, 230-kV construction, except for the crossing of the Colorado River, which may require steel towers. Transmission lines will be constructed from the Knob Substation to the Yuma Desalting Plant Substation (4.0 miles), and from the desalting plant to the Yucca-Axis Powerplant Substation (0.8 mile).

A.2.c.(8)(b) Substations

A breaker will be added at the Knob Substation to terminate a transmission line from the Yuma Desalting Plant Switchyard. The existing ring bus configuration will be changed to a main and transfer scheme. It may be necessary to replace the three existing circuit breakers because of inadequate short circuit capability.

Two circuit breakers and bays will be added at the Yucca-Axis Powerplant Substation to complete the ring bus. The breakers will be used to terminate the transmission line from the Yuma Desalting Plant Switchyard.

A five breaker ring bus scheme will be required at the Yuma Desalting Plant Switchyard to terminate the transmission lines from the Knob Substation, the Yucca-Axis Powerplant Switchyard, and the protective pumping well field. The fifth breaker, and other facilities, will be associated with the 34.5-kV transmission line to the protective pumping well field.

A.2.c.(8)(c) Transmission Lines and Substation Alternatives

The Yuma Desalting Plant will be connected into the joint transmission system in the Yuma area. The alternatives being considered are:

Alternate 1 - Since the existing 161-kV line from Pilot Knob Powerplant Switchyard to the Yucca-Axis Powerplant Switchyard is near the west boundary of the Desalting Plant, this line would be routed in and out of the Yuma Desalting Plant Switchyard. No additional transmission modifications were considered.

Alternate 2 - Knob Substation would be dismantled and the existing 161-kV line from Blythe Substation would be connected to the 161-kV line to Pilot Knob Powerplant Switchyard. The 161-kV line from Gila Substation would be rerouted to the Desalting Plant Switchyard requiring approximately 4 miles of new 161-kV transmission line construction. A new 161-kV line would be constructed from Pilot Knob Powerplant Switchyard to the Desalting Plant Switchyard.

Alternate 3 - Knob Substation would be dismantled and the existing 161-kV line from Blythe Substation would be connected to the 161-kV line to Pilot Knob Powerplant Switchyard. At Pilot Knob Powerplant Switchyard, the line to Knob Substation (now to the Blythe Substation) would bypass the switchyard and be routed to the Desalting Plant Switchyard, requiring about 1 mile of new 161-kV transmission line construction. The 161-kV line from Gila Substation to the Knob Substation would be rerouted to the Desalting Plant Switchyard, requiring about 4 miles of new 161-kV construction. In addition, a new 161-kV line, about 1 mile in length, would be constructed between Pilot Knob Powerplant Switchyard and the Desalting Plant Switchyard.

The original planned transmission addition to the Federal system and the three alternatives are shown in Figure 4.

A.2.c.(9) Desalting Plant Switchyard

The desalting plant switchyard will be located just to the northeast of the desalting building. Incoming voltage, at 161 kV, will be transformed to 13.8 kV by seven single-phase power transformers arranged into two 3-phase banks; the seventh transformer will be a spare. All transformers will have one-step reduced insulation and the station class surge arresters will be tank mounted for maximum protection of the transformers.

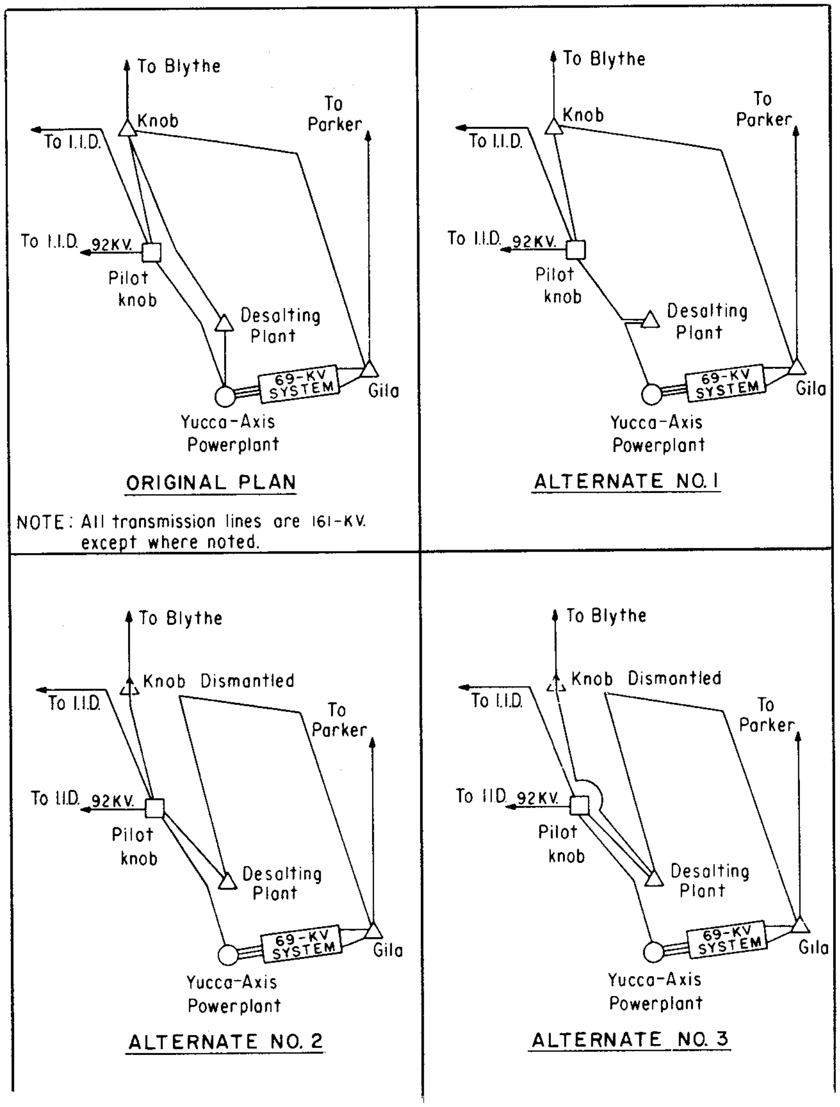
Power at 13.8 kV will be supplied from each power transformer bank to the desalting plant through outdoor metal-clad switchgear. The circuits from the metal-clad switchgear to the complex will be underground cable. Each of the seven 13.8-kV cable circuits will be protected by a power circuit breaker in the metal-clad switchgear.

To facilitate the performance of periodic testing, inspection, and maintenance of electrical switchyard equipment with the least possible disruption of service, adequate electrical clearances for live-line methods of maintenance will be provided. Also, fittings and terminals designed for live-line maintenance work will be provided.

Indoor equipment associated with the switchyard will be housed in a building just outside of the south switchyard fence. This equipment will consist of the devices and their enclosures necessary for switchyard protection, metering, alarms, and local manual control.

Two facing rows of duplex switchboards will be needed to house and mount the protective relays, annunciators, indicating and recording meters, and control devices. Other enclosures will include those for the 125-V station battery charging-eliminating equipment, alternating current and direct current distribution panels, powerline carrier-current transmitter-receiver panels, and cable terminal cabinets.

Metering and alarm for switchyard quantities will include switchboard-mounted indicating meters for local operation, telemetering to the plant master



TRANSMISSION ALTERNATIVES
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Figure 4

computer and the Phoenix Dispatch Office, annunciators, and revenue metering. Quantities metered will be amperes, kilovolts, megawatts, megavars, megawatt-hours, and power demand.

Local control (manual backup) of switchyard equipment will be by typical control board devices mounted on the duplex switchboards and those test functions in each equipment cabinet located in the switchyard.

Interface between the plant computer and switchyard equipment will be at the terminal cabinet(s) in the control room. Alarm, status, control, and telemetering points will be available for input to the computer.

A.2.c.(10) Electrical Distribution

Primary distribution will be made to the major load centers through 15-kV cable and stepped down to the proper voltage level at the unit substations located in the load centers. The 15-kV cables will be connected to the switchyard through metal-clad breakers located in the switchyard. Reliability will be increased for the load centers by bringing power to them from at least two sources. The cables and transformers will be protected by overcurrent devices.

Motors above 200 hp will have bearing temperature lockouts and ammeters provided in addition to overload protection, which will be provided for all motors. The motor control centers, for use with motors rated 460 V and less, will have overcurrent, undervoltage, and reverse phase relaying provided. Motor surge protection will be provided on the load side of all transformers providing power to 4-kV motors.

The 18 megavars (Mvar) required to bring the desalting plant up to unity power factor will be split into two 9-Mvar banks. They will be connected in delta and located at the clear well with one 9-Mvar bank on the north motor control equipment bus and one 9-Mvar bank on the south motor control equipment bus. One bank will be switched in before the plant is started and the other will be switched in as needed.

Potheads will be provided where required to provide suitable interface between cables and switchgear. Power cables will be the single conductor type with chemical resistant insulation. Outside cables will be run in concrete underground cable ducts. Shielding will be provided to permit control cables to be run in the same duct bank.

A.2.c.(11) Plant Site Canals

The existing Cooper Lateral is an open irrigation canal located along the northern boundary of the desalting plant site. The lateral has a capacity of 60 ft^3/s with a bottom width of approximately 10 feet and 1:1 side slopes. This lateral will be replaced by a 2,600-foot-long siphon constructed of 72-inch-diameter precast concrete pressure pipe. The inlet and outlet structures will be 16-feet-long monolithic concrete transitions. The pipe will have a minimum of 4 feet of cover from the finished grade of the desalting plant site to the top of the pipe.

The Harmon Lateral on the east boundary of the desalting plant site will remain as an open canal. Existing sublaterals on the desalting plant site will be abandoned.

A.2.c.(12) Spent Chemical Solution Pond

An evaporation pond has been selected as the means of disposal of detergent and proprietary solutions. The evaporation pond will require little maintenance and will be used as a holding/evaporation pond where cleaning solution could be introduced and treated in the sewage treatment plant. It is anticipated that hauling of dried solids would not occur more than once a year.

The evaporation pond will be located next to the desalting building as shown on Drawing No. 1292-D-1075. It will be 50 feet wide by 100 feet long by 3 feet deep, and will be lined with flexible polyvinyl chloride plastic film. The top of the pond will be at elevation 125.50.

A.2.c.(13) Access

The Yuma Desalting Plant will be reached by a single access road which will enter the site at its southwest corner, as shown on Drawing No. 1292-D-1075. This access road will continue along the west boundary and cross the Yuma Valley Levee and the MODE in the vicinity of the intake structure. Actual access to the site will be made at four areas: the visitor's entry, the employee parking area, the general plant area, and the recalcining plant area.

These access areas will be provided in order to readily separate different types of traffic to the site and to make it unnecessary for visitors and plant personnel to pass through the security check at the general plant access guard station. Security measures for the public will be provided at the building. The general plant area will be fenced, but plant and access arrangements will make it unnecessary to fence the landscaped area in front of the desalting and administration buildings.

Parking areas for visitors and plant personnel will be separated. Both areas will be covered and integrated into the overall design of the administration building to eliminate the need for visually unrelated sunshade structures. A third covered employee parking area will be provided at the rear of the desalting building.

Rail service will be provided adjacent to the main east-west onsite plant service road and will provide immediate access to all bulk transportation needs. This road rail relationship will insure both truck and railroad car service at critical points.

A.2.c.(14) Landscaping

Landscaping will be provided inside the full length of the south property line, around the administration building area, and along the access road on the west boundary. Landforms, rock, natural plant materials, grasses, shade trees, and shrubs will be integrated to provide an informal, esthetically satisfying setting suited to the region's characteristic environment. All landscape areas will be irrigated as required. Lawn irrigation water supply for landscaping will be pumped from the Cooper Lateral since it carries water allotted to the site.

A.3. Equipment Procurement and Specifications

The Bureau of Reclamation normally uses the advertised bid method of accomplishing its work. Advertised bids involve the preparation of definite detailed specifications or performance type specifications. Prospective bidders conform to these specifications and submit their bids. The responsible bidder that submits the lowest bid is awarded the contract. The following equipment and work will be accomplished by advertised bids:

1. Preparation of the site, including railroad spurs and roads.
2. The furnishing of pumping units for the process pumping plant.
3. The construction of intake works, including the intake structure, grit sedimentation basins, intake pumping plant, and grit handling facilities; and furnishing and installing pumping units, intake pipes, the discharge manifold, trashrake, and traveling water screens.

4. The construction of pretreatment facilities, including the clear well and the process pumping plant, which includes:
   a. The installation of pumping units (item 2).
   b. The furnishing and installing of:
      (1) The solids contact reactors, thickeners, carbonation basins, and dual media gravity filters.
      (2) The recalcining kiln and accessory equipment.
      (3) The lime storage, handling, and feed equipment.
      (4) The SHMP storage, handling, and feed equipment.
      (5) The polyelectrolyte storage, handling, and feed equipment.
      (6) The pH adjustment system.
      (7) The ferric sulfate storage, handling, and feed equipment.
      (8) The chlorination system.
      (9) The soda ash storage, handling, and feed equipment.
      (10) The sludge handling equipment (except for the recalcining kiln).
      (11) Manifolds, piping, and valves.
      (12) The fire fighting system.
      (13) The standby power system.
      (14) A potable water system.
      (15) The sewage treatment plant.
      (16) The switchyard and transmission line facilities.
      (17) The microstrainers.
5. The furnishing of rectifiers for the electrodialysis units.
6. The furnishing of the energy recovery turbines and generator.
7. The furnishing of the machine shop, maintenance, and test equipment.
8. The furnishing of multijet sleeve valves.
9. The construction of the desalting and energy recovery buildings, including the furnishing and installing of process piping, tanks, instrumentation, valves, and cranes; and the installing of the energy recovery turbines, generator, rectifiers, multijet sleeve valves, machine shop, maintenance, and test equipment.

10. Constructing and providing the administration building, landscaping, parking areas, roads, and fencing.

11. The drilling and completion of wells and the furnishing and installing of pumping units.

Negotiated procurement will be used to procure the membrane desalting equipment and the furnishing and installing of the process control and computer equipment. The negotiated procurement is used to award a contract on a project for which it is difficult to write detailed specifications and it is necessary for the offeror to provide design information. This procedure will require writing a Request for Proposals.

The Request for Proposals will provide general information and specific instructions relative to the preparation and submission of a manufacturer's proposal, and will also include evaluation criteria. Negotiated procurement procedures are set forth in the Code of Federal Procurement Regulation 41, CFR 1-3.

B. Bypass Drain

The Bypass Drain will extend from the present terminus of the MODE at Morelos Dam, in the United States, to the Santa Clara Slough on the northeast corner of the Gulf of California, in Mexico. It will be an open, concrete-lined channel 50.63 miles long, 16 miles of which will be in the United States and 34.63 in Mexico. The United States section will lie between the Yuma Valley Levee and the Colorado River, except for two short reaches--one where it will meander into the toe of the Levee and the other where it will cross through the Levee and back--and connect with the Mexican section about 2 miles west of San Luis.

B.1. Capacity

The Bypass Drain will function to carry the reject stream from the desalting plant, which will normally amount to a flow of 62.3 ft^3/s. Emergency conditions, which may result from power interruptions or similar factors that would render the plant inoperative, will require that the entire MODE flow be bypassed around the plant via the Bypass Drain; therefore, both sections of the drain will be designed for a maximum capacity of 353 ft^3/s to accommodate these flows.

B.2. Design

The 16-mile long Bypass Drain-United States will have a bottom width of 10.17 feet and side slopes of 2:1 from station 0+00 to station 0+50, and a bottom width of 12.0 feet and side slopes of 1-1/2:1 from station 1+11 to station 841+20.00. It will have a 3-inch thick concrete lining and an invert elevation of 84.91 feet at the Southerly International Boundary. Gated wasteways to the river will be provided for maintenance purposes and for emergency situations, and ladders and other escape devices will be included in the design for the safety of humans.

The 34.63-mile long (55.85 kilometers) Bypass Drain-Mexico will have a bottom width of 10.17 feet (3.10 meters), side slopes of 2:1, a 3.94-inch thick (0.1 meter) concrete lining, freeboard of 1.64 feet (0.5 meter), a flow depth of 5.09 feet (1.55 meters), and provisions for a combination maintenance road and levee on both sides (Photograph No. P1292-303-380A).

B.3. Structures

Structures along the United States section will consist of a modified Parshall flume at station 0+50 for flow measurements (the transition from the size of the Bypass Drain-United States to the size of the Bypass Drain-Mexico will be at the downstream end of the Parshall flume), two check structures to regulate the water surface elevation and dampen surges, a bifurcation structure to divert flows from the existing MODE, three siphons where the river channel is adjacent to the toe of the levee, a wasteway crossing, and 10 bridges for local access. Gates on the check structures and the bifurcation structure will be remotely controlled from the desalting plant control room.

The Mexican section of the drain will require 77 structures, which will consist of: one final discharge structure, 19 culvert bridges, one recorder, six storm drains, two drop structures, three culverts, 14 siphons, 23 bridge canals, two dam structures (checks), two drains, one pedestrian bridge, two bridge crossings (roads, etc.), and one gaging station (drop structure).

B.4. Foundation Conditions

The foundation for the Bypass Drain-United States is flood plain alluvium with some fill and windblown sand. The alinement crosses leveled, irrigated farmland in places,

PHOTOGRAPH NUMBER P1292-303-380A
BYPASS DRAIN - MEXICO
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

but most of the area is rough land that is partly overgrown with weeds and brush, with some open land. The surface soils appear to be mostly fine-grained, but soils at the drain invert grade appear to be more coarse-grained than fine. The soils above water table were dry to moist, except that some wet soils were encountered in irrigated farmland areas.

Rockfill was encountered during foundation exploration in a few cases within the excavation reaches. Riprap will have to be removed in at least four locations where the alinement cuts into or through the levee. Buried riprap or rockfill may be encountered elsewhere. No buried wood or trash was encountered but may be present in some locations. The water table is below the designed grade of the drain throughout its alinement.

The Bypass Drain-Mexico will be in the same general foundation soils as the United States section. The alinement is entirely on the delta plain of the Colorado River. The sediment age is Holocene, a portion of which is very young.

The water table is near or above the bottom of the drain in several locations. Many sections will require dewatering during construction. The average ground-water depth is 13.8 feet (4.2 meters) from ground surface, ranging from 1.6 feet to 29.5 feet (0.5 meter to 9.0 meters). The shallower levels are in the southern half of the alinement.

B.5. Rights-of-Way

The United States section of the drain will, for the most part, be located within existing Yuma Valley Levee rights-of-way. The total area required, including both the Levee right-of-way and additional land, will be about 350 acres. Additional right-of-way on Federal land will be required for borrow areas. The Mexican section of the drain will require about 370 acres of private land for rights-of-way.

C. Main Outlet Drain Extension Siphon

In order to maintain a reliable flow through the MODE to the desalting plant, a metal flume adjacent to the river, in the vicinity of Prison Hill at Yuma, has been replaced. The new structure, with inlet and outlet transitions, is a concrete siphon 120 inches in diameter and 3,491 feet long. The siphon has been located on the south side of the old flume alinement. It ties into the present concrete-lined drain channel at station 410+05.38, approximately 800 feet upstream from where the flume began, lies adjacent to the base of Prison Hill, extends under the railroad bridge and the U.S. Highway 80 Alternate bridge, continues downstream along the south bank of the Colorado River, and terminates at station 373+20.08, the approximate location of the end of the old flume (Photograph No. P1292-303-576A).

C.1. Foundation Conditions

The excavation for the MODE siphon was in river sand, placed fill, and bedrock. In this general vicinity the bedrock cropped out only at Prison Hill and across the river at Indian Hill. The Colorado River has cut a deep, narrow canyon through the bedrock and partially backfilled the channel with river sand.

The bedrock occurred as breccia and conglomerate, classified "granite breccia" and "granite boulder conglomerate." The breccia ranged from sand-size fragments to 8-foot boulders. The fragments were not visibly cemented, but were well keyed together. The conglomerate was lime cemented granitic clasts ranging up to boulder sizes. Below ground water the cementation was poor. The river channel sand was fine to medium-grained quartz sand with minor seams of gravel, clay, or silt. The sands were very loosely compacted, as indicated by penetration resistance tests in drill holes taken along the flume and siphon alinement.

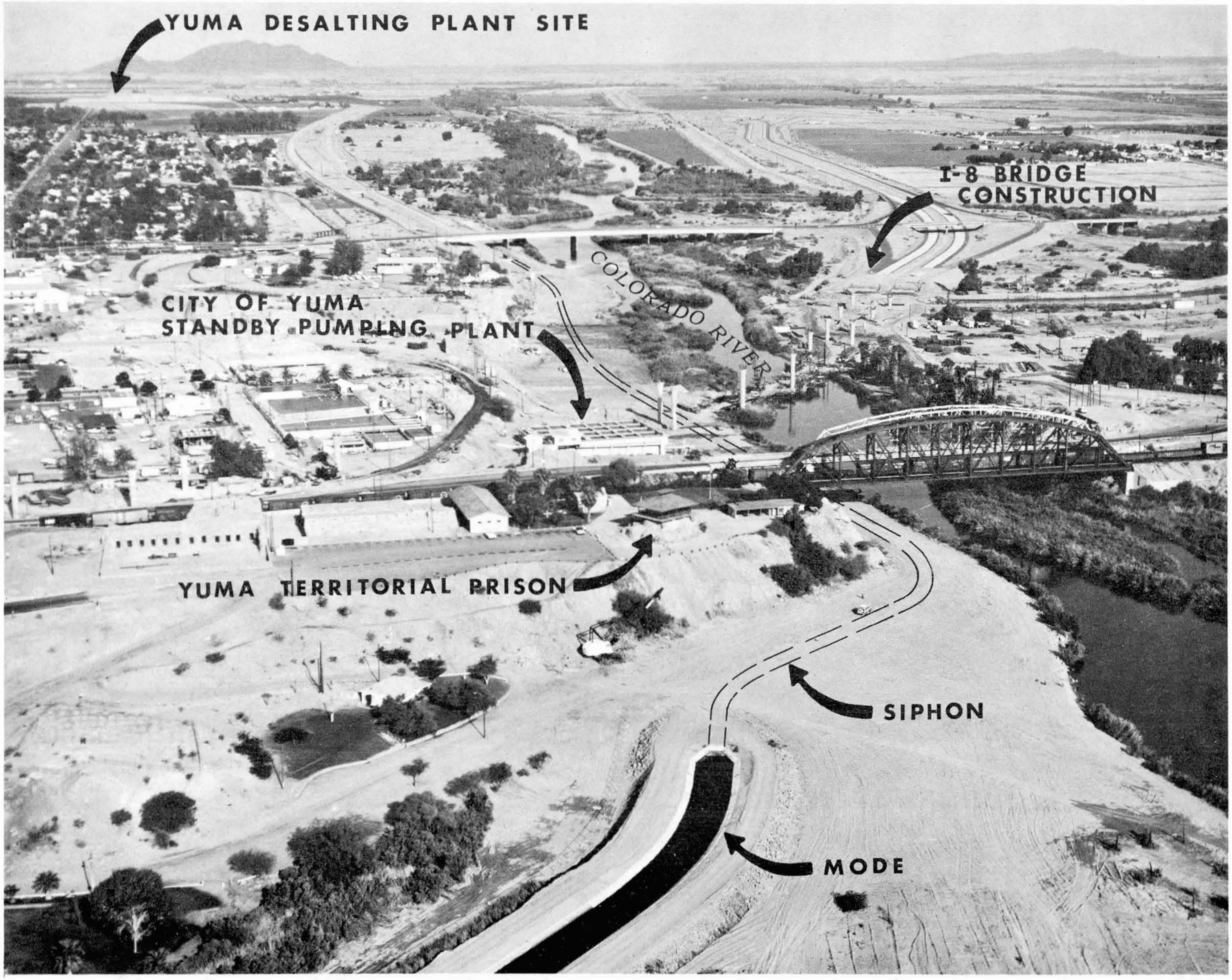
A considerable amount of wood, rocks, car bodies, and general trash was buried in the sand both upstream and downstream of the site. Along the bank the alluvium was generally covered with or mixed with fill consisting of virtually all kinds of soils and rock rubble, concrete blocks, riprap, wood, and trash.

C.2. Design

The siphon is a free-flow type structure without gates or other controls. Reinforced concrete pressure pipe, 120 inches in diameter with monolithic concrete transitions, has been used to obtain a design capacity of 353 ft^3/s. The siphon was buried with a minimum of 3 feet of cover and protected on the river side with a layer of rock riprap. The riprap was covered with a layer of earth and the entire area graded to the appearance of a natural riverbank. Cross drainage between the beginning and ending stations of the siphon was designed to cross over the structure without interference.

C.3. City of Yuma Standby Pumping Plant Relocation

Siphon construction required that portions of the city of Yuma water treatment plant and storm water system, including the standby pumping plant, be relocated. The



PHOTOGRAPH NUMBER P1292-303-576A
MAIN OUTLET DRAIN EXTENSION SIPHON AND YUMA STANDBY
PUMPING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Federal Government constructed a new, reinforced concrete, outdoor-type standby pumping plant structure which was designed to permit installation, by the city of Yuma, of the pumping units installed in the old standby plant. The new plant location avoided interfering with the MODE siphon and an existing municipal water supply line and gasline, yet minimized excavation into the steep earthbank south of it. A retaining wall north of the new site was removed.

The bottom elevation of the new plant was determined after consideration of a future river minimum water surface elevation of 108 and river bottom elevation of 106, resulting from future dredging of the river and required submergence of the pumps in the old plant. The submergence is adequate for wet-sump-type vertical pumping units to be installed in the future. The plant bottom elevation also permits the intake pipe to cross under the MODE siphon. The top deck was set at elevation 124.50, above the design flood elevation, but below the 100-year flood. There are plans to convert the riverbank into a park and, therefore, it was desirable to set the plant deck as low as possible to minimize any impact on the appearance of the park.

C.4. Rights-of-Way

The buried concrete siphon required approximately 6 acres of rights-of-way adjacent to the Colorado River channel along the northerly boundary of the city of Yuma. The rights-of-way are 80 feet wide and 40 feet each side of centerline for the length of the structure, beginning just east of Prison Hill and extending downstream approximately 3,600 feet.

D. Wellton-Mohawk Irrigation Efficiency Improvement Program

An increase in irrigation efficiency in the Wellton-Mohawk Division (an aerial view of the valley is shown in Photograph No. P50-300-01143) will reduce desalting plant costs by reducing the quantity of drainage water to be processed by the plant. This reduction will also decrease the quantity of water that will be lost as brine in the desalting process. The present Irrigation Efficiency Improvement Program is actually a combination of five subprograms under the direction of several different agencies.

D.1. Irrigation Management Services (IMS)

The Bureau of Reclamation entered into a cooperative agreement with the Wellton-Mohawk Irrigation and Drainage District on May 8, 1973, for the initiation of an IMS demonstration program. The objectives of IMS are to improve crop quality and yields and to promote efficient use of irrigation water. The enactment of *Public Law 93-320* modified the mission of IMS to accelerate this effort in order to reduce drainage return flows.

A staff of IMS technicians were assembled and trained in the fundamentals of soil physics, plant-soil moisture relationships, soil moisture measurements, and agronomic practices in the Division.

Some difficulties have been experienced, however, in structuring IMS to the Wellton-Mohawk area and in coordination of irrigation dates with other agronomic practices.

The improvement of irrigation water applications in the Division requires an understanding, on the part of the water user, of the amount of water required for plant growth and cultural practices; it is not enough to know the annual consumptive use of each crop. The irrigator needs to know what is related to each irrigation--how much to apply, at what rate, how often, and how best to apply the water with his irrigation system. The necessary technical information needed, assuming an adequately designed and installed irrigation system is in operation, requires knowledge of soil water-holding capacities and intake rates, and soil moisture content at the time of irrigation. The IMS program is adapted to collect and use this type of information and to provide the water user with the amounts and time of each irrigation.

The IMS program will be expanded to include as much irrigated land in the Division as possible. Following a period of demonstration and refinement of procedures, it is expected that the District will take over the program and continue to provide this service to the water users with Federal funding provided only for technical assistance that may be required.

D.2. Onfarm Improvements

The Soil Conservation Service (SCS) currently coordinates a voluntary program to provide technical and economic assistance for the installation of onfarm measures conducive to improved irrigation efficiency in the Wellton-Mohawk Division. A landowner/operator who wishes to implement structural, vegetative, or management

PHOTOGRAPH NUMBER P50-300-01143
IRRIGATED FARMLAND--WELLTON-MOHAWK DIVISION, GILA PROJECT, ARIZONA
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

practices pertinent to such improvement may make application to the SCS for assistance. The SCS, upon acceptance of the application, will (1) provide assistance to the individual to develop a plan of operation for his particular land unit and (2) enter into a contract with him to provide, through nonreimbursable Federal funds, 75 percent of the costs of the eligible onfarm improvements. The landowner/operator will then contract for the actual construction of the improvements at the price schedule set forth by the SCS; information on contractors capable of doing the work will be furnished by the SCS.

D.2.a. Proposed Improvements

Improved management on valley surface irrigation systems through the use of automatic control and accurate measuring devices is under consideration. The large irrigation heads necessary require a short application time which must be strictly adhered to if high efficiencies are to be obtained. Automation could save labor and permit the operator to have better control of the system with minimum inconvenience, in addition to accurately measuring the water to each set. As now generally used, it also provides for timing devices to sequence water from one set to the next on a predetermined schedule.

Efficient irrigation of lettuce, melons, and other vegetable crops will necessitate the use of sprinkler systems. Approximately 1-1/2 acre-feet per acre of deep percolation on the vegetable acreage could be eliminated if sprinklers are used for germination instead of conventional surface subbing. However, because the restricted use of such systems on a particular crop would be expensive, their adoption is expected to be limited. Economic assistance will not be available unless the sprinkler system is to be a permanent land improvement.

Established irrigation systems for the mesa citrus orchards cannot be significantly modified. Improvement of the system design would require cutting the lengths of the runs to 400 feet or less and, since this would necessitate the removal of trees, it is not deemed practical. Some improvement can be made by adding extra ports where needed to get a full 15 ft^3/s irrigation head into the border.

Due to the limitations present in modifying these established systems, major system improvements on the mesa citrus orchards will require a changeover to pressure systems. Such changes can be made with minimum disturbance to the established orchards.

Pressure systems will provide better control over water application than can be provided even with automated gravity systems. Sprinklers are not recommended for citrus orchards but full advantage of pressurized systems can be obtained with some form of trickle or bubbler irrigation. Bubblers and various types of emitters are available and will be tested through local application. In addition to securing high efficiencies, trickle irrigation provides for a more uniform application of water, possible water savings, more efficient application, the use of fertilizers, and labor savings.

D.2.b. Design Criteria

The SCS design criteria for onfarm improvements in the Division are based on an 80-percent irrigation efficiency that will be obtained after the construction of the improvements has been completed. The following design requirements are necessary to meet these criteria:

1. All dirt field ditches will be concrete-lined.
2. Areas where soil has a low water-holding capacity will be delineated and remedial action decided on.
3. The minimum length of run (distance from the field turnout to the end of the field being irrigated) is 330 feet.
4. The maximum depth of water application is 6 inches.
5. Each system will be designed to carry a minimum of 15 ft^3/s.

Designs will be based on actual field conditions to best fit the individual farmer's needs and to accomplish the objective at 80 percent irrigation efficiency. Field designs will provide for the utilization of heads larger than 15 ft^3/s where available. Some land leveling and soil borrowing may be necessary, and pressure systems for citrus will be designed to meet consumptive use requirements at 80 percent irrigation efficiency.

D.2.c. Technical Assistance

Technical assistance for design and construction on the onfarm improvements is available from the SCS and will be accelerated to meet the needs of the project. This assistance will be provided in cooperation with the Wellton-Mohawk Natural Resource Conservation District.

The criteria for accepting applications and providing assistance are based upon land eligibility and present irrigation efficiencies. Lands being considered for purchase and retirement by the Bureau of Reclamation are excluded.

D.3. Research and Demonstrations

The purpose of research and demonstration is to obtain additional information helpful in reducing return flows without adverse effects on agriculture. Six projects were selected and funded under direction of the Agricultural Research Service to document the effectiveness of increasing the efficiency of gravity irrigation systems and to obtain data useful for design and management of pressure irrigation systems on citrus. Two additional supportive projects in the Division have been undertaken by the Agricultural Research Service with funding support from the Environmental Protection Agency.

The six projects funded under direction of the Agricultural Research Service are as follows:

1. Monitoring of soil salinity.
2. Clogging of emitters in trickle irrigation systems.
3. Management of pressurized irrigation systems for citrus.
    a. Methods of applying irrigation water.
    b. Tree response to nutrient levels.
    c. Weed control with herbicides.
    d. Observation block of trees.
    e. Emitter geometry and application amount.
    f. Phytophthora root rot under trickle irrigation.
4. Management of dead level irrigation.
5. Automation of surface irrigation.
6. Economic evaluation of alternative irrigation systems.

Additional projects with funding support from the Environmental Protection Agency are as follows:

1. Determining partial pressures of CO_2.
2. Salt balance as affected by Irrigation Management.

D.4. Accelerated Education Program

Arrangements have been made with the Cooperative Extension Service, University of Arizona, for an accelerated extension education program in the Wellton-Mohawk region of Yuma County. One objective of this program is to keep the local community informed of the activities and progress of the various, diverse programs related to meeting the goals of *Public Law 93-320.* Other objectives are to assist farmers/land operators in expediting the adoption of irrigation conservation technology, to disseminate new information as it becomes available, and to assist IMS cooperators in the broad range of cultural practices related to farm profitability. A continuing series of information meetings will be organized and appropriate visual aids will be developed to enhance communications.

The current staff of three county agents of the Extension Service of Yuma County will assist a special irrigation agent who was appointed for this program. Further technical assistance and coordination will be provided by the Extension Agricultural Engineer in Tucson.

D.5. Technical Field Committee

The Technical Field Committee, composed of a chairman and six members from various concerned agencies, is charged with the responsibility for coordinating, monitoring, and evaluating the effectiveness of the Irrigation Efficiency Improvement Program. The committee meets regularly to assist the Bureau of Reclamation in the acreage reduction program, the Bureau and the Wellton-Mohawk Irrigation and Drainage District in the acceleration of the IMS program, the Soil Conservation Service in establishing criteria and procedures for onfarm improvements, the Agricultural Research Service in evaluating and establishing the most beneficial research and demonstration program, and the Arizona Cooperative Extension Service in establishing an effective education program. Periodically, all measures are evaluated by the Committee to insure adequate progress and to ascertain the effectiveness of the work.

E. Wellton-Mohawk Acreage Reduction

The irrigable acreage of the Wellton-Mohawk Division will be reduced from 75,000 acres to approximately 65,000 acres in order to reduce drainage flows.

E.1. Lands to be Retired

The land acquisition program has been initiated in accordance with the provisions of *Public Law 93-320.* The staff of the Yuma Projects Office, in consultation with the

Soil Conservation Service personnel in Wellton and the Board of Directors of the Wellton-Mohawk Irrigation and Drainage District, initially identified about 20,000 acres of irrigable land that met the criteria for acreage reduction, as presented in the *Land and Agricultural Supporting Data.*

The reason for identifying 20,000 acres for possible reduction was to locate sufficient land for acquisition so that the onfarm improvement program could be initiated on the remaining acreage. This procedure eliminated the possibility of constructing improvements on lands being considered for acquisition. About 3,800 acres of irrigable United States land exist within the Division. Therefore, 6,200 acres of private and State-owned land will need to be acquired to make up the total 10,000-acre reduction. After acquisition of the required 6,200 acres is assured, the remaining private and State-owned land originally considered for acquisition will be released so that it is eligible for participation under the onfarm improvement program.

Approximately 7,500 acres of private land have been offered for sale. However, whether these owners will sell their land cannot be determined until appraisals have been made and contracts for purchase have been presented to the landowners. Most of the land that has been offered for sale is located on the Wellton Mesa and is planted predominantly in citrus.

E.2. Contract Changes Required

A basic repayment contract, dated March 4, 1952, provided that the Wellton-Mohawk Irrigation and Drainage District repay the Federal cost of construction for irrigation facilities to divert Colorado River water to 75,000 irrigable acres of Division land. The District's repayment obligation was fixed not to exceed $42 million over a repayment period of 60 years, and was geared to the repayment ability of three major categories of land, designated as Productivity Groups I, II, and III, with Group I having the highest assessment rate.

Various supplements and amendments to the original contract have since occurred. One, on September 1, 1959, increased the District's maximum repayment obligation to $56 million by authorizing an additional $14 million expenditure for installation of urgently needed drainage facilities. This additional obligation was declared repayable over a 50-year period. Another, on March 4, 1962, combined and modified the 1952 and 1959 contract repayment provisions to constitute a consolidated general repayment obligation of $56 million to be repayed over a period of 55 years. This consolidated general repayment obligation was then reduced by supplemental and amendatory contract on August 15, 1968, by the amount of the nonreimbursable project costs of $5,915,268 allocated to flood control, making a new repayment obligation of $50,084,732.

Repayment of the consolidated general repayment obligation is tied to assessment rates established for each productivity group of land in the 75,000 irrigable acres. Any reduction in this acreage would affect the repayment schedule established by the March 4, 1952, contract, as supplemented and amended. Since this acreage is being reduced to 65,000 irrigable acres, a new repayment schedule will be negotiated with the Wellton-Mohawk Irrigation and Drainage District.

E.3. Future Disposition of Retired Lands

Retired lands will either remain under Government ownership or will be sold to interested parties as nonirrigable land with such possible uses as storage areas or building construction sites. Land remaining under Government ownership will either be allowed to return to native desert vegetation or will be maintained in a condition that will prevent erosion and possible damage to adjacent land and crops.

F. Painted Rock Reservoir Land Acquisition and Operation Schedule Modification

Painted Rock Dam (Photograph No. P1292-300-01114) is located on the Gila River about 20 miles northwest of Gila Bend, Arizona, and was constructed by the Corps of Engineers under the authority of the 1950 Flood Control Act. The single purpose of the dam is for flood control, and the reservoir would normally be dry except for impoundments during and following periods of heavy rainfall and upstream flood releases. The gross capacity of the reservoir is 2,491,700 acre-feet which includes 200,000 acre-feet allocated for sediment control. The dam provides protection from floods to agricultural lands along the lower Gila River, along the Lower Colorado River in Arizona and California, and in the Imperial Valley in California. Since the Gila River traverses the entire length of the Wellton-Mohawk Division, floodflows in the river can infiltrate the aquifer and

PHOTOGRAPH NUMBER P1292-300-01114
PAINTED ROCK DAM AND RESERVOIR, ARIZONA
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

significantly aggravate drainage conditions; such conditions require additional water to be pumped from the aquifer. In times of major flooding, operation of the dam will be closely coordinated with the operation of dams located on the Colorado River.

F.1. Proposed Changes in Operating Criteria

The Corps of Engineers initiated studies to determine the optimum release schedule to reduce infiltration of floodwaters to the Wellton-Mohawk aquifer. The schedules studied include the current approved schedule, designed to empty the reservoir in a short period of time, and schedules that would store water in the reservoir for longer periods of time during and following a flood. The new schedules would release water at a lower rate than the approved release schedule at lower water surface elevations in the reservoir to enhance, as much as possible, the infiltration to the ground-water basin between Painted Rock Dam and the eastern end of the Wellton-Mohawk Division. In the past, releases of 250 ft^3/s have evaporated or infiltrated the reach of the river between Painted Rock Dam and the eastern end of the Wellton-Mohawk Division.

The Corps has indicated that consideration will be given to the preparation of a new reservoir regulation manual for all flows that would take the reservoir above 610 feet mean sea level on a time-of-year basis. If, for example, the reservoir water surface is at elevation 610 feet mean sea level at the beginning of a flood season and a major flood event should occur, the releases would be made on a stepped schedule developed by the Corps to prepare the reservoir to receive and control further possible major floods during the remaining portion of the flood season. However, if a major flood event should occur at the end of a flood season, the releases above elevation 610 feet mean sea level would be gaged to restore the reservoir to that elevation by the beginning of the next flood season, approximately six to eight months later.

If the release schedule for Painted Rock Dam is changed, structural modifications may be required to accommodate water storage in the reservoir for extended periods of time. The estimated cost of the structural changes will depend on the release schedule adopted, but plans have not been initiated to authorize modifications to the dam. The work would include exploratory grout holes in the right abutment of the dam, installation of piezometers to monitor the phreatic line with a permanent reservoir, and modifications to the outlet works.

F.2. Land Acquisition in the Reservoir Area

Fee title has been acquired on all lands in Painted Rock Reservoir to a maximum pool elevation of 580 feet; these lands amount to 5,164 acres. Flowage easements were acquired on all privately owned, State-owned, and Indian-owned lands between 580 feet and the spillway elevation of 661 feet; these lands amount to 36,960 acres. Public domain lands within the reservoir, amounting to 37,821 acres, were also withdrawn for flowage easements. It is now estimated that 8,800 acres of additional private lands in the reservoir need to be acquired.

Public Law 93-320, in Section 101 (j), states as follows:

> The Secretary is authorized to acquire through the Corps of Engineers fee title to, or other necessary interests in, additional lands above the Painted Rock Dam in Arizona that are required for the temporary storage capacity needed to permit operation of the dam and reservoir in times of serious flooding in accordance with the obligations of the United States under Minute No. 242. No funds shall be expended for acquistion of land or interests therein until it is finally determined by a Federal court of competent jurisdiction that the Corps of Engineers presently lacks legal authority to use said lands for this purpose. Nothing contained in this title nor any action taken pursuant to it shall be deemed to be a recognition or admission of any obligation to the owners of such land on the part of the United States or a limitation or deficiency in the rights or powers of the United States with respect to such lands or the operation of the reservoir.

It has not yet been determined by a Federal court whether or not the Corps of Engineers lacks legal authority to operate Painted Rock Dam to minimize infiltration of Gila River flows to the Wellton-Mohawk Aquifer.

G. Fish and Wildlife Mitigation Measures

Environmental considerations and commitments, as presented in the *Final Environmental Statement* and summarized in Chapter XII of this report, are of major concern and will be actively followed during the design, construction, and postconstruction periods. The measures to be followed during these periods are as follows: (1) design concepts will be shaped to minimize the adverse effects of manmade structures on the natural environment; (2) systematic reviews on construction work will be performed with particular emphasis on environmental concerns, which will insure full awareness of environmental matters during the construction phase; and (3) maintenance review of the project after construction will be performed as appropriate. This will enable evaluation of the effectiveness of environmental monitoring programs, and will allow for the refinement of monitoring programs as needed.

An *Environmental Guidebook for Construction* has been published by the Bureau of Reclamation for its use during construction; the guidebook is also made available to contractor personnel. This 61-page pocket-size book generally delineates the aspects discussed in the Final Environmental Statement. The booklet represents a standard for the construction industry applicable to Bureau of Reclamation construction.

In addition to the guidebook, orientation sessions will be provided to employees in positions of responsibility and key inspection positions to heighten their awareness and sensitivity to environmental requirements identified in both the *Final Environmental Statement* and contract specifications. Of particular concern in the orientation sessions will be the need to recognize possible scientific, prehistorical, and archeological materials should they be uncovered during excavations for structures.

G.1. Hunter's Hole Pond Complex

Even though the Hunter's Hole ponds are now in existence, the water surface elevation will be reduced a minimum of 7 feet in 10 years. The ponds now have an average depth of approximately 6 feet with a maximum depth of 18 feet. They will essentially be lost as open water areas within 10 to 15 years as a result of existing pumping. The removal of the Wellton-Mohawk drainage flow from the river channel will only result in an immediate drop in surface elevation of 2 or 3 feet. Maintaining these ponds will be considered direct mitigation since their total demise would eventually occur due to natural succession and existing pumping practices.

In order to maintain the water as long as feasible in Hunter's Hole, a well equipped with up to a 5 ft^3/s capacity pump will be installed adjacent to the ponds to supply fresh water to them on a demand basis. Due to unpredictable percolation rates, the pumped ground water may not maintain the water level in perpetuity. The water surface elevation and water quality will be monitored to determine the efficiency of the measure. Use of the well water will not be an infringement on any water rights, but will be accountable under the 160,000 acre-feet per year stipulated in *Minute No. 242.* A water level control structure will be installed on the pond outlet to the river to prevent excessive outflow of water and to assist in maintaining the upper 3-foot elevation of the pond's water surface. The introduction of pumped water having a TDS of approximately 1,200 p/m as opposed to the existing pond water which now has a TDS level in excess of 4,000 p/m is expected to improve water quality in the pond. Seepage from the upper perimeter of the 12 acres of open water is expected to maintain approximately 8-12 acres of riparian vegetation around the pond complex. The vegetated area that will be sustained is existing suitable habitat for the endangered Yuma Clapper Rail and numerous other species of wildlife. A maximum of four Clapper Rails has been censused in the Hunter's Hole Complex.

Throughout the feasible life of the mitigation measures, operation and/or maintenance costs of this feature will be the responsibility of the designated management agency as outlined in a cooperative agreement.

G.2. Wildlife Management Area and Fish Rearing Facility

An adequate number of acres will be acquired by Reclamation and assigned to the Arizona Game and Fish Department for designation as a wildlife and recreation management area. The preferred location, the Dome Narrows Site, is along the Gila River within the narrows created by the Laguna Mountains on the north and the Gila Mountains on the south. This area will support a dredged ponded area for fish, wildlife and recreational use, marsh and riparian wildlife habitat, wildlife crops, a pumped supply of ground water, and a site for a fish rearing facility.

The Arizona Game and Fish Department, under contract to the Bureau of Reclamation, is presently exploring other sites for a wildlife management area, or disjunct areas, for fish and wildlife mitigation in the event there is a better site or the Gila area is not available.

Presently within the proposed Dome Narrows area there are developed farmlands, riparian habitat, including open water, marsh, woody riparian (mixed phreatophytes), wetlands, and undisturbed desert habitat. Irrigation and drainage facilities, U.S. Highway 95, and various access roads also pass through this area. These lands are located adjacent to Yuma County's Adair Park, irrigated farmlands, the Wellton-Mohawk Main Conveyance Channel, the Wellton-Mohawk Canal, and the Southern Pacific Railroad.

After acquisition of the land is complete, it will be designated as a wildlife and recreation management area, but will not have rights to receive Colorado River water. Water will, however, be supplied by pumped ground water. Ground water in the surrounding area varies from 1,100 p/m to 3,500 p/m at depths from 8 to 120 feet below ground-water level.

Land within the management area can be selectively utilized for producing wildlife feed crops and/or abandoned to revert to natural riparian growth. A low-lying area of 12 to 15 acres can be developed by dredging an 8- to 12-acre pond to provide aquatic habitat and peripheral hydrophytic vegetation.

If the Dome Narrows site is the final selection, the Gila River riparian habitat, presently consisting of marsh, mixed phreatophytes, and some open water, will be preserved and enhanced by selective channel dredging with consideration given to Gila River floodflows. A slightly meandering channel, varying in width and depth, will be dredged to create additional aquatic habitat. This will greatly enhance the fishery in this area. Branches off the main channel will be provided to create secluded coves for aquatic and semiaquatic wildlife.

A fish rearing facility will be constructed to provide for the annual stocking of fishing waters in the Yuma area. Sizing of the facility will be determined through negotiations with the Arizona Game and Fish Department in coordination with the Fish and Wildlife Ad Hoc Committee. It is anticipated that the facility may provide enough fish for the annual stocking of 200 to 300 surface acres of fishing water and for about 50,000 angler days of fishing activity per year. Locating the facility within a controlled management area will afford it security, a suitable and ample water supply, some protection from herbicide and pesticide aerial drift, and ready access to a main thoroughfare and power source.

Development of plans and designs for the wildlife management area and fish rearing facility will be coordinated with the Arizona Game and Fish Department and the

Fish and Wildlife Ad Hoc Committee. Costs and designs will be relative to land exchange, sizing of the fish rearing facility, capacities of ground-water wells, dredged pond surface areas, and other appurtenant features such as power transmission lines, access roads, and protective works. Operation and maintenance of the wildlife management area and fish rearing facility will be the responsibility of the designated management agency. The overall operation and maintenance responsibility for management of the area will be outlined in a cooperatively developed management agreement.

IX. OPERATIONAL PROCEDURES

A. Pretreatment System, Desalting System, and Appurtenant Works

Operation of the Yuma Desalting Plant will be coordinated to salvage Wellton-Mohawk pumped drainage as a supplement to Mexican water diversions such that the total quality of water arriving at the Northerly International Boundary will be in accordance with the salinity differential stipulated in *Minute No. 242*. The influence of the plant on constituent flows to the river between Imperial Dam and the Northerly International Boundary will be added to the present method of monitoring the variable salinity and flows of the overall river regimen. Table 12 shows the projected river operations for these constituent flows, including those which will come from the desalting plant. Primary control of the salinity differential is and will be by the adjustment, within limits, of these return flows (excluding the unmeasured flows). Variation, when possible, of the operational capabilities of the desalting plant will be used to help control the differential.

The overall control philosophy for the desalting plant will be total facility control from one central location utilizing a distributed digital computer process control system. The advantages of this control philosophy are: (1) all facility data will be centralized and available for plant operations; (2) all facility failure and shutdown conditions will be available to aid in diagnosing problems rapidly; (3) all functions will be controllable in quick succession to reduce process lag time by facilitating startup, shutdown, and change conditions; (4) all facility data will be available for processing and for management decisions or studies; (5) all changes in control parameters will be implemented by software changes without hardware changes; (6) most control processes will have the capability of being automatically controlled without operator intervention; (7) out-of-limit conditions will be identified before a failure or shutdown occurs; (8) maintenance schedules will be automatically derived to reduce the frequency of process equipment failures; (9) the number of plant operating personnel will be significantly reduced; and (10) plant processes will be centrally monitored, which will increase plant productivity and efficiency. The implementation of this type of a philosophy will require very reliable equipment, since a control center equipment failure would make overall plant control difficult, and a distributed computer control system, due to the functional requirements necessary for plant control and operation.

TABLE 12
PROJECTED RIVER OPERATIONS WITH DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

	Volume 1,000 Acre-Feet	Salinity p/m TDS	Salinity 1,000 Tons
Route or Source			
Colorado River Arriving at Imperial Dam	5,640	865	6,630.0
Releases from Storage:			
Colorado River Below Imperial Dam	289.3	855	336.2
Yuma Main Canal Wasteway	103.0	873	122.2
Pilot Knob Pumping Plant and Wasteway	594.1	835	674.2
Subtotal from Storage 1/	986.4	845	1,132.6
Other Return Flows:			
South Gila Pumping	55.0	2,200	164.5
Yuma Mesa Pumping	50.0	1,400	95.1
Other Measured Flows	70.0	1,300	123.7
Unmeasured Flows	75.0	1,500	153.9
Subtotal Return Flows	250.0	1,578	537.2
Yuma Desalting Plant:			
Product Water	102.7	386	53.9
Blend Water	20.9	3,155	89.7
Subtotal Desalting Plant	123.6	854	143.6
Total NIB	1,360	980	1,812.4
Salinity Differential		115	

1/ Includes deliveries to Tijuana, Mexico.

The key feature of the control system for the Yuma Desalting Plant will be a control center incorporating two medium size, realtime computers, one of which will be a standby. These computers, which will be located in the administration building, will communicate with smaller remote process control computers in the pretreatment and desalting areas. In turn, each process control computer will communicate to each individual process via remote multiplexers located near each process.

The control center equipment will be designed to be 99.80 percent available, which will provide a downtime of only 18 hours per year. This high availability will be accomplished by utilizing a redundant configuration for the control system that will incorporate such features as highly reliable solid-state equipment, quick diagnostic methods, modular component arrangement, quick component replacement methods, and automatic failover equipment.

The control center computer will provide displays for three CRT consoles. These consoles will be the man-machine interfaces to the control system, and will provide data to the operator in multicolored displays.

Control points on the CRT face will be accessed via a light pen to open or close a valve or breaker, to start or stop a motor, or to access a point on the CRT into which the operator may wish to insert a setpoint or limit. The control center will use the console operator to "close the loop" during control operations. The operator will select a desired operation with the light pen and then activate the operation directly from the CRT face. The control center computer will then send a command down the control chain specifying the desired action. The result of the action will be sent back up the communication chain as data that will be displayed on the CRT face. A record of the action will be printed out on one of the console loggers with the time of its occurrence.

The operator will be able to enter setpoints and limits at the CRT console. These quantities will define desired valve positions, chemical dosages, and alarm limits. The control center computer will communicate the alarm settings to a distributed computer, or remote terminal unit (RTU), which will continually check the process at a set rate and send back an "out of limits" message to the control center if a quantity exceeds the limit. The console operator will be able to enter a setpoint to increase or decrease a process quantity. The setpoint value will be inserted by the RTU computer into a closed-loop control sequence and the RTU computer will independently calculate the control changes needed to increase or decrease the process output. The operator will be able to initiate startup and shutdown sequences that will also be closed-loop functions performed by the RTU computer. The operator will continually receive information on the outcome of his actions as the process continues.

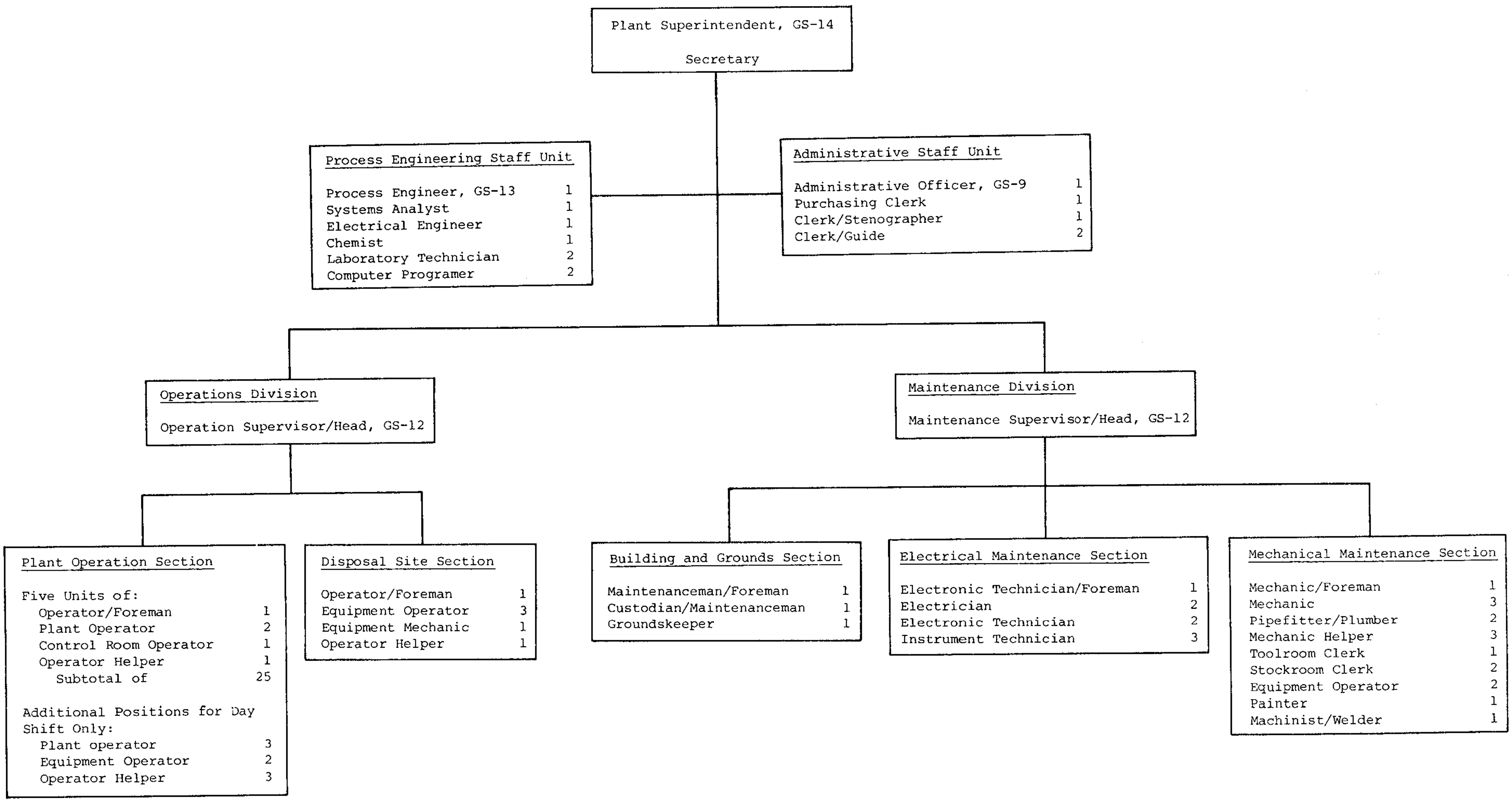
The man-machine interface will be such that the CRT will be utilized to the greatest extent possible. The CRT, in combination with a light pen, will provide dynamic data display and control. By utilizing the light pen for access of information, such as for paging through displays, the operator will be able to quickly obtain information needed for control. Also, by utilizing CRT "control trees" and "control points," the operator will be able to rapidly control the system.

Personnel for the desalting plant will be divided into administrative, operation, and maintenance staffs (see Figure 5). The plant will normally operate 24 hours a day, 7 days a week. The operation staff will work on a three shift per day basis. The majority of the maintenance staff will work a single daily shift; either a skeleton crew or oncall personnel will be available during the remaining shifts. The administrative staff will be on a single daytime shift and will include personnel to handle the visitor's center.

Additionally, all personnel who will be involved with the operation of the plant and those who will handle membrane elements will receive training in the operation, maintenance, and handling of the equipment from manufacturer's representatives. A plant operation document will also be developed in conjunction with the final design and will be completed before the plant goes into operation. This document, which will include detail to the extent of listing operation by valve number, will be used during initial plant startup and operation and, as modified by experience, will become the operating manual for the plant.

A.1. Pretreatment System

Operation of the desalting plant pretreatment system will be adjusted, due to the given range of feed water conditions within which the system will be dependent, to correspond to the variable conditions of the MODE drainage. The flow, salinity, pH,



STAFF ORGANIZATION
YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Figure 5

alkalinity, air and water temperature, and turbidity of the drainage water will be continuously monitored at station 0+00 on the Wellton-Mohawk Main Conveyance Channel, approximately 18 miles upstream from the desalting plant intake structure, and the readings telemetered to the plant control room so that any necessary modifications in the operation of the system will have sufficient time to be implemented. The MODE flow itself will be adjusted on a monthly basis, dependent on drainage conditions in the Wellton-Mohawk Division; however, daily control can only be maintained to within + 6.5 Mgal/d (10 ft^3/s).

Normal operation of the pretreatment system is expected to occur 332.5 days per year. Twelve additional days of the year will be comprised of no flow in the MODE due to scheduled maintenance and, therefore, no flow will occur through the pretreatment system. Shutdown and startup of the system during this outage will be as follows:

Shutdown - Ten hours after the well pumps are shut off, half the pretreatment system will be shut down for lack of water. Four hours later the other half will be shut down. These procedures will be sequentially executed by the computer.

Startup (for initial startup and for startup after a scheduled shutdown) - The first solids contact reactor will receive water 1 day after the well pumps are started. This will avoid putting the first MODE flow, which will likely have a high suspended solids loading, into the pretreatment system. The second and third reactors will be started a day later. These will be fed with sludge from the first reactor to expedite the formation of sludge blankets for proper operation. The fourth reactor will be started 12 hours later. It is expected that the solids contact reactors will require approximately 2 days to reach a condition where the suspended solids content of the effluent will be sufficiently low that it can be put into the filters. This time will be slightly curtailed for the fourth reactor. A period of 2 hours will be required to condition each battery of filters associated with the reactors. Until this conditioning is complete, the reactor effluent will be treated as operational waste and it will be bypassed to the Bypass Drain or the MODE-2 channel. When the filter effluent from each cluster of filters is satisfactory, turbidity is less than 0.5 Jackson Turbidity Unit, and plugging factor is less than 40 percent, it will flow to the clear well.

Power outages during normal operation are expected to occur throughout the year, the longest of which is assumed to have a 12-hour duration. Under such conditions, the pretreatment system will be maintained in nearly usable condition by recirculating the effluent under emergency power. The turnout gates at the intake structure will be closed so that MODE flow will go directly to the MODE-2 channel or Bypass Drain. A period of 4 hours will be allowed for the pretreatment system to stabilize after power is restored, during which time the effluent will be treated as operational waste.

Maintenance of the pretreatment system will be conducted to maximize equipment performance, and three basic types will be followed: preventive, corrective, and complete overhauls. The preventive maintenance program will include regular inspections and lubrication of equipment; mechanical equipment in the system will be disassembled, systematically inspected, lubricated and overhauled, as required, during the scheduled shutdown period, and a record on each piece of operating equipment will be kept. Corrective maintenance will be required to restore a piece of equipment to an operational status after a breakdown, or when the inspection cycle indicates a corrective task must be performed. Overhauls will include complete disassembly of a piece of equipment, and each part will be inspected, restored, and reassembled to start an operating cycle.

It is expected that the pretreatment system mechanical equipment, when properly operated and maintained, will have a life cycle of 20 years; this will include the major equipment in the intake structure, grit sedimentation basins, intake pumping plant, solids contact reactors, dual media gravity filters, and various chemical feed systems. The civil structures for the facility, assuming no damages to the structural concrete occur due to earthquakes, are expected to have a life cycle of 50 years. Replacement of the filter media is expected to take place after 10 to 15 years.

A.2. Desalting System

The membrane desalting plant will consist of a multiplicity of 1- to 5-Mgal/d control blocks, each separately controllable. Normal operation of the plant, once it is online, will be by automatic control of each control block. The primary control for the reverse osmosis sections will be on the reject concentration, since it will be essential that scaling not occur in the membrane elements or stacks. Since recovery is a function of reject concentration, the reject concentration will be controlled by adjusting the recovery. Normal operation is not expected to require throttling of the pump output to maintain operating pressure, but when necessary, it will be possible to reduce the operating pressure stepwise by controlling the number of pumps in operation. Flow through the electrodialysis stacks will be maintained at design conditions and the rectifier output adjusted to give the required product concentration. The reject concentration and, thus, the recovery of the section will be controlled by regulating the amount of concentrate recirculated.

Normal startup of the reverse osmosis section of the plant will be as follows:

> First, the entire system will be cleared of air and biocide (the biocide solution will at least partially fill each vessel). The air pockets will be removed either by pumping water through the system or by the use of air bleed valves at high spots in the system, and the biocide solution will be removed by pumping water through the system. The pressure used will be low, only that required to give a flow through the membrane elements equivalent to the lowest flow expected during normal operation, which would be the reject flow from the last elements. In order to accomplish this, each reject control valve will be set by the controller. The vertical turbine pumps at the clear well will then be started sequentially. This pump startup sequence is expected to last at least 2 hours, during which the air vent valves will be opened to vent air and reject lines monitored to insure that all air is expelled from the piping and membrane system. During this time, the reject line sleeve valves will be full open. All vertical turbine pumps, at the conclusion of this step, will be in operation and the reverse osmosis sections will be under a pressure of between 50 and 100 lb/in^2. A small quantity of product water will then be flowing from the membrane units.

The high-pressure pump will be started at this time, and the high-pressure pump bypass will be closed as the high-pressure pump discharge is opened. The computer will scan the conductivity of the reject at each reject flow control valve as operating pressure is approached, and switch from flow control to conductivity control when reject conductivity reaches a preset value. A flow controller will be used to insure that the flow remains within the required limits. Pressure in the main reject line will be controlled by the sleeve valve, with the turbine secured. The computer, by scanning the individual reject control valve positions, will adjust the sleeve valve such that no reject valve will be more than 90 percent open. Any reject control valves not already operating from the conductivity sensors when operating pressure is reached will be switched over. Some of the vertical turbine pumps may have to be shut down during this period to avoid overheating. Once satisfactory operation of the membrane sections is reached, the reject pressure control will be switched from the sleeve valve to the energy recovery turbine.

Normal startup of the electrodialysis section of the plant will be as follows:

The startup will be divided into a hydraulic and an electrical phase. The hydraulic startup will be accomplished first, followed by the electrical, and each will be sequential, all stacks of four stages being started separately. The removal of air from the system will be incorporated into the hydraulic startup, where most of it will be removed by hydraulic flushing. Air bleed valves, which will be provided at high points in the system, will be utilized. One pump in the clear well will be started and the main feedheader pressurized. A bypass will be provided to maintain the header pressure at the 60 lb/in^2 level required. The stack closest to the pump will then begin operation at about one-third the normal flow with the concentrate recirculation pump output valve off. The concentrate recirculation pump will be started when the pump section is flooded, and the discharge valve will be opened as the flow is increased to normal. The next stack will be put into operation when all air has been removed from the first stack and the flow is stable.

The rectifiers for two adjacent stacks will be turned on at minimum voltage when the stacks are operating hydraulically. The voltage will be slowly increased until the required current is reached, at which time the rectifiers will be switched to automatic voltage control.

The hydraulic startup time for each stack is estimated to be 20 minutes and electrical startup, allowing transients to die out, is estimated to take an additional 20 minutes. This procedure will continue until the entire electrodialysis section is on line.

Cleaning, maintenance, and membrane replacement performed while the plant is in operation will require the shutdown of controllable sections. The procedure to restart an electrodialysis stack will be identical to that used to start the entire section. Since stacks are arranged in pairs electrically, two of them will be shut down at one time. The procedure to start a single reverse osmosis unit, as follows, will differ from a section startup because both feed and reject headers will be at operating pressure.

To remove the air, the inlet valve on the feedline will be opened slightly to give the required flow to flush it out. The cleaning line return valve will be opened and the flow will be diverted to the cleaning return line and then to the Bypass Drain. The cleaning return line valve will be closed when the air is removed and the inlet valve will be slowly opened. After a several-second delay to permit pressure buildup in the unit, the reject valve will be opened using the flow control mode. As soon as the reject reaches the required concentration, the control will be switched to the conductivity mode. This will complete startup of a control unit.

Three types of system shutdown will or may occur during plant operation: an emergency shutdown due to loss of power, a routine shutdown of a controllable segment of the plant, and a routine shutdown of the entire plant. The basic procedure will be similar for all types but some differences among them will exist.

A power outage shutdown in the reverse osmosis sections will be followed by about a 30-second rundown of the pumps, at which time the main feed header pressure will be near zero and flow will have essentially stopped. As soon as the emergency generator assumes the load, the flushing pump will pressurize the feed manifold to 60 lb/in^2. The reject flow valves will be automatically set to a predetermined position and the sleeve valve on the main reject line will be set at full open. The valve between the low pressure manifold and the reject discharge line and the valve on the feed header connection direct to the second stage inlet will open. Feed will then be pumped through all segments for at least 10 minutes. The system will be secured when all reject conductivity meters indicate a predetermined conductivity. The pumps will then be stopped and valves necessary to prevent siphoning of water will be closed.

In the electrodialysis sections, the starting systems of the pumps and rectifiers will be such that their action during power interruptions will be identical. After an interruption which stops the pumps and rectifiers, the current from the rectifiers will cease almost instantaneously, while it will take about 30 seconds for the pumps to run down. Valves required to prevent drainage from the stacks will then be closed.

Membrane replacement or mechanical maintenance will require that a controllable segment of the plant be shut down.

In the reverse osmosis section, feed inlet and reject valves will be shut simultaneously and, as soon as pressure in the segment is below 60 lb/in^2, the cleaning return line valve will be opened and the feed inlet valve opened slightly to flush concentrated reject from the unit. When completed, the feed inlet valve and the cleaning return line valve will be closed and the unit will be ready for membrane replacement or maintenance work.

In the electrodialysis section, the first step will be to shut down the rectifier. After 5 minutes, the flow to the stacks will be stopped. This interval will be sufficient to flush all the concentrated reject and electrode rinse from the stack. The stacks will then be ready for maintenance.

The entire plant will be shut down once a year for routine plant maintenance during the annual MODE outage. One method will be to intentionally interrupt power to pumps and rectifiers and proceed as in the case of an emergency shutdown. A second method will be to stop each controllable unit in sequence. This procedure will require that pumps be stopped sequentially as units, and taken offline. It has the advantage that each controllable unit can be flushed of its concentrated reject in sequence.

Two aspects of membrane maintenance will be routine membrane element replacement and troubleshooting to locate and replace individually failed membranes. The maintenance will be performed on 1-Mgal/d sections, and provision will be made for shutting down each section, performing the necessary work, then reinstalling the section. Major maintenance will be completed during the annual plant shutdown. Maintenance associated with the required plant productivity will be on an emergency basis only during the rest of the year, except that it may be performed on control blocks while they are down for membrane replacement or cleaning.

The membrane elements and electrodialysis stacks will be cleaned semiannually with solutions which will depend on the type of equipment being used and the type of fouling occurring. A cleaning system will be permanently installed, including tanks, pumps, and piping, to each control block for cleaning on a block-by-block basis.

The projected economic life of the reverse osmosis membrane equipment is 5 to 6 years. In addition, certain membrane elements will fail completely during their projected economic life.

The detection of a single element that will be performing below warranty, or for that matter one that may have completely failed, will be impossible with the installed instrumentation. This means that a program of manual testing on a continuing basis will be required to maintain a record of each element's performance and to determine the need for replacement under the terms of the guarantee.

This program will make practical the replacement of elements on the basis of their performance and will be preferable to arbitrary replacement at the end of their projected economic life. The replacement will probably not be performed on an element-by-element basis, as the labor costs would be high. Costs will be reduced by replacing all the elements in a group of 10, or so, pressure vessels at the same time. If the performance of all elements in this group is the same initially and they have deteriorated uniformly, then all elements will be replaced. If element performance varies widely or deterioration has occurred at varying rates, it may be economical to test each element and save those operating above a certain level for later use. Due to the large difference in performance between these elements and new elements, replacement of only the below standard elements in a group will not be practical; the retained elements will be combined with others of a similar operating level for use in a single group replacement.

The electrodialysis section will contain on the order of 6,000 membranes, half of them cation (positively charged) membranes, half of them anion (negatively charged) membranes. A stack, which will consist of 600 membranes, or 300 cell pairs, will be the smallest unit on which performance will be determined automatically. The economic life of the membranes is projected to be 10 years, with some failing mechanically during this time, primarily due to handling. Normally, all the membranes will deteriorate uniformly; however, mechanical failure of several membranes may appear as a decrease in current efficiency, and localized scaling in several cell pairs will appear as an overall resistance increase. Scaling is the more serious of the two problems, but will be easily detected by measuring the resistance of small increments of cell pairs in a stack. Mechanical failure will best be determined by disassembly and visual inspection. In both the above cases, only the affected membranes will need to be replaced. When it is determined that essentially all membranes in a stack have deteriorated below acceptable levels, then the entire stack will be replaced.

A.3. Appurtenant Works

Most of the appurtenant works will require minimal operation procedures and only minor periodic maintenance. Allowances for replacements have been included in the operating cost estimates. Specific features which will require more than minimal attention will be the sewage treatment plant and the grounds landscaping.

Operation and maintenance of the sewage treatment plant will be in accordance with the manufacturers' instructions. These instructions will be improved and supplemented, as necessary, to consistently obtain a high-quality effluent, as some operating procedures are best determined through plant operating experience and experimentation.

A minimum of three test analyses will be performed to insure good operation and for evaluating plant performance. These tests will be for dissolved oxygen, settable solids, and residual chlorine.

The following items will be included in the normal plant operating and maintenance schedule:

A cleaning of the screening basket

An inspection of the aeration equipment

A check of the airlift pump, skimmer, and lines for clogging

A cleaning of the walls and surfaces of the aeration compartment and settling compartment

Performance of laboratory tests

An adjustment in plant operations and the program time switches for the air blowers, as required

Replacement of worn parts and/or equipment, as needed

Landscaping for the areas around the administration building will consist of natural plant materials, grasses, shrubs, and ground cover. Irrigation for the landscaping will be by an underground sprinkler system with pop-up, nonadjustable sprinkler heads. An automatic electric program controller located in the mechanical equipment room of the administration building will control the station ON-OFF time of the system. A drain valve will be located at a low point to manually drain the system. A normal operating and maintenance schedule for the landscape irrigation system will include the following:

An inspection of the sprinkler heads

A check for leaking and/or broken pipes

An adjustment of the required time for each station

Replacement of worn parts of the lawn irrigation system pumps

B. Bypass Drain

It is assumed that operation and maintenance of the Bypass Drain will be equivalent in scope and method to other concrete-lined conveyance channels in the area. Ditchriders will be required to detect any maintenance problems and to provide for the operation of the drain. Maintenance is expected to encompass periodic removal of foreign debris from the canal and upkeep of the various structures contiguous with it.

C. Painted Rock Dam and Reservoir

Operation, maintenance, and replacements for Painted Rock Dam are the responsibility of the Corps of Engineers. It is not anticipated that a change in the operating criteria (release schedule) will require substantial modifications to the present practices. No operation, maintenance, or replacement costs, therefore, have been included in the cost analysis for the dam.

Five million dollars has been included in the cost estimate for purchase of lands in Painted Rock Reservoir. The purchase is dependent, however, on a legal finding that the Corps of Engineers presently lacks authority to impound floodwaters in the reservoir on the lands designated for purchase.

D. Fish and Wildlife Mitigation

The two major environmental mitigation measures developed to compensate the impacts of the Yuma Desalting Plant are the Hunter's Hole Pond Complex and the Wildlife Management Area and Fish Rearing Facility. Both measures will require procedures for operation, maintenance, and replacements, once completed; however, due to the urgent initial authorization and funding of *Public Law 93-320*, time was not adequate to fully develop these procedures, and final plan formulation is still under consideration.

X. ENVIRONMENTAL CONSIDERATIONS

A. Environmental Assessments

The *Final Environmental Statement* [26], prepared by the Bureau of Reclamation, is the most comprehensive study to date on environmental features and considerations in the project area; therein is contained a more detailed analysis of the material presented in this chapter. In addition to the *Final Environmental Statement* there have been other studies made by various entities which relate to more specific aspects of the project area.

In regard to the portion of Section 7 of the *Endangered Species Act (Public Law 93-205)* dealing with the modification of possible critical habitat, the Bureau developed and submitted status reports of endangered species habitat (specifically that of the Yuma Clapper Rail) to the U.S. Fish and Wildlife Service (the agency responsible for implementing and coordinating the Act) at the field level for comments and recommendations. These reports included an analysis of population density, quantification of existing habitat, impact of the project on habitat, mitigation measures, and resulting net change in habitat. The Fish and Wildlife Service, in a memorandum to the Bureau of Reclamation's Lower Colorado Region, stated that:

> Based on the "threshold" examination, it is our opinion that, from a biological standpoint, the project will not result in modification, or destruction of habitat critical to the continued survival of the Yuma Clapper Rail. In addition, we do not believe the project will cause jeopardy to the continued existence of the Yuma Clapper Rail as a subspecies.

There have also been undertaken detailed but short-term environmental inventories (financed by the project) in the areas that would be affected. In order to guide and participate in these studies (as well as to aid in other environmental analyses and the development of mitigation concepts) two Ad Hoc Committees for fish and wildlife were organized; one for the Coachella Canal Unit (not included in this report) and another for the Desalting Complex and Protective and Regulatory Pumping Units. All fieldwork on the studies was completed by November 15, 1974, and the reports were submitted, reviewed, and accepted by the Ad Hoc Committees and the Bureau of Reclamation. The specific studies referred to are listed below:

Study Title	Agency
1. Inventory of Aquatic Habitats and Fishes of the Yuma Valley, Arizona	Arizona State University
2. Wildlife Use and Density Inventory and Vegetation Types Along the Colorado River from Morelos Dam to the Southerly International Boundary	Arizona State University
3. A Special Report on: The Recreational Use of Areas along the Lower Colorado River, Limitrophe and Neighboring Areas	Arizona State University
4. Fishes of Hunter's Hole, Yuma County, Arizona	Arizona State University
5. Analog Model of: Protective and Regulatory Ground-Water Pumping	U.S. Geological Survey 1/
6. Cost and Effects of Federal Buy-Out of Wellton-Mohawk District	Bureau of Reclamation

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1/ Yuma area ground-water model was structured and constructed in 1966 with funds provided by the Geological Survey, the Bureau of Reclamation, and the United States Section of the International Boundary and Water Commission. Data input was furnished by all three agencies. Model runs applicable to the protective and regulatory ground-water pumping plan and alternates were run in 1974 and were financed by the project.

In addition to these formal studies, numerous lesser studies of specific items have been undertaken by project personnel. Preliminary feasibility reports and analysis of all of the original mitigation concepts were developed for use of the Ad Hoc Committee by study teams on the committee. The results of the studies and inventories have been utilized by the Ad Hoc Committee in preparing mitigation proposals. The data from these reports will be used in resolving the final details of the mitigation concepts recommended and accepted as project objectives.

Follow-up studies are planned subsequent to project completion to assess the actual environmental implications that will result. In conjunction with these there may be continuous studies to monitor the affected areas of the environment.

B. Environmental Impacts of Project Features

B.1. Physical Environment

B.1.a. Water Resources

The construction and operation of the desalting plant will result in the delivery of a higher quality water to Mexico, in compliance with the provisions of *Minute No. 242*, and will also conserve up to 123,500 acre-feet per year of stored water in the United States. The releases of blended water into the Colorado River above Morelos Dam will improve the quality of the river water for 2 miles above the dam.

There may be an eventual loss of 261 acres of ponded and surface water due to construction and operation of the project. These losses include 141 acres in Arizona along the mainstream of the Colorado River between Morelos Dam and the Southerly International Boundary, and 120 acres associated with the Yuma Valley drains. The drains may dry up due to ground-water surface decline caused by protective pumping.

The discharge of all the Wellton-Mohawk drainage for 3 years prior to desalting plant operation, and operational brine and waste thereafter, will cause a substantial increase in the open water areas of the Santa Clara Slough. The cessation of Wellton-Mohawk drainage flows in the Colorado River below Morelos Dam during this 3-year period will cause the loss of the surface water in the river channel in the limitrophe reach and in Mexico, except for agricultural drainage flows from Mexican lands, occasional storm runoff, and sporadic floodflows.

The construction of two siphons for the Bypass Drain, where the Colorado River approaches the levee, between Morelos Dam and the Southerly International Boundary, will create temporary turbidity in the river.

Supplying water for use in construction of project features will be the contractor's responsibility. Existing canals or the river will probably be used and no lasting impact on the overall environment of the project area is anticipated. Environmental guidelines included in contract specifications assure compliance by the contractor.

A change in the management of floodflow releases from Painted Rock Reservoir will have a beneficial impact on the Wellton-Mohawk Division. Drainage conditions will be improved since the flows will be controlled and infiltration to underground aquifers will occur mostly upstream from the Division.

There will be an increase in the salinity of stored waters in Painted Rock Reservoir due to longer periods of impoundment and increased evaporation.

B.1.b. Mineral Resources

Sand, gravel, and rock will be used in the construction of project features, but there will be no other impact on mineral resources within the project area. It is anticipated that these materials will be obtained primarily from excavation of structure sites and from new and existing borrow and quarry sites in the area. Other fabricated or refined minerals and chemicals required for construction or operation of the project will be obtained from commerical sources.

Normally, all excavated material will be used for embankment construction within the project. Areas required for disposal of excess material will be evaluated along with the potential borrow areas to lessen impacts. Disposal of solid waste material will be accomplished with and under approval of the appropriate county authorities in Arizona.

B.1.c. Energy

The impacts of providing 296 million kWh per year of electrical energy for the desalting plant are far-reaching. Regardless of the source of power there will ultimately be an irreversible and irretrievable commitment of natural resources such as fossil fuels, nuclear fuel, or geothermal energy.

Supplying power to the project from the Navajo Project Powerplant on an interim basis until other power sources can be derived will have certain adverse impacts. The Navajo Project Powerplant uses about 8,395,000 tons of coal per year to generate about 20,148,000,000 kWh per year of electrical energy and requires a consumptive use of 34,100 acre-feet of Colorado River water per year for use in its cooling towers. The desalting plant will use about 1.5 percent of the annual energy produced by the powerplant and will, therefore, proportionately account for an annual consumptive use of 126,000 tons of coal and 500 acre-feet of cooling tower water. In addition to the consumptive use of natural resources, production of the required electrical energy for the project will result in about 5.6 tons of smokestack emissions and fly ash per day at the powerplant site, as follows:

SO_2	- 1.2 tons/day
NO_x	- 4.2 tons/day
Fly ash	- 0.2 tons/day
Total	5.6 tons/day

The use of Navajo Project power will not diminish the supply available to preference customers from Federal power systems operated by the Secretary of the Interior. Additional sources of energy, such as equipment, fuel, and lubricants, will be consumed during construction of the project. Partial recalcining of pretreatment sludge will require about 70,400 barrels of fuel oil per year.

B.1.d. Erosion

Due to the limited slope of the lands and the small amount of rainfall in the project area, erosion from surface runoff is not expected to increase materially from the added disturbance to the land. Wind erosion during extremely dry seasons can be serious and may result in the loss of disturbed topsoil by blowouts, cause drifting, and contribute to local dust and air pollution.

Due to carefully planned landfill operations which will be used in disposing the sludge from the desalting operation, there will be no leaching of toxic substances from the sludge disposal into the ground-water aquifer.

B.2. Biological Environment

B.2.a. Vegetation

Disturbance of vegetation during construction will be kept to a minimum. There will be a loss of vegetation on portions of desert and desert mesquite habitat, mixed riparian habitat, and cropland required for rights-of-way. Storage of construction equipment and materials will cause temporary losses of vegetation. Natural revegetation of desert areas will occur slowly.

Approximately 4,200 acres of irrigated cropland will be retired from agricultural production in the Wellton-Mohawk Division. These lands will revert back to native vegetation or will be used for other purposes. Approximately 6,600 acres of irrigated cropland behind Painted Rock Reservoir will also be affected by the project if and when they are inundated by impounded storm waters.

The 500 acres of State land at Painted Rock Reservoir and the greater portion of all Federal lands affected by the project are characterized by sparse desert habitat. The vegetation on these lands will remain essentially unchanged.

Cessation of Wellton-Mohawk drainage flows below Morelos Dam in addition to ground-water drawdown will adversely affect the riparian community along the Colorado River. The only marsh type vegetation which will remain after 10 years of project operation will be about 7 acres of cattails in the river channel immediately below Morelos Dam where seepage from the dam and the adjacent Alamo Canal will still occur.

Approximately 30 acres of saltgrass and emergent vegetation along Yuma Valley drainage channels will be lost at about the same rate with or without the project.

Overall, the project will have an adverse impact on a small portion of the cultivated land and a large portion of desert habitat in the project areas. The effect will not be significant with respect to the total amount of those habitats in the general vicinity.

A portion of the 370 acres of agricultural vegetation in Mexico and 380 acres of sparse Sonoran desert vegetation affected by rights-of-way will be lost. The loss of agricultural vegetation will amount to less than 0.1 percent of the 430,000 acres of farmland in the Mexicali-San Luis Valley. Loss of the desert vegetation will be even less significant due to the extensive desert habitat in the general area.

B.2.b. Fish

Approximately 412 acres of fish habitat will be lost due to project implementation. The most abundant fish species which will be affected will be catfishes, largemouth bass, bluegill, other sunfishes, mollies, shiners, and mosquito fish. The sustained streamflow in the Colorado River below Morelos Dam will be lost, as will the fish populations in the area. In addition, fish populations in the MODE below the desalting plant will be adversely affected by the reduction in flow and increased salinity of the Bypass Drain. It is expected that fishing activities at the discharge point of the product water above Morelos Dam will be enhanced. Fish will be lost as the agricultural drains of Yuma Valley dry up. This will happen at about the same rate with or without the project.

The discharge of brackish drain flows into Santa Clara Slough will increase the overall value of the aquatic habitat for a variety of fish species, but may be detrimental to the desert pupfish in that other fish species may be introduced which could result in increased competition pressures and predation. Depending on the point of discharge of the Bypass Drain into the Slough, there may be some deterioration and scouring of the habitat preferred by the pupfish.

B.2.c. Wildlife

Construction activities related to borrowing, disposal of waste material, traffic pattern, night lighting, and temporary storage of construction equipment will cause temporary disturbances to and some loss of wildlife species. Wildlife will generally be lost from within the project rights-of-way in proportion to the amount of habitat which is lost in the construction of the facilities.

There will be a reduction of wildlife species occurring as the 2,323 acres of riparian habitat along the Colorado River below Morelos Dam and 30 acres in the Yuma Valley drains are lost, due to ground-water withdrawal. Generally, wildlife species which will be affected the most will be those which are solely or partially dependent on the aquatic and semiaquatic habitats which will be lost due to project implementation.

The Yuma Clapper Rail is the only endangered species which will be affected by the project. Cessation of sustained Colorado River flows below Morelos Dam and ground-water drawdown will affect less than 1 percent (30 to 40 acres) of the suitable rail habitat and less than 1 percent (one to four individuals) of the rails known to be along the Lower Colorado River. Considering the available habitat and number of rails which exist along the Lower Colorado River, the losses will be small.

A small percentage of wildlife food sources in the Wellton-Mohawk and Painted Rock areas will be lost when agricultural lands are taken out of production. However, with the expected increase and stabilization of riparian habitat at Painted Rock Reservoir and in the Wellton-Mohawk Division, wildlife populations will be sustained. New nesting areas may even be created for white-winged and mourning doves, as well as habitat for a variety of small animals. There may also be an increase in wildlife as a result of habitat expansion due to the flow of the reject stream into the Santa Clara Slough.

B.3. Cultural Environment

B.3.a. Land Use

The proposed project will require a total of 750 acres of land in Mexico and up to about 1,100 acres in the United States for rights-of-way. The land in Mexico will consist of 200 acres of land belonging to the Mexican Government and 550 acres of private land. In the United States, 910 acres of Federal land and 190 acres of private land will be required. In conjunction with this land, project features will utilize land on rights-of-way of existing features.

The project will also involve the acquisition of 6,200 irrigable acres of private land and withdrawal of 3,800 acres of irrigable Federal land in the Wellton-Mohawk Division. It may also be necessary at a later date to preclude from irrigation up to 5,000 additional acres, but this possibility is not included in the initial plan.

Lands in Painted Rock Reservoir will be utilized in order to reduce the infiltration of floodflows on the Gila River into the Wellton-Mohawk aquifer. The proposal is to withdraw 22,100 acres, consisting of 12,800 acres of Federal land, 500 acres of Arizona State land, and 8,800 acres of private land. At the present time, 2,600 acres of the Federal land are under lease from the Fish and Wildlife Service to the Arizona Game and Fish Department, who sublease the land to farmers for agricultural purposes.

Overall, the project will thus involve approximately 22,954 acres. this will be comprised of 200 acres of Mexican Government land and 550 acres of private land in Mexico; 17,510 acres of Federal land and 500 acres of Arizona State land; and 15,194 acres of private land in the United States. Only a small portion of this land (less than 2,000 acres) will actually be utilized as the sites of physical structures.

Since construction equipment will require a certain amount of periodic maintenance and repair, some land use will be required for service areas. These areas will probably be centrally located near major facility sites, with the locations controlled by access from existing roads, field conditions, and proximity to the construction work. Temporary buildings will generally be used for service facilities. The duration of the facilities at each location will probably be 1 to 2 years. Depending upon the location, service areas will generally disrupt the tranquillity of the environment because of the continual activity, noise, and problems associated with the repair and maintenance of heavy-duty equipment. The activities will be of a nature such that oil, diesel fuel, grease, and solvents may be spilled on the ground; however, the contractor will be responsible for conducting spill prevention methods of operation and for any cleanup of such spills.

The environmental impacts of facilities required for construction will be temporary. Upon completion of construction, all equipment, supplies, buildings, and personal property will be dismantled and/or removed from the construction area and disposed of in an acceptable manner and in conformance with current policy. Disturbed areas will be dressed and leveled and allowed to revegetate under natural conditions.

B.3.b. Recreation

Due to degradation and loss of aquatic and riparian habitat resulting from a cessation of sustained riverflows below Morelos Dam and the possible dry up of Yuma Valley agricultural drains, it is estimated that there will be an annual loss of about 10,000 man-days of fishing activity and over 3,000 man-days of hunting in the Yuma Valley area. Other recreational activities such as picnicking, camping, and interest visitation will also be reduced by perhaps 50 percent.

B.3.c. Archeology and History

In compliance with the directive set forth in Section 106 of the *National Historic Preservation Act* of October 1966 (*Public Law 89-655*), and Section 101 (b) (4) of the *National Environmental Policy Act* of 1969 (*Public Law 91-190*), the proposed project has been fully evaluated relative to the impacts it may have on historical and archeological resources and action will be taken to preserve them.

Only one registered historical site was affected by construction of the project. The Yuma Crossing and associated sites are located in the area where the concrete siphon replacement for the MODE metal flume was installed. Since this was already a modified and congested area, no direct adverse impacts resulted through construction activities. There was, in fact, an immediate beneficial impact on esthetic values as a consequence of the replacement of the flume. The removal of the old above-ground structure was conducive to the possible restoration of the Yuma Crossing. The extent of the impact on the Yuma Crossing was assessed in cooperation with the Advisory Council on Historic Preservation and clearance for the replacement of the metal flume was granted prior to siphon construction.

At the present time, there are no known archeological sites that will be affected by the project. Archeological surveys have been conducted at all project facility sites under the auspices of the National Park Service and archeological clearance has been granted for all sites. The Bureau of Reclamation proposes to mitigate the impact of the undertaking on any archeological or historical resources located during construction activities. Any properties located will be evaluated by an appropriate professional who will make a determination in consultation with the State Historic Preservation Officer as to the properties' significance. Should the property be determined eligible for nomination to the National Register of Historic Places, the Bureau of Reclamation will follow the procedure outlined in 36 CFR, Part 800. Should it then be determined that extensive recovery and study are required, such activities would be both beneficial and adverse. The beneficial impacts would include the actual location and documentation of the site, the information gained through excavation, and the preservation of artifacts found. The adverse impacts would involve the physical loss of the site, which would preclude any future evaluation at some later date when newer technology might allow for more detailed findings.

In addition to the archeological surveys by the National Park Service, the State Liaison Officer for Historic Preservation and the State Archeologist in Arizona have been consulted relative to the proposed location of project facilities.

Where proposed project facilities involve lands in Mexico, coordination will be maintained with the Mexican Government in regard to an archeological survey and other concerns for the sites of historical interest. Compliance with the requirement of the National Environmental Policy Act will be encouraged where they are not contrary to policies of the Mexican Government.

B.3.d. Social and Economic Factors

Construction of the Desalting Complex Unit, which has an estimated total cost of approximately $230,000,000, will have social and economic impacts in the United States and Mexico. Employment opportunities will be available to many people directly and to many more indirectly, and the need for special equipment will create employment in specialized industries beyond the local and State boundaries. It is estimated that approximately 50 percent of the construction cost will be used for employment in the project area.

The desalting plant site is about 4 miles west of Yuma, Arizona, and it is assumed that essentially all of the individuals associated with the work force, amounting to a maximum of about 163 in 1980, would reside with their families in and around the city of Yuma, Arizona along with about 101 additional Federal employees and their families.

The State of Arizona, Office of Economic Planning and Development, has prepared a report on a study of the economic and demographic impacts that may be generated in the southwest portion of Yuma County by installation of the Desalting Complex Unit. The report, *An Arizona Trade-Off Model Analysis of a Proposed Desalting Complex in Yuma County, Arizona,* [21] was distributed in November 1974, as the first phase of a study analysis by the State. The report presents estimates of overall increases in the labor force and demands for public services based on Bureau estimates of labor force requirements directly related to the construction and operation of the Desalting Complex Unit. The following discussion presents some of the basic conclusions of the report:

> The construction and operation of a desalting complex in Yuma County are expected to generate a peak increase in jobs of 468 by 1979. However, after completion of construction, the impact of the complex will be far less dramatic with only 75 additional jobs expected by 1990. Yuma County population is expected to grow by 963 by 1981, as a result of the desalting complex. However, after construction is completed and temporary residents leave, the permanent population impact is expected to be approximately 200 additional residents by 1985 and 1990. With population growth there will be increased demands for housing in Yuma County. Housing demands are expected to rise to 378 units by 1981, but additional demand is expected to fall to 78 units by 1985, as temporary residents move out of the county by completion of plant construction. The pattern of construction related housing demands (197 in 1980, falling to 14 in 1985) dramatically illustrates that a good portion of total increased housing demand may be for temporary quarters; mobile homes may provide adequate interim shelter for most transitory residents. The projected population increases will generate an estimated additional 269 (aged 5-20) school enrollees by 1981. But by 1985,

the permanent impact on school enrollment should only be 26 additional students; therefore, it may not be necessary to add to the permanent school plan.

These demographic and economic impacts, as predicted by this report, will be centered in the cities of Yuma, Somerton, Gadsden, and San Luis, Arizona.

The Bureau of Reclamation feels that Yuma County is in an excellent position as far as public services are concerned because of the very nature of its tourist-oriented economy. The seasonal variation in population associated with winter visitors in the county is estimated to be at least 10,000 persons. Therefore, the impact of temporary population increases of less than 500 persons due to construction and operation of the project features should not be significant as far as most public services are concerned.

The presence of construction camps in the project area will have some social impacts relating to disturbance and sanitation. The only construction camps anticipated will be temporary construction field office areas and may include temporary or mobile structures, maintenance facilities, and security guard quarters. Water and sewage facilities at the project site are nonexistent, which will require temporary facilities that meet requirements of Federal and Arizona health laws.

Construction workers will occasionally utilize camp trailers or pickup-type campers for a short duration of time in the vicinity of construction. Control of this aspect will be difficult and will be the primary responsibility of the landowner. Contractor's employees may be discouraged from this practice by the work schedule, contractual relationships, and the establishment of adequate facilities within the right-of-way boundaries, in nearby communities, or on private lands. Due to the large number of winter visitors in the area utilizing similar camping equipment it will be difficult to distinguish between construction workers and visitors during the winter season.

Access roads will be necessary to facilitate construction work and allow safe travel for personnel. Existing roads in the project area will be used for this purpose whenever possible and will be improved where required to handle construction traffic. Those which are already in good condition and capable of handling the increased load will be maintained in their present condition. New roads which will be required will be located within the project rights-of-way whenever possible. Public safety will be provided for on all roads utilized for construction activities. Existing operation and maintenance roads closed during construction work will cause an inconvenience to the general public. However, the upgrading of the road system will be a long-term advantage to travelers in the area.

Vehicular and pedestrian accidents may be greater than normal during the construction period due to the increased traffic. Off-highway travel and extensive traveling to and from the construction area during all hours of the day may present a potentially hazardous traffic situation. Local residents will not be allowed on the closed access roads, thereby eliminating a major safety concern by restricting access. Construction personnel traveling through the local area will be controlled by State and local traffic regulations. Detours or other appropriate measures will be provided to allow private citizens access to private or leased lands along project rights-of-way.

B.4. Environmental Quality

B.4.a. Noise

During construction of project facilities, large earthmoving equipment and heavy construction activities will produce a high level of noise, which is highly objectionable in confined areas or near developments. Utilization of equipment on a round-the-clock basis will be common in the construction areas, and the greatest relative increase in noise levels will occur during the night. However, the construction areas are generally remote, and there should be no great disturbance of the populace. Wildlife will be disturbed by the noise, but should repopulate the area after construction is completed.

The use of electric motors in operation of the desalting plant will insure relatively low sound levels at the plant site. Particular attention will be paid in designing the plant to baffle areas where noise levels may occur.

B.4.b. Air Quality

Inherent with thunderstorms, windstorms, construction, travel, and other activity in desert regions is an ever-present dust problem. The amount of ambient particulate matter in the project area exceeds the Federal and State standards about 98 percent of the time. Additional temporary discomfort to people and wildlife may occur from the construction of the various project features. Dust problems will normally be localized during construction, however, and this discomfort will not exceed that experienced during periods of high winds or duststorms in the area. Removal of vegetation and disturbance of soils along rights-of-way and at borrow and excavation sites will create additional dust sources until revegetation occurs on those areas which are not permanent features of the project. Active dust abatement procedures by the contractor will reduce the dust hazard created by movement of heavy construction equipment along access roads and at construction sites.

Operation of the desalting plant will create essentially no bothersome aerial emissions. There will be some dust created during the landfill operations at the sludge disposal sites, but this should be minimal.

B.4.c. Visual Quality

No special scenic sites will be affected by the project; however, loss of riparian communities along the Colorado River will change the visual quality of the area. Permanent structural features of the project such as the desalting plant, power transmission facilities, and the Bypass Drain and their associated structures will have a permanent effect on the visual quality at their respective locations.

XI. INVESTMENT COSTS

Federal investment costs for the Desalting Complex Unit consist of expenditures for the Yuma Desalting Plant and appurtenant works, Bypass Drain, MODE Siphon, Wellton-Mohawk Irrigation Efficiency Improvement Program, Wellton-Mohawk acreage reduction, Painted Rock Reservoir land acquisition and operation schedule modification, fish and wildlife mitigation measures, and for otherwise bringing the project to a stage of readiness for sustained and reliable operation.

A. Estimating Procedures

Cost estimates for the project are generally feasibility grade estimates developed by means of itemized costs. Exceptions occur in cases where studies to determine the size, scope, or location of features are still in progress, in which case appraisal grade estimates have been used and are so noted. Grade levels have not been assigned where estimates are based on bid prices.

A.1. Field Costs

The cost estimates are generally prepared to show a summary of field costs for each major unit of work. The field cost of a unit represents the estimated cost of performing the physical work, generally represented by payments to contractors for construction work. Feasibility grade field costs were generally estimated by means of itemized costs for significant items, plus an additive for unlisted items (usually 10 percent), plus a contingency allowance to cover uncertainties associated with the plans and estimates. The contingency allowance is generally about 20 percent, but it differs in accordance with the degree of uncertainty in an estimate.

A.2. Indirect Costs

Indirect costs were added to the field costs to determine total installation cost. Indirect costs for features to be constructed consist of costs of investigations prior to and subsequent to project authorization, preparation of designs and specifications, supervision of construction, and the necessary support facilities for these activities. In general, indirect costs were estimated by applying a percentage to the field costs based on experience with similar types of construction. Typical indirect allowances are 32 percent for the desalting plant and appurtenant facilities and 25 percent for drain construction.

The cost of the Yuma Desalting Test Facility is fundamentally an indirect cost in that it facilitates the investigation and design of desalting processes and equipment. However, because of its magnitude and because it is an unusual item, it is presented in the cost estimates as a separate investigation program.

A.3. Price Levels

Construction costs in this investigation are based on October 1975 price levels. Exceptions occur in cases where contracts have been awarded for construction and other work; in such cases the cost estimates reflect bid prices.

B. Yuma Desalting Plant

B.1. Construction Cost

The cost estimate for construction, including engineering and other overhead costs, consists of the following major portions of the plant:

General Site Improvements	$ 7,300,000
Pretreatment Facilities	56,000,000
Process Pumps and Piping	9,300,000
Desalting Plant	61,000,000
Energy Recovery Facilities	1,400,000
Discharge Lines	360,000
Incoming Power Facilities	8,800,000
Control and Operating System	5,300,000
Total Cost	149,460,000

A more detailed presentation of construction quantities, with a breakdown by plant account, is shown on Table 13 (Project Cost Estimate).

The estimates for the desalting system and peripheral facilities are based on a plant capacity of 108.47 Mgal/d, of which 20.52 Mgal/d is spiral wound RO, 19.43 Mgal/d is hollow fine fiber RO, 22.86 Mgal/d is electrodialysis, and 45.66 Mgal/d is unspecified, as discussed in Chapter VI, subparagraph B.2.a.

The design and cost of energy recovery facilities presented in this report are based on utilization of the reject brine from the two RO segments of the plant.

The estimate for pretreatment facilities includes the cost of an oil-fired, fluidized bed furnace of sufficient size to recalcine all the lime sludge formed in the contact reactors,

Table 13

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

DESALTING COMPLEX UNIT

PROJECT COST ESTIMATE

Yuma Desalting Plant

OFFICE PREPARED BY:

COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PROJECT TITLE I DIVISION, DESALTING COMPLEX UNIT
Date of Estimate February 5, 1976; Rev. 4-19-76
Prices as of October 1975

Sheet 1 of 4

Previous Estimate Prices as of

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS 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
			DESALTING COMPLEX UNIT - TOTAL COST								229,870,000	
12			SPECIAL PLANTS								212,030,000	
	01		YUMA DESALTING PLANT - 108.5 Mgal/d Capacity					108,132,000	34,968,000	143,100,000		
			Spiral Wound RO Membranes - 20.5 Mgal/d									
			Hollow Fine Fiber RO Membranes - 19.4 Mgal/d									
			Electrodialysis Membranes - 22.9 Mgal/d									
			Undesignated Membranes - 45.7 Mgal/d									
			01 - GENERAL SITE IMPROVEMENTS					(5,475,000)	(1,825,000)	(7,300,000)		
		100	Land and Rights		270,000		270,000					
		110	Relocation of Property of Others	1	450,000		450,000					
		130	Structures and Improvements	1	4,755,000		4,755,000					
			.01 - Site Facilities	2	(2,700,000)		(2,700,000)					
			.02 - Administration Building	3	(1,900,000)		(1,900,000)					
			.03 - Maintenance Building	4	(155,000)		(155,000)					
			02 - PRETREATMENT FACILITIES					(42,290,000)	(13,710,000)	(56,000,000)		
		153	Waterway Structures		37,990,000		37,990,000					
			.01 - Turnout Structure	5	(320,000)		(320,000)					
			.02 - Grit Basins and Intake Pumping Plant	6	(2,400,000)		(2,400,000)					
			.03 - Reactor-Filter Area	7	(16,500,000)		(16,500,000)					
			.04 - Clear Well	8	(2,200,000)		(2,200,000)					
			.05 - Sludge Handling Facilities	9	(11,500,000)		(11,500,000)					
			.06 - Interconnecting Piping and Valves	10	(4,300,000)		(4,300,000)					
			.07 - Waste Disposal Site Facilities	11	(770,000)		(770,000)					
		170	Accessory Electrical Equipment	12	4,300,000		4,300,000					
			03 - PROCESS PUMPS AND PIPING					(7,000,000)	(2,300,000)	(9,300,000)		
		130	Structures and Improvements	13	100,000		100,000					
		153	Waterway Structures	13	2,700,000		2,700,000					
		160	Pumps and Prime Movers	13	2,700,000		2,700,000					
		170	Accessory Electrical Equipment	14	1,350,000		1,350,000					
		199	Miscellaneous Installed Equipment	14	150,000		150,000					
			04 - MEMBRANE DESALTING PLANT					(45,800,000)	(15,200,000)	(61,000,000)		
		130	Structures and Improvements	15	6,900,000		6,900,000					
		153	Waterway Structures		7,220,000	28,700,000	35,920,000					
			.01 - RO-SW Piping and Valves	16	(2,200,000)		(2,200,000)					
			.02 - RO-HFF Piping and Valves	17	(2,300,000)		(2,300,000)					
			.03 - ED Piping and Valves	18	(1,700,000)		(1,700,000)					
			.04 - RO-SW Equipment	19	(120,000)	(5,300,000)	(5,420,000)					
			.05 - RO-HFF Equipment	19	(110,000)	(4,900,000)	(5,010,000)					
			.06 - ED Equipment	19	(370,000)	(6,500,000)	(6,870,000)					
			.07 - Unspecified Equipment	19	(420,000)	(12,000,000)	(12,420,000)					
		170	Accessory Electrical Equipment	20	2,600,000		2,600,000					
		190	Miscellaneous Installed Equipment	21	380,000		380,000					

GPO 835-

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

DESALTING COMPLEX UNIT

PROJECT COST ESTIMATE

Yuma Desalting Plant, Bypass Drain-United States

OFFICE PREPARED BY:

COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PROJECT TITLE I DIVISION, DESALTING COMPLEX UNIT
Date of Estimate February 5, 1976
Prices as of October 1975
Sheet 2 of 4

Previous Estimate Prices as of

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS 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
	01		YUMA DESALTING PLANT (continued)									
			05 - ENERGY RECOVERY FACILITIES					(1,040,000)	(360,000)	(1,400,000)		
		130	Structures and Improvements	22	220,000		220,000					
		152	Waterways	22	280,000		280,000					
		165	Turbines and Generators	23	480,000		480,000					
		170	Accessory Electrical Equipment	23	60,000		60,000					
			06 - DISCHARGE LINES					(275,000)	(85,000)	(360,000)		
		152	Waterways		275,000		275,000					
			.01 - Brine Line	24	(115,000)		(115,000)					
			.02 - Product Waterline	24	(160,000)		(160,000)					
			07 - CONTROL AND OPERATING SYSTEM					(4,000,000)	(1,300,000)	(5,300,000)		
		180	Installed Supervisory Control and Communications Equipment	25	4,000,000		4,000,000					
			08 - OPERATING EQUIPMENT					(1,672,000)	(168,000)	(1,840,000)		
		195	Other Tangible Property			1,672,000	1,672,000					
			.01 - Heavy Equipment at Desalting Plant	26		(520,000)	(520,000)					
			.02 - Machine Shop Equipment	26		(96,000)	(96,000)					
			.03 - Laboratory Furniture and Equipment	26		(108,000)	(108,000)					
			.04 - Office Furniture and Equipment	27		(48,000)	(48,000)					
			.05 - Heavy Equipment at Disposal Site	27		(900,000)	(900,000)					
			09 - MATERIALS FOR TESTING					(580,000)	(20,000)	(600,000)		
		195	Other Tangible Property	27		580,000	580,000					
	02		BYPASS DRAIN-UNITED STATES--16.0-Miles Long, 353-ft^3/s Capacity					6,670,000	1,630,000	8,300,000		
		100	Land and Rights	28	95,000		95,000					
		110	Relocation of Property of Others	28	465,000		465,000					
		140	Roads and Road Structures	28	160,000		160,000					
		152	Waterways	29	3,970,000		3,970,000					
		153	Waterway Structures	29	1,980,000		1,980,000					

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Table 13 (continued)

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

DESALTING COMPLEX UNIT

PROJECT COST ESTIMATE

Bypass Drain-Mexico, Main Outlet Drain Extension Siphon, Wellton-Mohawk Irrigation Efficiency Improvement Program, Wellton-Mohawk Acreage Reduction, Painted Rock Reservoir

OFFICE PREPARED BY:

COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PROJECT TITLE I DIVISION, DESALTING COMPLEX UNIT
Date of Estimate February 5, 1976
Prices as of October 1975
Sheet 3 of 4

Previous Estimate Prices as of

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS 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
	03		BYPASS DRAIN-MEXICO--55.85 km (34.7 miles) Long, 10.0-m^3/s (353-ft^3/s) Capacity					21,066,000	3,759,000	24,825,000		
		100	Land and Rights	30	800,000		800,000					
		110	Relocation of Property of Others		1,250,000		1,250,000					
			.01 - km 0+000 to km 31+320	30-31	(280,000)		(280,000)					
			.02 - km 31+320 to km 55+850.50	32-34	(970,000)		(970,000)					
		120	Clearing Land and Right-of-Way		46,000		46,000					
			.01 - km 0+000 to km 31+320	35	(31,000)		(31,000)					
			.02 - km 31+320 to km 55+850.50	35	(15,000)		(15,000)					
		152	Waterways		18,970,000		18,970,000					
			.01 - Materials and Freight Charges	36	(2,830,000)		(2,830,000)					
			.02 - Civil Works, km 0+000 to km 31+320	36-37	(8,960,000)		(8,960,000)					
			.03 - Civil Works, km 31+320 to km 55+850.50	38-39	(7,180,000)		(7,180,000)					
			Project Studies and Planning						(170,000)			
			Engineering and Administration						(3,185,000)			
			U.S. Section-IBWC Engineering and Administration						(160,000)			
			USBR Engineering and Administration						(244,000)			
	04		MAIN OUTLET DRAIN EXTENSION SIPHON--10-ft Diameter, 3,491 ft Long, 353-ft^3/s Capacity					2,900,000	700,000	3,600,000		
		110	Relocation of Property of Others	40	100,000		100,000					
		153	Waterway Structures	40-41	2,800,000		2,800,000					
	05		IRRIGATION EFFICIENCY IMPROVEMENT PROGRAM					8,358,000	1,490,000	9,848,000		
		195	Other Tangible Property				8,358,000					
			.01 - Irrigation Management Services	42		1,210,000						
			.02 - Education on Irrigation Efficiency	42	178,000							
			.03 - Research and Demonstrations	42	600,000							
			.04 - Onfarm Improvements	43	6,370,000							
			Technical Field Committee Activities						(270,000)			
			Technical Assistance for Onfarm Improvements						(1,220,000)			
	06		WELLTON-MOHAWK ACREAGE REDUCTION	44				14,180,000	820,000	15,000,000		
		100	Land and Rights		11,500,000		11,500,000					
		110	Relocations		1,000,000		1,000,000					
		120	Clearing		1,680,000		1,680,000					
	07		PAINTEL ROCK RESERVOIR	45				4,750,000	250,000	5,000,000		
		100	Land and Rights		4,750,000		4,750,000					

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Table 13(continued)

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

DESALTING COMPLEX UNIT

PROJECT COST ESTIMATE

Fish and Wildlife Mitigation Measures, Incoming Power
Brine Stream Replacement Studies

OFFICE PREPARED BY:

COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PROJECT TITLE I DIVISION, DESALTING COMPLEX UNIT
Date of Estimate February 5, 1976
Prices as of October 1975
Sheet 4 of 4

Previous Estimate Prices as of

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR	LABOR AND MATERIALS BY GOVERNMENT	FIELD COST	TOTAL FIELD COST	OTHER COSTS	TOTAL COST	TOTAL COST	TOTAL COST
					Cost	Cost	Plant Account	Identified Property	Identified Property	Identified Property	Property Class	Identified Property
1			2	3	4	5	6	7	8	9	10	11
	08		FISH AND WILDLIFE MITIGATION MEASURES	46				2,162,000	195,000	2,357,000		
			.01 - Gila River Wildlife Management Area and Fish Rearing Facilities					(2,093,000)				
		100	Land and Rights		115,000		115,000					
		195	Other Tangible Property		1,978,000		1,978,000					
			.02 - Hunter's Hole Pond Complex					(69,000)				
		195	Other Tangible Property		69,000		69,000					
	09		YUMA DESALTING TEST FACILITY	47				6,389,289	210,711	6,600,000		
		195	Other Tangible Property				6,389,289					
			.01 - Physical Facilities		720,000	169,289						
			.02 - Operation and Testing		4,050,000	1,450,000						
13			TRANSMISSION LINES, SWITCHYARDS, AND SUBSTATIONS								8,800,000	
	01		INCOMING POWER					7,030,000	1,770,000	8,800,000		
			01 - SWITCHYARD		4,600,000		4,600,000					
		130	Structures and Improvements		(300,000)		(300,000)					
			.01 - Site Preparation	48	(140,000)		(140,000)					
			.02 - Control Building	48	(160,000)		(160,000)					
		175	Station Equipment	49	(4,300,000)		(4,300,000)					
			02 - TRANSMISSION LINES, 161-kV		650,000		650,000					
		100	.01 - Land and Rights	50	(80,000)		(80,000)					
			.02 - Knob-Desalting Plant		(490,000)		(490,000)					
		182	Poles and Fixtures	50	(280,000)		(280,000)					
		183	Overhead Conductors and Devices	50	(210,000)		(210,000)					
			.03 - Yucca Powerplant-Desalting Plant		(80,000)		(80,000)					
		182	Poles and Fixtures	50	(40,000)		(40,000)					
		183	Overhead Conductors and Devices	50	(40,000)		(40,000)					
			03 - KNOB SUBSTATION ADDITION		1,200,000		1,200,000					
		175	Station Equipment	50	(1,200,000)		(1,200,000)					
			04 - YUCCA-AXIS POWERPLANT SWITCHYARD ADDITION		580,000		580,000					
		175	Station Equipment	50	(580,000)		(580,000)					
GL		116	BRINE STREAM REPLACEMENT STUDIES	51		2,440,000	2,440,000	2,440,000	0	2,440,000	2,440,000	

GPO 835-542

and includes the necessary air pollution control equipment. The pretreatment facilities also include work to be constructed at the Cactus waste disposal site for the disposal of excess sludge, grit, and trash. These facilities include railroad trackage and switches, a well, a powerline, a portable office, a relocatable utility building, and yard fencing. The cost estimate for these facilities is at appraisal grade.

B.2. Operating Equipment Cost

The project will require an initial investment in equipment to operate the desalting plant and the sludge disposal area. It will be necessary to obtain motorized equipment ranging in size from fork lifts for use inside the plant to a 15-ton truck-mounted crane for outside use. Heavy equipment will also be needed for use at the waste disposal site to meet disposal requirements in conjunction with partial sludge recalcining. It will be necessary to furnish and equip a water laboratory and a machine shop, and to acquire a stock of hand tools and electrical and chemical testing equipment. The total acquisition cost of operating equipment is estimated to be $1,840,000, and is presented in Table 13.

B.3. Materials for Testing

Testing of the pretreatment and desalting systems will be in progress for a year and a half prior to the final plant completion date (see Drawing No. 1292-D-1 in Chapter XIII). The physical transition from the construction phase to the operation phase, due to this relatively long period of testing and shakedown operation, will be gradual.

Equipment testing, prior to calendar year 1981, will be conducted as part of the construction program. Initial training of operators will be partially conducted by the membrane suppliers. The cost of operating personnel, power, and materials is included in the allowance for overhead on construction. However, a separate allowance was made for the cost of pretreatment chemicals and recalcining fuel used during this period, estimated to be $600,000. This estimate is based on an operation time equivalent to 3.2 months full production, and a 2-month supply of purchased lime for pretreatment plant startup.

The various desalting plant systems will be sequentially acceptance tested during 1981, and full-scale shakedown operation will be conducted to get the plant ready for reliable and sustained operation. Desalted water will be produced on an unscheduled basis, and will be used, as available, to meet deliveries to Mexico. Operating costs will build up to their full estimated amount during the year. Consequently, the costs of testing and shakedown operation in 1981 will be provided for by means of an operation and maintenance budget.

C. Bypass Drain

C.1. United States

The cost of the Bypass Drain - United States, is estimated to be $8,300,000. Construction costs are summarized on Table 16, and construction quantities and unit prices are shown on the Project Cost Estimate.

C.2. Mexico

The Secretariat of Hydraulic Resources has accepted two bids for work on the drain to be performed by construction contract, and the construction is currently underway. The Secretariat has estimated, based on contract prices, that the cost to Mexico of constructing the Bypass Drain - Mexico, will be approximately $24,421,000. This cost estimate is based on bid prices, plus contingencies of 10 percent and an allowance of 12 percent for cost escalation, in accordance with provisions in construction contracts. Construction prices in United States dollars are shown on Tables 13 and 16.

In addition to the cost to Mexico, there will be administrative and overhead costs to the United States Section of the International Boundary and Water Commission, estimated at $160,000, and to the Bureau of Reclamation, estimated to be $244,000. The total costs of the Bypass Drain - Mexico, is estimated to be $24,825,000.

D. MODE Siphon

The cost of the MODE Siphon and relocating the City of Yuma Intake Pumping Plant is estimated to be $3,600,000. Construction prices are shown on the Project Cost Estimate.

Bids for most of this work were opened on August 19, 1975, and a contract was awarded to the low bidder. The estimate reflects the bid prices plus some known increases in construction quantities, and has a contingency allowance of 20 percent and an overhead allowance of 25 percent.

E. Wellton-Mohawk Irrigation Efficiency Improvement Program

This overall program embraces a variety of cooperative programs involving the Department of Agriculture and the Wellton-Mohawk Irrigation and Drainage District (see Chapter VIII, Paragraph D.).

Appraisal cost estimates for the various programs were originally made with price levels as of April 1973. The estimates were updated to October 1975 price levels for this report. Costs of constructing the onfarm improvements were updated using a factor of 1.23, which was obtained through a comparison of selected Soil Conservation Service construction prices in the Wellton, Arizona area between April 1973 and October 1975. Average unit prices for onfarm improvement work are published and updated regularly in the Wellton-Mohawk Irrigation Improvement Program Handbook, published by the Soil Conservation Service state office in Phoenix.

The other program items consist essentially of professional services, and in order to index them a composite factor was prepared which includes increases in the Federal salary schedules and in the costs of travel and materials. Expenditures were made for some of these programs prior to July 1975. In such cases the estimates were first updated to June 1975, and expenditures were deducted, then the balances were updated to October 1975 price levels.

Federal costs of the various programs are estimated to be as follows:

Irrigation Management Services	$	1,210,000
Technical Field Committee Activities		270,000
Education Program on Irrigation Efficiency		178,000
Research and Demonstrations		600,000
Onfarm Improvements		
Installation Costs		6,370,000
Technical Assistance		1,220,000
Total Cost	$	9,848,000

The installation costs shown for the onfarm improvements consist of 75 percent of the total estimated cost of the physical work, in accordance with a cost-share rate of 75 percent Federal and 25 percent cooperator (landowner), established by the Secretary of the Interior. The cost estimate is based on the combination of improvements contemplated under one of several alternative program levels (Program Level 3) formulated by the Advisory Committee on Irrigation Efficiency (see Chapter VI, subparagraph B.1.).

F. Wellton-Mohawk Acreage Reduction

This program will involve costs of acquiring lands, clearing groves, razing certain irrigation improvements, and relocating affected landowners, as discussed in Chapter VIII, Paragraph E. All the specific tracts of land to be acquired are not yet known, but will be identified during a program of appraisals and negotiations with landowners. Consequently, the cost estimate for this program, shown on Table 14, is at appraisal grade.

The cost of land and land rights was estimated on the basis of several appraisals made in fiscal year 1975. Relocation costs were estimated by applying a percentage to the basic acquisition costs. Clearing and razing costs were based on clearing 4,500 acres of citrus groves of trees and facilities.

The reduction of acreage in the Wellton-Mohawk Division will be accompanied by a reduction in the Wellton-Mohawk District's repayment obligation to the United States, as discussed in Chapter VIII, Paragraph E. The reduction in repayment will be a nonfunded cost to the Federal Government and will not be included in the cost analysis for the Desalting Complex Unit. The amount of the repayment reduction is not presently known, but will be determined through negotiation with the District.

G. Painted Rock Reservoir Land Acquisition and Operation Schedule Modification

The cost estimate supporting the total expenditure cited in *Public Law 93-320* for the Title I Division included the amount of $5,000,000 for acquisition of additional rights-of-way in Painted Rock Reservoir, based on an April 1973 price level. There have been no discernible changes in land values in the vicinity and the cost estimate has not been changed. The area involved is estimated at 8,800 acres.

There is a question as to whether it will be necessary to acquire these additional lands for operation of the reservoir, as proposed for the project, or whether sufficient rights are already held by the Federal Government. Pending a legal determination of this matter, the estimated cost of the land is included in the project cost analysis.

Table 14
COST SUMMARY--WELLTON-MOHAWK ACREAGE REDUCTION
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Land Acquisition	
Citrus Land - 4,500 Acres at $2,000	$ 9,000,000
Noncitrus Land - 1,500 Acres at $1,000	1,500,000
Relocation of Landowners (8.5% of Land Cost)	900,000
Contingencies (10% of Land plus Relocation)	1,100,000
Subtotal - Land Acquisition	$12,500,000
Clearing	
Clearing Citrus Groves - 4,500 Acres at $250	$ 1,125,000
Removing Irrigation Facilities - 5,500 Acres at $50	275,000
Contingencies (20% of Clearing and Removal)	280,000
Subtotal - Clearing	$ 1,680,000
Indirect Costs	
For Land Acquisition (4% of $12,500,000)	$ 500,000
For Clearing (19% of $1,680,000)	320,000
Subtotal - Indirect Costs	$ 820,000
TOTAL COST	$15,000,000

H. Fish and Wildlife Mitigation Facilities

The fish and wildlife facilities proposed for mitigation of the Desalting Complex Unit are discussed in Chapter VIII, Section G. Studies to determine the scope and capacity of the mitigation program are still in progress. Estimated costs are:

Gila River Wildlife Management Area and Fish Rearing Facility		
Construction Cost	$	1,764,000
Land and Land Rights		105,000
		1,869,000
Hunter's Hole Pond Complex		63,000
Contingencies at 12 Percent		230,000
Field Cost		2,162,000
Overhead		195,000
Total Cost	$	2,357,000

I. Related Investigations

I.1. Yuma Desalting Test Facility

The Yuma Desalting Test Facility and its role in the design of the project are discussed in Chapter VII, Section F. The cost estimate for this feature includes the physical establishment of the test facility, and the costs of research and development work on desalting and pretreatment processes performed at and in conjunction with work at the facility. The Bureau plans to operate the test facility until the end of fiscal year 1979. Estimated costs of the facility and related development work are as follows:

Installation and Expansion of Test Facility	$	627,998 1/
Contracts for Research and Development of Desalting and Pretreatment Processes		
Contract 14-06-300-2571 2/		522,578
Contract 14-06-300-2605 2/		1,474,117
FY 1978 and FY 1979 3/		1,500,000
		3,496,695
Minor Contracts and Contingencies		500,000
Investigations by the Bureau of Reclamation and the Office of Water Research and Technology, plus overhead costs		1,975,307
Total Cost	$	6,600,000

1/ Includes nonappropriation transfer of property from Office of Water Research and Technology - $169,289.
2/ Contracts with Burns and Roe, Inc.
3/ Contractor to be selected

I.2. Reject Stream Replacement Studies

The cost estimate supporting the total expenditure cited in *Public Law 93-320* for the Title I Division included the amount of $2,000,000 for reject stream replacement studies, based on an April 1973 price level. That amount was indexed to an October 1975 price level using a composite index factor which includes increases in Federal salary schedules and in costs of transportation and materials. The estimated cost is $2,440,000.

J. Control Schedule

A schedule of expenditures by year for implementation of the Desalting Complex Unit is shown on Table 15. The estimated expenditures for Painted Rock Reservoir are not identified with a specific year of future construction because of uncertainties related to the need for acquisition of lands. The entries for Service Facilities, Depreciation, and Salvage were estimated from the consolidated Control Schedule for Title I Division by prorating these items among the three units in the Title I Division, which are the Desalting Complex Unit, Coachella Canal Unit, and Protective and Regulatory Pumping Unit.

K. Interest During Construction

Federal interest during construction was considered on the expenditures for project features shown on the Control Schedule. Interest was calculated at 5-5/8 percent simple

LEGEND: Types of Activity — Preconstruction and Other Work / Construction

Table 15

LINE NO.	PROGRAM ITEM	QUANTITY	ESTIMATED TOTAL	Estimated TOTAL TO SEPT 30,1976	FISCAL YEARS 1977	1978	1979	1980	1981	1982	1983	BALANCE TO COMPLETE	LINE NO.
					ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS		
	1	2	3	4	5	6	7	8	9	10	11	12	
1	PROGRAM GOALS	1/	2/										1
2													2
3	CONSTRUCTION PROGRAM												3
4	Yuma Desalting Plant	108.5 Mgal/d	151,900,000	2,938,000	7,595,000	13,360,000	64,835,000	49,165,000	11,645,000	2,362,000			4
5	Bypass Drain	353 ft^3/s											5
6	United States	16.0 miles	8,300,000	2,137,000	6,163,000								6
7	Mexico	34.7 miles	24,825,000	13,152,000	11,673,000								7
8	MODE Siphon	353 ft^3/s 3491 feet	3,600,000	3,255,000	345,000								8
9	Wellton-Mohawk Irrigation Efficiency Improvement Program		9,848,000	1,597,000	1,508,000	2,871,000	3,872,000						9
10	Wellton-Mohawk Acreage Reduction		15,000,000	6,015,000	4,639,000	4,346,000							10
11	Painted Rock Reservoir		5,000,000									5,000,000	11
12	Fish and Wildlife Mitigation Measures		2,357,000		327,000	2,030,000							12
13	Service Facilities, Depreciation, and Salvage			500,000	-25,000	-80,000	-110,000	-70,000	-65,000	-150,000			13
14													14
15	TOTAL CONSTRUCTION COST		220,830,000	29,594,000	32,225,000	22,527,000	68,597,000	49,095,000	11,580,000	2,212,000		5,000,000	15
16													16
17	Other Project Costs												17
18	Yuma Desalting Test Facility		6,600,000	3,808,000	854,000	1,028,000	910,000						18
19	Brine Stream Replacement Studies		2,440,000	569,000	300,000	590,000	700,000	281,000					19
20													20
21	TOTAL PROJECT COST		229,870,000	33,971,000	33,379,000	24,145,000	70,207,000	49,376,000	11,580,000	2,212,000		5,000,000	21
22	Consolidated Expenditures and Credits		-169,289	-169,289									22
23	TOTAL EXPENDITURES		229,700,711 3/	33,801,711	33,379,000	24,145,000	70,207,000	49,376,000	11,580,000	2,212,000		5,000,000	23
24													24
25													25

NOTES:

1/ Measures required for implementation of Title I of the Colorado River Basin Salinity Control Act (Public Law 93-320)--Desalting Complex Unit.

2/ Cost estimates are based on October 1975 price levels.

3/ Estimated total expenditure exceeds amount authorized in Public Law 93-320 of $155,500,000 plus cost indexing.

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

RECOMMENDED: ______ (Regional Director) ______ (Date)

RECOMMENDED: ______ (Chief, Div. of P C & F) ______ (Date)

APPROVED: ______ (Commissioner) ______ (Date)

REVISED: ______ (Date) SHEET ____ OF ____ SHEETS

PF-2 (8-75)

UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

CONTROL SCHEDULE

Colorado River Basin Salinity Control Project
Title I Division
DESALTING COMPLEX UNIT

Boulder City, Nevada (OFFICE) — April 19, 1976 (DATE) — LC (REGION)

☐ GENERAL INVESTIGATIONS ☐ LOAN PROGRAM
■ CONSTRUCTION ☐ OTHER

interest during the period between the year of expenditure and the time when the features were placed in service, as shown on the Control Schedule. Accordingly, the period during which interest was counted varied with each individual feature. The Wellton-Mohawk Irrigation Efficiency Improvement Program and the Wellton-Mohawk Acreage Reduction Program were not subject to interest because the benefits will accrue immediately following expenditures. Interest during construction is presented on Table 16.

L. Total Federal Investment

The total Federal investment cost consists of the total project cost shown on the Control Schedule plus the value of interest during construction. Federal investment costs are summarized in Table 16. It should be noted that this cost estimate is based on the sizes and configurations of project features contemplated in the fall of 1975, and on October 1975 prices. Further refinements in designs will undoubtedly lead to changes in the project cost estimate.

Table 16
SUMMARY OF FEDERAL INVESTMENT COSTS
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

	Installation Cost 1/	Interest during Construction 2/	Investment Cost
'uma Desalting Plant	$151,900,000	$21,100,000	$173,000,000
;ypass Drain			
United States	8,300,000	340,000	8,640,000
Mexico	24,825,000	1,530,000	26,355,000
Total - Bypass Drain	33,125,000	1,870,000	34,995,000
IODE Siphon	3,600,000	275,000	3,875,000
Iellton-Mohawk Irrigation Efficiency :mprovement	9,848,000	--	9,848,000
Iellton-Mohawk Acreage Reduction	15,000,000	--	15,000,000
'ainted Rock Reservoir	5,000,000	--	5,000,000
'ish and Wildlife Mitigation Measures	2,357,000	85,000	2,442,000
;UBTOTAL	$220,830,000	$23,330,000	$244,160,000
)ther Costs			
Yuma Desalting Test Facility	6,600,000	--	6,600,000
Brine Stream Replacement Studies	2,440,000	--	2,440,000
:OTAL	$229,870,000	$23,330,000	$253,200,000

:/ October 1975 prices.

?/ Interest rate 5-5/8 percent.

XII. OPERATION, MAINTENANCE, REPLACEMENT, AND ENERGY COSTS

A. Yuma Desalting Plant

Normal operational expenditures for the Yuma Desalting Plant will be made for personnel, supplies and materials, equipment operation, replacements, energy, special operation and maintenance, and administrative and general functions.

A.1. Personnel

Personnel costs for operating and maintaining the desalting plant are presented on Table 17, which contains a list of employees based on plant organization and staffing, as presented in Figure 5 in Chapter IX. The estimated hourly wages shown are based on current rates in the Yuma area.

Continuous plant operation will involve extra pay during holidays for most operation positions and a few maintenance positions; an allowance of 2 percent was added for this pay. Overtime will occasionally be necessary to cover absence due to sickness, and unexpected operating and maintenance requirements; an allowance of 2 percent was added for this purpose. An allowance was also made for Bureau of Reclamation contributions to employee retirement and health plans, and contributions for unemployment and workman's compensation. These payroll additives currently amount to 10 percent of the base salaries.

A.2. Supplies and Materials

A.2.a. Chemicals

Chemicals will be used in the desalting plant for pretreatment, membrane cleaning, and temporary and long-term membrane storage. The estimated annual pretreatment chemical quantities (based on 332.5 days annual operation, with minor exceptions) and prices (obtained from suppliers during the fall of 1975) are as follows:

Table 17
STAFF POSITIONS AND ANNUAL COST
YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Position	Number	GS Grade 1/	Hourly Wage (Including Shift Differential)	Annual Salary (2,080 Hours Per Year)	Total Annual Cost
Administrative					
Plant Superintendent	1	14		$30,400	$ 30,400
Administrative Assistant	1	9		15,300	15,300
Purchasing Clerk	1	4		8,800	8,800
Secretary	1	5		10,100	10,100
Clerk/Stenographer	1	3		8,000	8,000
Clerk/Guide	2	3		8,000	16,000
Subtotal	7				$ 88,600
Process Engineering					
Process Engineer	1	13		26,000	26,000
Systems Analyst	1	12		22,000	22,000
Electrical Engineer	1	12		22,000	22,000
Computer Programer	2	11		18,400	36,800
Chemist	1	12		22,000	22,000
Laboratory Technician	2	9		15,300	30,600
Subtotal	8				$ 159,400
Operations 2/					
Operations Supervisor	1	12		22,000	22,000
Operator/Foreman	6		$7.75	16,120	96,700
Plant Operator	13		6.75	14,040	182,500
Control Room Operator	5		6.75	14,040	70,200
Equipment Operator	5		7.50	15,600	78,000
Equipment Mechanic	1		7.50	15,600	15,600
Operator Helper	9		6.00	12,480	112,300
Subtotal	40				$ 577,300
Maintenance					
Maintenance Supervisor	1	12		22,000	22,000
Mechanic/Foreman	1		9.00	18,700	18,700
Mechanic	3		6.75	14,040	42,100
Pipefitter/Plumber	2		6.75	14,040	28,100
Machinist/Welder	1		7.50	15,600	15,600
Painter	1		7.50	15,600	15,600
Helper	3		6.00	12,480	37,400
Toolroom Clerk	1	4		8,800	8,800
Stockroom Clerk	2	6		10,900	21,800
Equipment Operator	2		7.50	15,600	31,200
Electronic Maintenance Foreman	1		9.00	18,700	18,700
Electrician	2		7.75	16,120	32,200
Electronic Technician	2	9		15,300	30,600
Instrument Technician	3	9		15,300	45,900
Maintenanceman/Foreman	1		6.00	12,500	12,500
Custodian/Maintenanceman	1		5.50	11,400	11,400
Groundskeeper	1		5.50	11,400	11,400
Subtotal	28				$ 404,000
Subtotal Salaries	83		(Average: $14,808)		$1,229,300
Allowance for Overtime and Holiday Pay - 4 Percent ± of Salaries					48,700
Allowance for Payroll Additives - 10 Percent ± of Salaries					122,000
Total Annual Personnel Cost					$1,400,000

1/ All GS grades are in 5th step.

2/ Includes 6 positions for sludge disposal site.

Type of Chemical	Annual Use (Tons)	Cost ($/Ton)	Annual Cost
Pretreatment Chemicals			
Lime (as CaO)	41,600	42	$ —
Ferric Sulfate	166	102	17,000
Polyelectrolyte	20	3,800	76,000
Sulfuric Acid (93.2%)	150	37	6,000
Chlorine	760	160	121,000
Sodium Hexametaphosphate	670	560	375,000
Carbon Dioxide	29,900	---	---
Sodium Ash	830	98	81,000
			676,000
Cleaning and Conditioning Chemicals			24,000
Total Chemical Cost			700,000

Ferric sulfate, polyelectrolyte, and soda ash are assumed to be needed only 10 percent of the time. The annual sulfuric acid requirement is based on an estimated 10 days downtime of the carbon dioxide pH control system. Chemicals will generally be unloaded into project silos and tanks as they are received by rail or truck. Lime and carbon dioxide will be produced onsite in the process of recalcining sludge from the pretreatment lime softening process.

Chemicals used for membrane cleaning will be specified by membrane manufacturers, and will depend on the types of membranes used and variations in the quality of the MODE flow.

A.2.b. Materials and Other Supplies

Materials and supplies needed during the operation of the desalting plant, other than chemicals, consist of such items as pipe fittings, lubricants, repair parts for machines and pumps, hardware, expendable tools, laboratory supplies, and machine shop supplies.

The current industry practice is to allow about 1 percent of the plant investment cost for materials and supplies; however, because of the accruals for replacement that are included in the operating costs, an allowance of 1/2 percent of the installation cost was used for this analysis.

The estimated annual cost of materials and supplies, then is $112,490,000 x .005 = $560,000 (rounded).

A.3. Equipment Operation

Equipment operation includes the operation of basic personnel transportation vehicles, mobile equipment, and haulage of sludge to the disposal area.

Vehicles such as sedans and pickups will be needed for official travel from the plant to the city of Yuma, the sludge disposal site, other associated features of the Desalting Complex Unit (as needed for desalting plant operation), and to offices of other agencies. Service trucks will be needed for servicing mobil and stationary equipment. These vehicles will be leased from the General Services Administration; the annual cost of their lease and operation is estimated to be $40,000.

The operating costs of motorized equipment, exclusive of operators' wages, were estimated using hourly rates multiplied by the number of hours of annual operation anticipated. The annual costs total $90,000--$25,000 for equipment at the plant and $65,000 for equipment at the sludge disposal site. These costs also cover the servicing of equipment and, for the sludge disposal site, a rigorous preventive maintenance and overhaul schedule to avoid unscheduled downtime. Purchase of the equipment is provided for as an investment cost in Chapter XI.

The cost of hauling sludge to the Cactus disposal site was estimated on the basis of disposing 260 tons of sludge and 41.5 tons of grit and debris per day, which amounts to a total of approximately 104,000 tons per year. Haul distance by rail is approximately 24 miles, and a car movement is contemplated every other day. The railroad freight rate is not known, but would be negotiated with the local carrier.

It is estimated that the rate would be about 10 cents per ton-mile, for which the annual cost of the haul is estimated to be approximately $250,000 per year.

The total annual equipment operation cost will be $380,000.

A.4. Replacements

Desalting membrane replacement costs are based on the element costs and lives listed in the following tabulation. Replacement costs were estimated for each of the three approximately 20 Mgal/d segments of desalting equipment. The costs for the unspecified segment of the plant were estimated using the average unit replacement costs of the three specified segments.

	Total Cost	Membrane Life	Annual Replacement Cost
Spiral wound elements 6,480 - 8" elements @ $222 each	$1,438,600	5 years	$ 288,000
Hollow fine fiber elements 1,320 - 10" elements @ $809 each	$1,067,900	6 years	178,000
Electrodialysis stages 104 - 300 cp stages @ $17,280 each	$1,797,100	10 years	180,000
Total for 60 Mgal/d			646,000
Average cost = $646,000 ÷ 60 = $10,770 per Mgal/d			
Remaining unspecified 44 Mgal/d 44 Mgal/d x $10,770 per Mgal/d =			474,000
Total membrane replacement cost			$ 1,120,000

Desalting and pretreatment equipment, exclusive of membranes, was considered to have a 20-year life, and replacement costs were calculated using a sinking fund factor at an interest rate of 5-5/8 percent. Replacement factors for pumps and motors, accessory electrical equipment, and station equipment for the switchyard were derived from Table 4 of *Replacement Factors and Depreciation Rates*, Bureau of Reclamation, May 1969. Replacements for the supervisory control and communications equipment were based on a 15-year sinking fund factor. Various other replaceable parts of the plant, such as the roofing, elevator, and motor generator set, were included with a 20-year sinking fund factor. Replacement costs are presented on Table 18. An interest rate of 5-5/8 percent was used because that was the Federal discount rate in effect for evaluation of water supply projects at the time the project was authorized.

Replacement costs for operating equipment were estimated by means of sinking fund accounting over the estimated life of the equipment. Much of the mobile equipment at the sludge disposal site would not be used continuously, so it was estimated to have an average effective useful life of 15 years. The lives of the mobile equipment used at the desalting plant will probably vary substantially, with some of the smaller equipment

Table 18
ANNUAL ACCRUAL FOR REPLACEMENT RESERVE
YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Item	Construction Cost	Replacement Factor 1/	Replacement Cost
Desalting Equipment			
Membranes	$ 6,600,000	2/	$1,120,000
Other Equipment, including Piping	47,100,000	0.0282999 3/	1,330,000
Pretreatment Equipment	28,100,000	0.0282999 3/	800,000
Pumps and Prime Movers	3,600,000	0.003463 4/	12,000
Accessory Electrical Equipment	11,000,000	0.008489 4/	93,000
Station Equipment for Switchyard	7,700,000	0.005488 4/	42,000
Supervisory Control and Communications Equipment	5,300,000	0.044204 5/	230,000
Miscellaneous Parts of Plant 6/	600,000	0.013508 7/	8,000
Operating Equipment at Plant	570,000	0.044204 5/	25,000
Operating Equipment at Disposal Site	990,000	0.044204 5/	44,000
TOTAL			$3,704,000
ROUND TO			$3,700,000

1/ Based on interest rate of 5-5/8 percent.

2/ Replacement cost calculated separately for various membranes.

3/ Twenty-year sinking fund.

4/ Developed from Table 4 of "Replacement Factors and Depreciation Rates," Bureau of Reclamation, May 1969.

5/ Fifteen-year sinking fund.

6/ Includes roofing, elevator, and motor-generator set.

7/ Thirty-year sinking fund.

in daily use lasting 7 to 10 years and some of the larger, more expensive equipment, lasting 20 years or more. An average effective life of 15 years was selected. Replacements of equipment for the laboratory, machine shop, and office furniture are considered in the estimate for materials and supplies.

A.5. Energy

A.5.a. Electric Power

The electric power demand of the desalting plant, including the pretreatment system, is estimated to be 39 megawatts (MW) when operating at full capacity. In order to estimate the annual energy requirement, an equivalent annual use factor of 86 percent was applied (based primarily on the projected desalting system plant factor of 84.5 percent), with allowances for longer pretreatment system operation and other incidental power use during shutdowns. The project would also be charged for transmission losses, and some additional capacity would be required to offset the difference in plant factors between the desalting plant and the power sources.

The desalting plant will have an energy recovery turbine that will operate on the high pressure reject from the reverse osmosis segments. The electric energy which will be produced is estimated to be 7.4 million kWh per year. This energy will be fed directly into the desalting plant switchyard and will partially offset the total power requirement of the plant.

The desalting plant's electric requirements will be obtained from the Navajo Project Stream Generating Plant through 1984. Thereafter, depending on the needs of the Central Arizona Project, power may continue to be obtained from the Navajo Project if available, or it may be obtained from one or more alternative sources still under investigation. The cost estimate in this report has been based on the use of power from the Navajo Project through 1984, and power from an alternative source thereafter.

The use of the Navajo Project Powerplant (with an estimated plant factor of 75 percent) as the power source results in the following requirements:

Requirement for Navajo Power

Item	Estimated Demand (MW)	Annual Energy 1/ (kWh)
Desalting plant requirement	39.00	293,800,000
Transmission losses (9%) 2/	3.51	26,400,000
Additional capacity required to offset difference in plant factors of the desalting plant and Navajo Project	6.23	0
Subtotal	48.74	320,200,000
Credit for output of energy recovery facilities	0	(-) 7,400,000
Total Requirement at Navajo Powerplant	48.74	312,800,000

1/ Calculated with an equivalent annual use factor of 86 percent.

2/ Five percent for Navajo Project transmission system losses plus 4 percent for Federal transmission system losses.

The cost of this power is based on January 1976 unit prices, which are $30 per kilowattyear and 5 mils/kWh. In addition, there will be a charge of $8.40 per kilowattyear for wheeling the power through the Federal transmission system. The annual power cost is estimated to be:

Cost of Navajo Power

Capacity charge (48,740 kW @ $30)	$	1,460,000
Energy charge (312.8 x 10^6kWh @ $0.005)		1,560,000
Wheeling charge (42,510 kW @ $8.40)		360,000
Total	$	3,380,000

Alternate sources of power are several thermal powerplants that are presently under construction and expected to be in service by 1985.

When an alternative power source is used, the deaslting plant power requirement would be different from the requirement when Navajo power is used because of differing plant factors (alternative power source plant factor estimated to be 70%).

Requirements for Alternative Power

Item	Estimated Demand (MW)	Annual Energy 1/ (kWh)
Desalting plant requirement	39.00	293,800,000
Transmission losses (9%) 2/	3.51	26,400,000
Additional capacity required to offset difference in plant factors of the desalting plant and alternative power source	9.71	0
Subtotal	52.22	320,200,000
Credit for output of energy recovery facilities	0	(-) 7,400,000
Total requirement at alternative source	52.22	312,800,000

1/ Calculated with an equivalent annual use factor 86 percent.

2/ Five percent for Navajo Project transmission system losses plus 4 percent for Federal transmission system losses.

The cost of power from other sources would depend on the type of fuel to be used. Assuming a coal-fired powerplant, it is estimated that the current (1975) cost of power from such new facilities would be approximately 13.7 mils/kWh plus $82 per kilowattyear. In addition, there would be a wheeling charge of $8.40 per kilowattyear, the same as is estimated for power from the Navajo Project. The annual cost of power from an alternate source, based on these unit prices, is estimated to be as follows:

Cost of Alternative Power

Capacity Charge (52,220 kW @ $82)	$	4,280,000
Energy Charge (312.8 x 10^6 kWh @ $0.0137)		4,290,000
Wheeling Charge(42,510 kW @ $8.40)		360,000
Total from alternative source	$	8,930,000

The annual equivalent power cost in this report has been calculated using \$3,380,000 for the first 3 years and \$8,930,000 for the next 47 years, with an interest rate of 5-5/8 percent and a 50-year period of analysis. The resulting annual equivalent power cost is \$8,000,000.

The longer the desalting plant uses Navajo power, the lower will become the annual equivalent cost. For example, if the change of sources is delayed one year the annual equivalent cost would be \$7,800,000; if six years, \$6,600,000.

A.5.b. Fuel for Recalcining

Lime and carbon dioxide from the pretreatment process will be obtained through recalcination of lime sludge in a fluidized bed kiln. Fuel requirements in this report are based on recalcining the amount of sludge required to produce the necessary amount of lime for pretreatment system operation.

The estimated amount of lime required is 41,600 tons per year, based on a pretreatment system operation factor of 91 percent. This will require the recalcining of approximately 390 tons of sludge per day. Energy requirements for recalcining were estimated on the basis of a heat requirement of 8,000,000 Btu/ton of calcium oxide produced. Consequently, the total annual energy requirement will be approximately 333 x 10^9 Btu per year. The recalcining kiln will be fueled with #6 fuel oil, which has a heat value of 6,500,000 Btu per barrel. The total fuel requirement would be approximately 51,000 barrels, and at an estimated price of \$12 per barrel, the total cost is approximately \$610,000 per year. If full recalcination is undertaken, the fuel requirement would increase by approximately 69 percent.

A.6. Special Operation and Maintenance

Services of the Parker-Davis Project will be used for operation and maintenance of the powerlines and switchyard for the desalting plant. The cost of such services, based on power facilities operating experience in the Lower Colorado Region, is estimated to be \$55,000 per year.

The Bureau of Reclamation, Yuma Projects Office, will perform the water scheduling studies necessary to coordinate operation of the desalting plant with operation of the Colorado River and the Wellton-Mohawk Division. Such coordination will be done in conjunction with currently performed work of a similar nature. The share of the water scheduling costs that will be chargeable to the Desalting Complex Unit is estimated at $30,000 per year.

It is anticipated that the computer control system will be serviced under contract with a computer manufacturer. The estimated annual cost is $25,000 per year.

The total cost of special operation and maintenance is $110,000 per year.

A.7. Administrative and General Expenses

General plant expenses will include utilities, office supplies, the lease of office machines, and official travel expenses outside the project area. The annual cost of such items is estimated to be $40,000.

The Yuma Projects Office will conduct such administrative functions as personnel management, purchasing, fiscal programing, safety, and the preparation of operational reports on the Desalting Complex Unit. Recent and projected Yuma Projects Office costs for such functions were reviewed to form a basis for making projections and the annual administrative expense for the office is estimated to be approximately $290,000.

The Bureau of Reclamation, Lower Colorado Regional Office, will exercise general control over and provide general administrative assistance to the Desalting Complex Unit. The projected FY 1977 Regional Office cost in connection with administration of the Yuma Projects Office operation program is estimated to be about 11 percent. An allowance of 10 percent, considering minor economy of scale, appears to be appropriate when applied selectively to operation and maintenance items and to the Yuma Projects Office administrative expense, along with a 1-percent allowance applied to chemicals and energy. The Regional Office administrative cost, on this basis, is approximately $320,000 per year.

Technical assistance will be obtained from the Bureau's Engineering and Research Center in connection with operation and maintenance of desalting membranes and other mechanical equipment. The estimated cost of this assistance is approximately $200,000 per year. The total annual administrative and general expense is estimated to be $850,000 per year.

A.8. Potential Credits from the Sale of Desalted Water and Plant Byproducts

A potential exists for the sale of excess desalted water and byproducts from the Yuma Desalting Plant. *Public Law 93-320* allows for the sale of surplus desalted water produced by the plant, with the city of Yuma having the first right of refusal; however, the possible availability of such water has not yet been determined.

A surplus of lime and carbon dioxide may be produced during the recalcining process, and this surplus could be marketed in the Yuma area. Prospects for such markets and the financial return therefrom are only speculative at the present time. The sale of these surplus products would partially offset the Federal cost of operating the desalting plant; however, no credits from such sales have been included in the project cost analysis.

A.9. Summary of Desalting Plant Operation Costs

The total annual cost of operating the desalting plant under full production is as follows:

Personnel	$	1,400,000
Chemicals		700,000
Materials and Other Supplies		560,000
Equipment Operation		380,000
Replacements		3,700,000
Electrical Power		8,000,000
Recalcining Fuel		610,000
Special Operation and Maintenance		110,000
Administrative and General Expense		850,000
Total	$	16,310,000

B. Bypass Drain

B.1. Bypass Drain - United States

The Bypass Drain - United States, will be operated and maintained by the Yuma Projects Office. The costs for operation and maintenance were estimated to be similar, on a per-mile basis, to those experienced for the MODE during calendar years 1973 through 1975, as well as those estimated for 1976. These normalized costs, $1,200 per mile for operation and $2,400 per mile for maintenance, were applied to the 16-mile long Bypass Drain - United States, to arrive at the total annual cost of $19,000 for operation and $39,000 for maintenance (rounded).

B.2. Bypass Drain - Mexico

Minute No. 242 and *Minute No. 248* of the International Boundary and Water Commission provide that the United States reimburse Mexico for the cost of operating and maintaining its section of the Bypass Drain. Consequently, this reimbursement will be a project cost.

Mexico has not yet advised the United States of its projected costs for operating and maintaining its section of the Bypass Drain. An estimate, then, was made using the United States section of the drain as a base and making adjustments for component factors such as remoteness, wage rates, and costs of equipment, fuel, and materials. In general, lower wage rates in Mexico appeared to be offset by higher costs on the other items, and it was concluded that the operation and maintenance costs of the 34.7-mile long Mexican section of the drain would probably not differ significantly, per mile, from those of the United States section. Consequently, the same per-mile costs were used as for the United States section of the drain, with two additional allowances for administration: 5 percent for the International Boundary and Water Commission and 10 percent for the Bureau of Reclamation. The representative annual costs, then, on this basis, are:

Operation and Maintenance	$	125,000
Administration by the International Boundary and Water Commission (5 percent)		6,000
Administration by the Bureau of Reclamation (10 percent)		13,000
Total	$	144,000

C. MODE Siphon

The MODE Siphon will be operated by the Yuma Projects Office, under an existing operation and maintenance program. There will be no cost to the Desalting Complex Unit for its operation and maintenance. The city of Yuma standby pumping plant will become the property of, and will be operated by, the city of Yuma.

D. Wellton-Mohawk Irrigation Efficiency Improvement Program

The operation and maintenance of the various facets of this program will be funded by the irrigation operators of the District, and such costs are not considered as project costs. It is estimated that the annual cost of operating the Irrigation Management Services Program will be approximately $3.00 per acre, which will be borne by the irrigation operators of the District. The financial return to be realized from the program by the irrigation operators, in terms of increased productivity and reduced costs, will more than pay for the annual costs of the program. The onfarm improvements will become part of the physical systems of individual farm operators and will be operated by them.

E. Wellton-Mohawk Acreage Reduction

Project costs involved in administering the lands acquired under this program are projected to be negligible. It is expected that any such costs will be submerged in the general cost of administering Bureau of Reclamation withdrawn lands in the Lower Colorado Region.

F. Painted Rock Reservoir

Changes in reservoir operating criteria and release schedules to minimize recharge of the aquifer underlying the Wellton-Mohawk Division are not expected to significantly increase reservoir operating costs. The Corps of Engineers will continue to operate the reservoir and no operating costs are anticipated to be charged against the Desalting Complex Unit.

G. Fish and Wildlife Mitigation Measures

The fish and wildlife mitigation measures are still in a conceptual stage and, therefore, operation and maintenance activities have not yet been determined.

It is anticipated that project fish and wildlife facilities will be operated by appropriate State fish and wildlife agencies with State funds, but that the cost of maintaining the facilities will be a project cost; however, this arrangement will not be conclusively established until a management agreement is negotiated between the Federal Government and the State fish and wildlife agencies having jurisdiction. Therefore, in this cost estimate, an allowance of approximately 1-1/2 percent of the construction cost of the facilities has been projected for their maintenance, which amounts to $23,000.

H. Summary of Operation and Maintenance Costs

Annual costs of operating and maintaining the entire Desalting Complex Unit are presented in Table 19. The costs presented for the Yuma Desalting Plant are for full

Table 19

SUMMARY OF OPERATION, MAINTENANCE, REPLACEMENT, AND ENERGY COSTS
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Project Feature	Annual Cost
Yuma Desalting Plant 1/	
Personnel	$ 1,400,000
Supplies and Materials	1,260,000
Equipment Operation 2/	380,000
Replacements	3,700,000
Energy	8,610,000 3/
Special O&M	110,000
Administrative and General	850,000
	$16,310,000
Bypass Drain	
United States	
Operation	19,000
Maintenance	39,000
	58,000
Mexico	
Operation and Maintenance	144,000
	$ 202,000
MODE Siphon	$ 0
Wellton-Mohawk Irrigation Efficiency Improvement Program	$ 0
Wellton-Mohawk Land Acquisition	$ 0
Painted Rock Reservoir	$ 0
Fish and Wildlife Mitigation Measures	
Maintenance Costs 4/	$ 23,000
Total Annual Cost	$16,535,000

1/ Costs of operating at full annual production capacity.

2/ Includes railroad freight cost of hauling sludge and grit.

3/ Annual equivalent energy cost using Navajo Project power until 1984 and alternate source thereafter.

4/ Subject to negotiation with agency that undertakes responsibility for management of facilities.

annual production capacity; however, there may be significant departures from these costs if excess Colorado River flows permit operation of the plant at reduced capacity.

XIII. FINANCIAL ANALYSIS AND PROJECT SCHEDULE

The financial analysis for the Desalting Complex Unit is based on project costs for which Federal appropriations are necessary under Title I of *Public Law 93-320*, plus interest during construction. The costs of investigations prior to authorization and interests in lands presently held by the Federal Government have been excluded, as well as the possible reduction in the irrigation repayment obligation of the Wellton-Mohawk Irrigation and Drainage District.

The period of analysis is 50 years, which is the estimated useful life of the Yuma Desalting Plant, the major feature of the Desalting Complex Unit. The discount rate for project analysis is 5.625 percent, the Federal discount rate that was in effect when the project was authorized. Considerations of project economic justification, financial feasibility, and repayment were not investigated since Federal costs of the Desalting Complex Unit, as provided in *Public Law 93-320,* are nonreimbursable national obligations.

Project costs for the Desalting Complex Unit are summarized in Table 20. The investment costs shown include interest during construction, where applicable, and the operation and maintenance costs shown are for full desalting plant production capacity and full nonstructural program operation. The cost of electric power is an annual equivalent cost based on a supply from the Navajo Project through 1984 and from an alternative source thereafter.

The costs of the Yuma Desalting Plant presented on Table 21 are in terms of cost per unit of installed desalting plant capacity, per acre-foot of water desalted, and per ton of salt removed.

The desalting plant will have an installed capacity of 108.47 Mgal/d and, with a plant factor of 84.5 percent, will produce 102,653 acre-feet of product water per year. In combination with 16,178 acre-feet of MODE flow which will bypass the plant, there will be a yield of 118,831 acre-feet of blended water while the plant is operating normally.

In addition to the blend of product water and MODE flow that will be produced during normal plant operation, transient flows amounting to 4,759 acre-feet per year will also be released to the river. Transient flows will consist of pretreated water that will bypass the plant during startup and shutdown operations, and some direct MODE flows

Table 20
COST SUMMARY
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Feature	Investment Cost 1/	Annual Equivalent Investment Cost 2/	OMR&E Cost	Total Annual Equivalent Cost
Yuma Desalting Plant 3/	$173,000,000	$10,400,000	$16,310,000	$26,710,000
Bypass Drain (United States and Mexico)	34,995,000	2,100,000	202,000	2,302,000
MODE Siphon	3,875,000	230,000	0	230,000
Wellton-Mohawk Irrigation Efficiency Improvement Program	9,848,000	590,000	0	590,000
Wellton-Mohawk Acreage Reduction	15,000,000	900,000	0	900,000
Painted Rock Reservoir	5,000,000	300,000	0	300,000
Fish and Wildlife Mitigation Measures	2,442,000	147,000	23,000	170,000
Yuma Desalting Test Facility	6,600,000	400,000	0	400,000
Brine Stream Replacement Studies	2,440,000	147,000	0	147,000
TOTAL	$253,200,000	$15,214,000	$16,535,000	$31,749,000

1/ October 1975 prices; includes interest during construction.

2/ Fifty-year period; 5-5/8 percent interest (factor = 0.060148).

3/ Includes operating equipment and chemicals for acceptance testing.

Table 21
COST OF DESALTED WATER
YUMA DESALTING PLANT
Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

Plant Data	
Installed Capacity	108.47 Mgal/d
Product Water	102,653 acre-feet/yr
Blended Water	123,590 acre-feet/yr 1/
Salt Removed	582,800 tons/yr
Plant Cost	
Investment Cost 2/	($173,000,000)
Annual Equivalent Investment Cost 3/	10,400,000
Annual OMR&E Cost	16,310,000
Total Annual Equivalent Cost	$ 26,710,000
Unit Cost of Desalting Water	
Investment Cost Per Daily Gallon of Installed Capacity	$ 1.59
Annual Operating Cost Per 1,000 Gallons 4/ of:	
Product Water	0.49
Blended Water 1/	0.41
Total Annual Equivalent Unit Cost of Desalting Drainage Water from 3,200 p/m to 386 p/m at 71 Percent Recovery and 84.5 Percent Plant Factor (product water):	
Per Acre-Foot	260.00
Per 1,000 Gallons	0.80
Total Annual Equivalent Unit Cost of Reducing Salinity of Drainage Water from 3,200 p/m to 854 p/m at 74 Percent Recovery (blended water 1/):	
Per Acre-Foot	216.00
Per 1,000 Gallons	0.66
Total Annual Equivalent Unit Cost of Salt Removal Per Ton	46.00

1/ Blended water is the combination of product water, blend flow of 16,178 acre-feet/yr during normal operation of the desalting plant, and 4,759 acre-feet/yr of transient flows during plant startup and shutdown.

2/ October 1975 prices; includes operating equipment, chemicals for testing, and interest during construction.

3/ Fifty-year period of analysis and interest rate of 5-5/8 percent (factor of 0.060148).

4/ One acre-foot = 325,850 gallons.

which will occur at such time. The transient flows are included in the annual accounting for quantity and quality of blended water; however, in the interest of clarity, the analysis on Table 21 is based on normal operation of the desalting plant, and does not include transient flows.

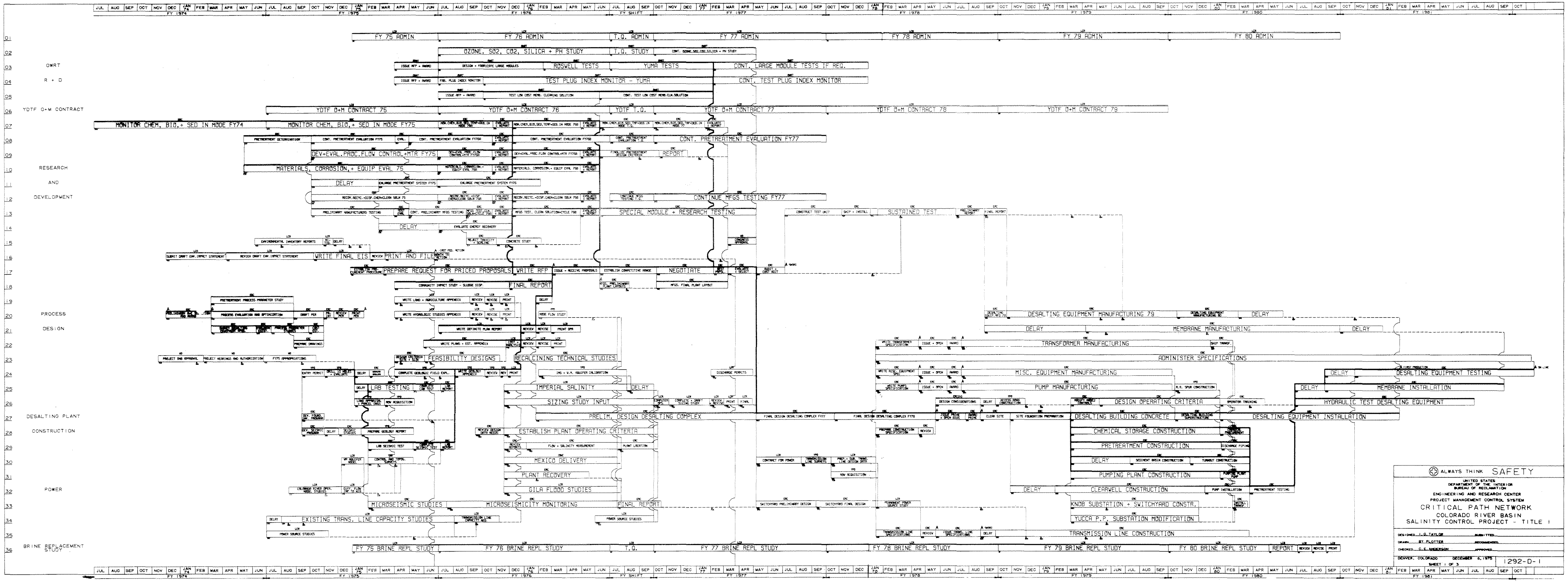
The time frame for implementation of the Desalting Complex Unit is presented on Drawings Nos. 1292-D-1 and -2. This schedule, or critical path network, was developed in order to identify the activities required to complete the design and construction of project facilities by 1981. In addition to delineating the time frame for the various activities, the schedule illustrates the interrelationship of those activities and their dependence upon one another. Completion of the activities shown is dependent upon the availability of adequate funding.

The first project schedule for the Desalting Complex Unit was developed for the September 1973 Special Report, *Colorado River International Salinity Control Project* [15], and identified the plant completion date as December 1978. This schedule was based on the assumption that work would continue uninterrupted from September 1973, until completion of the project. However, key items of work were held in abeyance pending authorization and funding of the project, which caused a 13-month delay.

A further 23-month delay was incurred based on a more realistic approach to the schedule than had originally been assumed, primarily the result of two principal factors. First, because the *Special Report* was prepared in confidence, the delivery, installation time, and cost of the plant had to be synthesized without the benefit of consultation with the membrane equipment manufacturers. Until the manufacturers were canvassed during the preparation of the *Preliminary Engineering Analysis* [20] by Burns and Roe, Inc., production capabilities of the industry were not well known. No single manufacturer had the capability to produce all of the equipment needed within the original time schedule. In addition, discussions with the manufacturers indicated that installation procedures needed to be modified and that the time allowed for installation needed to be increased to protect the membranes from damage during the equipment testing stage.

Second, observations of existing plant operations indicated that initial operations were rarely up to expectations; in some cases, only marginally adequate production could be maintained, even after extensive and costly plant modifications, all at capital and production losses. The main reasons for these difficulties appear to be that inadequate attention was given to pretreatment of the feed water and to the verification of the characteristics of equipment proposed.

Since marginal or poor plant operations could seriously jeopardize the United States ability to meet the conditions of *Minute No. 242* and result in an even greater delay, time has been allowed in the schedule to develop a pretreatment system that will promote trouble-free plant operation. Time has also been extended to carefully scrutinize technical requirements and demonstration of equipment to reasonably insure that supplier's proposals are in fact technically sound and able to meet the needed requirements.


OWRT
R + D
YDTF O+M CONTRACT
RESEARCH
AND
DEVELOPMENT
PROCESS
DESIGN
DESALTING PLANT
CONSTRUCTION
POWER
BRINE REPLACEMENT STUDY
FY 75 ADMIN
FY 76 ADMIN
T.Q. ADMIN
FY 77 ADMIN
FY 78 ADMIN
FY 79 ADMIN
FY 80 ADMIN
OZONE, SO2, CO2, SILICA + PH STUDY
T.Q. STUDY
ROSWELL TESTS
YUMA TESTS
CONT. LARGE MODULE TESTS IF REQ.
TEST PLUG INDEX MONITOR - YUMA
CONT. TEST PLUG INDEX MONITOR
YDTF O+M CONTRACT 75
YDTF O+M CONTRACT 76
YDTF T.Q.
YDTF O+M CONTRACT 77
YDTF O+M CONTRACT 78
YDTF O+M CONTRACT 79
MONITOR CHEM, BIO, + SED IN MODE FY74
MONITOR CHEM, BIO, + SED IN MODE FY75
CONT. PRETREATMENT EVALUATION FY77
DEV+EVAL.PROC.FLOW CONTROL+MTR FY75
REPORT
MATERIALS, CORROSION, + EQUIP EVAL 75
DELAY
CONTINUE MFGS TESTING FY77
SPECIAL MODULE + RESEARCH TESTING
SUSTAINED TEST
WRITE FINAL EIS
PRINT AND FILE
PREPARE REQUEST FOR PRICED PROPOSALS
WRITE RFP
NEGOTIATE
FINAL REPORT
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MEMBRANE MANUFACTURING
TRANSFORMER MANUFACTURING
FEASIBILITY DESIGNS
RECALCINING TECHNICAL STUDIES
ADMINISTER SPECIFICATIONS
MISC. EQUIPMENT MANUFACTURING
DESALTING EQUIPMENT TESTING
LAB TESTING
IMPERIAL SALINITY
PUMP MANUFACTURING
MEMBRANE INSTALLATION
SIZING STUDY INPUT
DESIGN OPERATING CRITERIA
HYDRAULIC TEST DESALTING EQUIPMENT
PRELIM. DESIGN DESALTING COMPLEX
DESALTING BUILDING CONCRETE
DESALTING EQUIPMENT INSTALLATION
ESTABLISH PLANT OPERATING CRITERIA
CHEMICAL STORAGE CONSTRUCTION
PRETREATMENT CONSTRUCTION
MEXICO DELIVERY
PLANT RECOVERY
PUMPING PLANT CONSTRUCTION
GILA FLOOD STUDIES
CLEARWELL CONSTRUCTION
MICROSEISMIC STUDIES
MICROSEISMICITY MONITORING
KNOB SUBSTATION + SWITCHYARD CONSTR.
EXISTING TRANS. LINE CAPACITY STUDIES
YUCCA P.P. SUBSTATION MODIFICATION
TRANSMISSION LINE CONSTRUCTION
FY 75 BRINE REPL STUDY
FY 76 BRINE REPL STUDY
T.Q.
FY 77 BRINE REPL STUDY
FY 78 BRINE REPL STUDY
FY 79 BRINE REPL STUDY
FY 80 BRINE REPL STUDY
REPORT
FY 1974
FY 1975
FY 1976
FY SHIFT
FY 1977
FY 1978
FY 1979
FY 1980
FY 1981
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
ENGINEERING AND RESEARCH CENTER
PROJECT MANAGEMENT CONTROL SYSTEM
CRITICAL PATH NETWORK
COLORADO RIVER BASIN
SALINITY CONTROL PROJECT - TITLE I
DESIGNED I.G. TAYLOR
SUBMITTED
DRAWN BY PLOTTER
RECOMMENDED
CHECKED C.E. ANDERSON
APPROVED
DENVER, COLORADO DECEMBER 8, 1975
SHEET 1 OF 3
1292-D-1


IRRIGATION EFFICIENCY PROGRAM
TFC 1ST ANNUAL REPORT
TFC 2ND ANNUAL REPORT
TFC 3RD ANNUAL REPORT
TFC 4TH ANNUAL REPORT
TFC 5TH ANNUAL REPORT
12000 ACRES TOTAL UNDER IMS
26000 ACRES TOTAL UNDER IMS
30000 ACRES
48000 ACRES TOTAL UNDER IMS
60000 ACRES TOTAL UNDER IMS
T.F.C. ACTIVITIES FY75
T.F.C. ACTIVITIES FY76
T.F.C. ACTIVITIES FY77
T.F.C. ACTIVITIES FY78
T.F.C. ACTIVITIES FY79
ACREAGE APPRAISALS FY75
ACREAGE APPRAISALS FY76
DELAY
ACREAGE NEGOTIATIONS + ACQUISIT FY76
ACREAGE NEGOTIATIONS + ACQUISIT FY77
RESEARCH + DEMONSTRATION PROG FY76
RESEARCH + DEMONSTRATION PROG FY77
TOTAL OF 5000 ON FARM ACRES TREATED
TOTAL OF 12000 ON FARM ACRES TREATED
TOTAL OF 18000 ON FARM ACRES TREATED
TOTAL OF 24000 ON FARM ACRES TREATED
U.A. EDUCATION PROGRAM FY76
U.A. EDUCATION PROGRAM FY77
U.A. EDUCATION PROGRAM FY78
U.A. EDUCATION PROGRAM FY79
SCS TECHNICAL ASSISTANCE FY76
SCS TECHNICAL ASSISTANCE FY77
SCS TECHNICAL ASSISTANCE FY78
SCS TECHNICAL ASSISTANCE FY79
SIPHON + STANDBY PUMPING PLANT
MOVE CITY FACILITIES
MOVE APS GAS LINE
SIPHON FINAL DESIGN
SIPHON + STANDBY P.P. CONSTRUCTION 77
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BYPASS DRAIN - U.S. CONSTRUCTION FY77
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BYPASS DRAIN MEXICO
DRAIN - MEXICO NEGOTIATIONS
REVIEW
DRAIN - MEXICO CONSTRUCTION
FY 1974
FY 1975
FY 1976
FY SHIFT
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